Fraunhofer Institut
Systemtechnik und
Innovationsforschung

Vortragsunterlagen
**25-Jahr-Feier des ISI**

Lecture materials
**25th Anniversary of Fraunhofer ISI**

# 25

3. Juni 1997
Festakt zum 25jährigen Bestehen des ISI

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(Herausgeber)
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## Vorwort

Am 3. und 4. Juni 1997 hat das ISI sein 25-jähriges Bestehen mit einem Festakt und einem internationalen Symposium gefeiert. Wegen der Vielfalt der angesprochenen Themen, der erheblichen zeitlichen Belastung der geladenen Rednerinnen und Redner und auch wegen der Zweisprachigkeit war nicht geplant, einen Konferenzband mit publikationsreifen Manuskripten herauszubringen. Die große Nachfrage nach den Vortragsunterlagen hat uns nun doch bewogen, diese in vorliegendem Heftchen zusammenzustellen. Es handelt sich um Notizen, Entwürfe, Abzüge der Projektionsfolien und dergleichen, also teilweise unfertige und nicht redigierte Schriftstücke. Alle Referenten sind einverstanden, dass sie den Zuhörern schnell und ohne weiteres Aufheben in dieser Form zugänglich gemacht werden. Wir bedanken uns an dieser Stelle für dieses Einverständnis und die unkomplizierte Zusammenarbeit.

Die zu Beginn der Festveranstaltung überbrachten Grußworte haben wir nicht abgedruckt, da diese in etwas veränderter Fassung bereits im diesjährigen Tätigkeitsbericht zweisprachig enthalten sind. Institutsleitung, Mitarbeiterinnen und Mitarbeiter des ISI möchten an dieser Stelle noch einmal allen Referenten, Gästen und vor allem Helferinnen und Helfern an dieser gelungenen Veranstaltung recht herzlich danken.

## Preface

The 25th anniversary conference of ISI took place on June 3rd and 4th, 1997, in the City Festival Hall in Karlsruhe. We did not ask the speakers to hand in a polished manuscript for obvious reasons: the mixture of subjects was very broad, the speakers are very busy and the contributions were presented in two languages. However, the request for conference materials from the audience was so overwhelming that we decided to compile the conference materials into this booklet. You will find here drafts, notes, copies of projection material and the like, but not always manuscripts 'camera-ready' for publication. We are grateful to the speakers that they agreed to this volume in such a flexible manner and that we are able to send out the conference materials very early.

The opening speeches and words of welcome are not reproduced here as they appeared in the institute's annual report in German and English. Once again, staff and directors of ISI would like to take the opportunity to express their thanks to the speakers and guests for coming and staying with us, and to all the helpers whose good management made the conference such a success.

Karlsruhe, Juni/June 1997

Hariolf Grupp

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**Begrüßung 25-Jahrfeier**
*Frieder Meyer-Krahmer*

Lieber Herr Warnecke,
sehr geehrter Herr Leitterstorf,
sehr geehrter Herr Epple,
lieber Herr Eidenmüller und Herr Konecny,
lieber Helmar Krupp als Gründungsdirektor,
sehr geehrte Damen und Herren, Kollegen und Freunde,
liebe ISIaner et finalement mes chères collegues de l'université Louis Pasteur Strasbourg,

im Namen des ISI möchte ich Sie alle herzlich begrüßen. Wir freuen uns, daß viele Menschen gekommen sind, um mit uns den 25. Geburtstag des ISI zu feiern.

Über das Lob aus berufenem Munde freuen wir uns sehr. Wer Herrn Warnecke kennt, weiß, daß der vorhin vergebene Stempel "brauchbar" für uns ein hohes Präsidentenlob darstellt. Wer hat es hauptsächlich verdient? Das Institut, seine Leiter? Ich meine, im Mittelpunkt sollten die Mitarbeiter des Instituts stehen. 25 Jahre zu feiern, das ist Würdigung und Hommage an die Kreativität, die Motivation, das Engagement und den Ehrgeiz aller Mitarbeiterinnen und Mitarbeiter, wissenschaftlich fundierte Beratung von Politik und Wirtschaft zu betreiben und in der Welt etwas zu bewegen. Das Lob und die Ermunterung meiner Vorredner für diese Ambitionen nehme ich gerne im Namen der Mitarbeiter an. Diese Ermunterung wird uns sicherlich nicht zu Kopfe steigen. Die Komplexität der Probleme verlangt Bescheidenheit und einen klaren Blick für die Grenzen des eigenen wissenschaftlichen Tuns. Auch die Einwirkung auf das Innovationsgeschehen selbst sollte mit Nüchternheit - manchmal leider auch mit Ernüchterung - gesehen werden.

Das Wort von der Innovationskrise wurde schon erwähnt. Aus meiner Sicht handelt es sich eher um einen z. T. schmerzlichen System- und Strukturwandel in fast allen industrialisierten Ländern der Welt. Dafür ist Innovation eine mögliche Lösung, keinesfalls die einzige und auch nicht immer angebracht. Man kann auch bereits beobachten, daß manche politische Programmatik auf das Thema Innovation in der Illusion umschwenkt, wichtige grundsätzliche Fragen der Umverteilung oder Marktgestaltung vermeiden zu können. In jedem Fall ist absehbar, daß vieles sich ändern wird: Ein neuer Umgang mit Gesundheit, andere Formen des Bauens, drastische Änderungen von Kommunikation, Arbeit, Produktion sowie der Nutzung von Produkten. Umwelt, Klima und Energie fordern nach wie vor Lösungen. Institutionelle Änderungen, z. B. in der Wissenschaft, rücken wieder verstärkt in den Vor-

dergrund. Es mag etwas seltsam klingen, aber man kann die heutige Lage gerade wegen ihres hohen Problemdrucks als Eldorado für Innovationsforscher ansehen. Es gibt viel zu tun.

Auch das ISI muß sich bewegen: Neue Themen sondieren, Methoden verbessern, Theorien aufgreifen, verstärkt zukünftige alternative Entwicklungspfade und Optionen herausarbeiten. Nicht nur unsere Kundenorientierung verbessern, sondern auch neue organisatorische Formen der Vernetzung mit der Grundlagenforschung aufbauen.

Damit komme ich zu unserem Programm und meiner Rolle als Conférencier. Unser Programm wird in den nächsten zwei Tagen die Möglichkeit bieten, sich zusammen mit Partnern, Auftraggebern, wissenschaftlichen Kollegen und kritischen Begleitern mit zwei Fragen zu beschäftigen:

- Wie entwickeln sich spezifische Felder, auf denen das ISI tätig ist? Welches sind die wichtigsten Trends, Probleme und Herausforderungen?
- Welches sind wichtige Themen, die in den nächsten Jahren aufgegriffen werden sollten?

Wir wollen also unsere Geburtstagsfeier dazu nutzen, Sie und uns zu inspirieren, und damit auch über die Rolle und die Tätigkeit eines Forschungsinstituts, wie es das ISI darstellt, seine Möglichkeiten und Grenzen reflektieren.

Auf dem Programm stehen viele Referenten mit ihrer zum Teil ganz persönlich geprägten Sichtweise. Um etwas Dialog herzustellen, haben wir die Referenten gebeten, sich auf eine gute halbe Stunde zu beschränken, so daß wir jeweils etwa 10 - 15 Minuten Diskussion über den Vortrag anschließen können.

Das ISI arbeitet im Dreieck von Technik, Wirtschaft und Politik (oder weiter gefaßt: Gesellschaft). Das bedeutet nicht nur, sich mit den Wechselbeziehungen dieser drei Welten zu befassen, sondern sich auch ganz unterschiedlichen Interessen und Erwartungen gegenüberzusehen. Wie tätig sein in diesem Spannungsfeld? Darüber zu sprechen haben wir anerkannte Fachleute und einige Grenzgänger gebeten, die sich in der Wissenschaft, der Politik und der Wirtschaft beruflich aufgehalten haben.

**Hansjörg Sinn**

# Beziehungen zwischen Wissenschaft, Wirtschaft und Politik - ein Erfahrungsbericht

## 25 Jahre ISI Karlsruhe

Zum 25. Geburstag bringe ich dem ISI, seinen Erfindern und seinen Betreibern zunächst meinen herzlichen Glückwunsch. Das ISI ist für mich eine Institution, gäbe es sie nicht seit 25 Jahren, sie hätte vor längstens 24 Jahren erfunden werden müssen.

Ich trete hier auf in verkehrter Rolle, denn ISI-Sache wäre es, aufgrund von System-Analysen über die Beziehungen zwischen Wissenschaft, Wirtschaft und Politik zu berichten, denn ich habe ja keine Untersuchungen zu diesem Thema angestellt, wäre aber an dem Ergebnis solcher Untersuchungen sehr interessiert. ISI hat deshalb auch das Thema anders vorgegeben, nämlich „Seiltanz zwischen Wissenschaft, Wirtschaft und Politik", aber Seiltanz klang mir nicht seriös genug für eine Festveranstaltung. Aus Rückfragen ergab sich, daß die Veranstalter in der Tat auch nicht an tiefgründigen Überlegungen zu den Wechselbeziehungen zwischen Wissenschaft, Wirtschaft und Politik interessiert sind, sondern vielmehr an einem Bericht über die Erfahrungen, die beim Tätigsein in diesen Bereichen gemacht wurden. Solchen Erfahrungen ist man ausgeliefert, unterworfen. Man kann sie nicht bestellen. Ich kann auch nicht behaupten, daß es typische Erfahrungen seien. Andere können ganz andere Erfahrungen machen und gemacht haben, als ich sie gemacht habe beim Wechsel zwischen den genannten Sektoren. Die Wechsel waren nicht uneingeschränkt freiwillig. Aber sie hatten immer ein Ziel: Technik für die Menschen und das Vehikel dazu war die Chemie. „Seiltanz" wäre richtiger gewesen, vielleicht sogar Seiltanz mit Netz, denn zumindest aus der Politik konnte ich ins Netz des Institutes zurückfallen, und es war auch immer die Absicht, sich dahin fallen zu lassen, manchmal eine die Innovationsgeschwindigkeit fördernde Drohung.

Lassen Sie mich daher den Erfahrungsbericht beginnen mit der Wissenschaft, mit dem Studium:

Die Studienwahl war „politisch" bedingt: Theoretische Physik erschien mir wunderbar, ideologiefrei, wenngleich im Gegenstand eingeschränkt. Aber bald kam die Erkenntnis, daß ich zu schöpferischen Leistungen auf diesem Gebiet maximaler mathematischer Komplexität nicht befähigt sein würde. Ein mittelmäßiger Chemi-

ker erschien mir immer noch als ein nützlicher Mensch - deshalb wurde ich Chemiker.

Während des Studiums gab es Begegnungen mit beeindruckenden Chemikern: Otto Bayer, Karl Wurster, Karl Winnacker, Walter Reppe, Chemiker, die das Wirtschaftswunder miteingeleitet und realisiert haben; es waren Chemiker, die bei aller Machtausübung sich als dem Volk oder der Menschheit Dienende verstanden. Straßmann, Kern in Mainz, Bretschneider in Innsbruck, Helferich in Bonn, Bohlmann (Inhoffen-Schüler) in Braunschweig, waren Leute höchster fachlicher Kompetenz und Beispiele menschlicher Bescheidenheit. Brauchte man etwas Ausgefallenes im Institut - der Chef beschaffte es durch Anruf bei der „Industrie". Industrie und Wirtschaft, das waren für den Studierenden „Beziehungen" der Institutsleiter zu den Vorstandsetagen, die dem Institut und damit den Studierenden zugute kamen. Es war selbstverständlich, daß das Institut dafür etwas leisten „wollte" und man daran mithalf. Neben der Syntheseaufgabe, die mir gestellt war, interessierte mich, warum bei elektrophiler Reaktion die Doppelbindung schneller reagierte als die Dreifachbindung, obwohl doch letztere viel mehr Elektronen hat; dann das Stäbchen aus lauter konjugierten Dreifachbindungen: Di-tert.Butyl-Oktaacetylen. Irgendwann habe ich bilanziert: Alles in allem 40 kg Lösungsmittel und Ausgangssubstanz lieferten 500 mg unreines Produkt - das konnte nicht richtig sein. Unbeschadet dessen bewarb ich mich bei dem Acetylenchemiker Walter Reppe.

Meine Bewerbung wurde sistiert, weil der Institutsdirektor anordnete, daß ich zu habilitieren hätte, nicht bei ihm, darüber waren wir uns einig. "Mein Freund Franz Patat in München, das ist der richtige Lehrer für Sie". So war es.

Ich war damit einverstanden, zunächst promovierte wissenschaftliche Hilfskraft zu sein, aber ich unterschrieb nicht, daß das Maß meiner Arbeitsleistung meiner Besoldung angemessen sei. Der „Alte" regelte das ohne Unterschrift, bemerkte allerdings, daß es ihm angekündigt gewesen sei, daß es mit mir Ärger gäbe, meinte aber: „Recht ham's, man muß sich wehren". Mein Chef brachte mir bei, wie ich seine Briefe zu entwerfen hatte. Ich lernte den Unterschied zwischen „sehr geehrter Herr Kollege", „lieber und sehr verehrter Herr Kollege", „lieber Freund". Ich war in einem Institut, dessen Chef in Brüssel Beraterfunktion hatte, in der Industrie angesehen - wenngleich auch angefeindet - war, vor allem aber durch unkonventionelle Ideen ausgezeichnet war. Montags in der Assistentenbesprechung wurden zuerst die volkswirtschaftlichen Berichte gelesen. Das alles war Erziehung zu ehrfürchtig respektvollem Lernen, kritischer Opposition und Durchhalten (Frustrationstoleranz). Persönliche Industriekontakte entstanden durch das Arbeitsgebiet. 1953 hatte Ziegler die Niederdruckethylen-Polymerisation gefunden. In völliger Respektlosigkeit bekam ich 1957 den Auftrag, „anzuschauen wie es geht", weil, „die es zwar gefunden haben, es aber nicht verstehen, es geht nämlich ganz anders". Hinter der Bemerkung stand die Vision einer enzymanalogen Reaktion. Ende 1957 stand plötzlich Winnacker in meinem Labor und Patat forderte mich auf, Herrn Winnacker zu

erklären, wie „es" geht. Ich tat, was ich mußte, und Winnacker forderte mich auf, das auch in Hoechst zu erzählen. In Hoechst wurde ich behandelt wie ein kleiner Gott, Mittagessen und Abendessen im Casino, zugleich aber mit eisiger Distanz. Mein Chef erklärte mir später, es sei vielleicht eine etwas unglückliche Personalführung gewesen, daß Winnacker gesagt habe, er wisse nicht, warum er ein Hauptlabor unterhalten müsse, wenn ein junger Mann in München das schon an die Tafel schreiben könne. Er schloß: „Stimmt's, ist es gut, stimmt es nicht, so hat es doch eine ungeheure Wirkung." Mir wurde langsam bewußt, was Konkurrenz heißt. Glücklicherweise dominiert bei Industriekontakten schließlich der mögliche Unternehmenserfolg die persönlichen Eitelkeiten. Unsere Theorie ist zwar aus heutiger Sicht nicht ganz richtig gewesen, aber sie war - und ist noch - sehr fruchtbar. Sie hatte nämlich zur Konsequenz, daß man Polymere gleicher stofflicher Zusammensetzung durch Reaktionsführung mit ganz unterschiedlichen Eigenschaften ausstatten können muß, und zwar nunmehr auf theoretischer Grundlage ganz gezielt. Dieser Vision gingen wir nach.

Nach der Habilitation ist es für einen technischen Chemiker zweckmäßig, „Industrieerfahrung" - was immer das ist - zu erwerben. Von der Gehaltsbasis eines habilitierten Oberassistenten (18 Mark mehr als nichthabilitiert) ausgehend, ist das Sammeln von Industrieerfahrung auch lukrativ. Über meine Habilitationsarbeit war ich ein gefragter Gesprächspartner. Die mir in der Industrie zugewiesene Arbeit betraf aber völlig andere Gebiete. Sehr nahe an Produktionsentwicklung und Verfahrenstechnik lernte ich Kostendenken. Nichts geht in der Industrie ohne Angabe der Kostenstelle. Bis heute ist mir unverständlich, warum man Kostendenken und Kostenstellen nicht an den Universitäten durchsetzen kann. Nur weil man nicht will - so ist zu beklagen.

Besonders wichtig und nachhaltig war die Erfahrung, daß es für bestimmte Aufgaben ein Zeitbudget gibt. Bis zur „dead line" ist eine Lösung zu finden, eine Lösung, nicht die beste, sondern eben eine Lösung, die bis zur „dead line" gefunden werden kann.

Es ist nicht ganz einfach, die Personalführung für eine größere Zahl von Untergebenen zu lernen. Einerseits ist Vertrauen sehr wichtig, andererseits bedarf es einer gewissen Distanziertheit. Man muß innerhalb der Arbeitsgrupe (und des Unternehmens) ein Wir-Gefühl vermitteln, aber darf darauf gefaßt sein, daß in 10 % der Fälle schlimme Enttäuschungen warten. Was ist, wenn 0 Uhr 30 der Schichtmann, dem man vertraute, die Werte für 1 Uhr schon eingetragen hat?

Der Industrieaufenthalt dient auch zur Reflexion über die Nützlichkeit des Gelernten und das Auffinden von Defiziten. Mangelnde Sprachbeherrschung ist eines der schlimmsten Defizite. Beeindruckend in der Industrie war das ungeheure Ausmaß der Identifikation der Beschäftigten mit dem Unternehmen: Ein echtes Wir-Gefühl.

Die Neueintretenden waren die eigentlichen Träger des Technologietransfers für das Unternehmen.

Nach 18 Monaten wurde der Industrieaufenthalt beendet, weil schon nach 6 Monaten ein Ruf nach Hamburg gekommen war.

Aus den Berufungsverhandlungen erinnere ich, daß versucht wurde, meine Gehaltsforderungen zu drücken unter Hinweis darauf, daß ich als junger Ordinarius doch nun alle Freiheiten zu Nebeneinkommen hätte und mich nirgends verantworten müsse. Es löste Verwunderung aus, daß ich erwiderte, mich aber verantworten zu wollen und am konsequenten Aufbau eines bisher nicht vorhandenen Lehrstuhles und nicht an Nebeneinkommen interessiert sei. Ich erhielt schließlich das geforderte Gehalt.

Der Abschied wurde versüßt mit einem Lastzug, 18 Tonnen, „für das Unternehmen nicht mehr brauchbares Labormaterial". Ich zahlte dafür 1 DM an Professor Steinhofer. Als der Lastzug ankam, enthielt er auch ein knallgelbes 200-Liter-Faß, das ich jedenfalls nicht hatte aufladen lassen. Es enthielt ein komplettes IR-Gerät und einen Brief des Obermeisters, wonach ich erfahren solle, was eine Deutsche Mark wert sei und die Direktion selbstverständlich Bescheid wisse. Die Erwartungen der Großindustrie an den zukünftigen Hochschullehrer wurden anläßlich eines aus dem Karenzvertrag hervorgehenden Mitarbeitervertrages erörtert:

> Gute Studenten sollten ausgebildet und dem Werk empfohlen werden;
> Interessante Arbeitsgebiete sollten begründet werden und ab und an darüber berichtet;
> Einmal im Jahr sollte ein Vortrag und oder ein Gespräch in der Industrie sein, dabei sollte etwas angesehen werden. Ab und zu brauche man einen, der nicht betriebsblind ist.
> Unterstützung bei meinen Aufgaben als Hochschullehrer, insbesondere Förderung von Exkursionen mit Studenten und Lieferung von Chemikalien, wurden mir zugesagt (und gewährt). Abgesehen von der Senatorenzeit hat dies 30 Jahre gehalten.

Die Behörde tat sich schwer mit der erbetenen Genehmigung dieses Vertrages und teilte schließlich mit, daß nichts zu genehmigen sei, weil Gesetze dadurch nicht berührt würden. Versteckt erhielt ich den Hinweis, daß solche Genehmigungen nicht nachgesucht werden sollten.

Mit Erwartungen mittelständischer Unternehmen wurde ich rasch konfrontiert:

> Mein Amtsvorgänger habe immer mal wieder schwierige Analysen und Probedestillationen durchgeführt, ob ich das nicht auch wolle.

Ich verwies an ein öffentliches Untersuchungslabor in bezug auf Analysen. In bezug auf Probedestillationen wollte ich mir überlegen, eine Kompetenz zu entwickeln - wenn dies kommerziell nicht zugänglich sei.

Fragen dieser Art kommen immer wieder. Meist muß man wegen der Konkurrenz zu kommerziellen Unternehmungen ablehnen. Hat man ein GC-MS-Kombination, ist eine Analyse oft ja eine schnelle Sache, sie läßt sich dazwischenschieben. Aber wäre dies korrekt? Die GC-MS-Kombination für 1,2 Mio. DM ist aus öffentlichen Mitteln bezahlt, die Installation und die Räume ebenso.

Ich habe die Überzeugung entwickelt, daß Aufgaben, die von kommerziellen Einrichtungen erledigt werden können, auch von diesen erledigt werden sollen gegen Entgelt und mit Umsatzsteuer. Es ist nicht Aufgabe von Hochschuleinrichtungen, einem Untersuchungslabor Konkurrenz zu machen. Anders ist die Sachlage, wenn ein kommerzielles Untersuchungslabor sich bei einer bestimmten Fragestellung als inkompetent bezeichnet und anfrägt, ob es z. B. mit dem Institut gemeinsam eine Frage klären könne. Dann läuft das unter „Technologietransfer".

Die von Anfang an klare Haltung hat sich im wahrsten Sinne des Wortes ausgezahlt. Als ich nach drei Jahren in Hamburg den Lehrstuhl in Schwung und einen Ruf nach Dortmund hatte, sammelte die Hamburger Wirtschaft, angeregt von einem Hamburger Mittelständler, 800.000 DM, um eine Erweiterung des Baukörpers einzuleiten. Der Bund akzeptierte nicht, daß dieses Spendengeld den Hamburg-Anteil der Baukosten nach HBFG ersetzte. Hamburg wollte das Spendengeld, nachdem eigens eine Änderung des Haushaltsplanes zur Annahme der Spende beschlossen worden war, aber auch nicht zurückgeben. So einigte man sich schließlich, daß auch Hamburg noch 800.000 DM dazugab, so daß die Baukörpererweiterung für 2,4 Mio. DM durchgeführt werden konnte. 1968 waren 2,4 Mio. DM viel Geld!

Gleichzeitig gründete die Universität einen Strukturausschuß. Ich wurde Vorsitzender. Bewältigung der Platznot, Universitätsausbau, Vollständigkeit des Lehrangebotes, Regelung der Drittmittel und Lehrkörpermodell auf der Basis von Empfehlungen des Wissenschaftsrates waren die Themen. Die Wankelmütigkeit der Hochschulpolitiker erzeugte langsam, aber sicher, rasende Wut.

Die Bundesassistentenkonferenz probte den Aufstand. Nach Teilnahme an einer ihrer Konferenzen beeindruckte mich das „Kreuznacher Hochschulkonzept", aber ich gewann auch die Meinung, daß man die 10 aktiven Leute zu Professoren machen sollte, dann wäre die BAK ohne Kopf. Die Politiker exkulpierten sich, indem sie die Ordinarien für alles als die Schuldigen darstellten und „entmachteten". In Wirklichkeit entmachteten sie eine angeschlagene, aber noch partiell kritische Instanz: die Universität.

Einerseits lief die Arbeit im Institut sehr gut. Ich hatte eine sehr dynamische Mannschaft, u. a. auch intelligente Aufmüpfige. Zum Geburtstag schenkten sie mir die Mao-Bibel. Ein Zufall ließ mich die richtige Seite aufschlagen, die ich den Schenkenden vorhielt. „Ein Tor ist, wer nicht auf den Lehrer hört". Danach waren die Schenkenden ganz zahm. Andererseits fand das im Strukturauschuß entwickelte „Hamburger Lehrkörpermodell" eine breite Zustimmung. Durch die Anhörungen in den Fakultäten kam ich mit allen Fächern und Gruppen in Berührung. Die Uni-Stiftung bemängelte den Kauf sozial- und politikwissenschaftlicher Bücher durch den Chemiker. Gleichzeitig fühlten sich die Studenten ernst genommen. Der Prorektor Schäfer frug mich eines Tages, ob ich die Wahl zum Rektor annehmen würde. Ein drittelparitätisch besetztes Konzil wählte mich mit 95 % der Stimmen. Dies war der eigentliche Eintritt in die Politik. Ich machte Antrittsbesuche, natürlich bei Bürgermeister Weichmann; ich forderte neue Gebäude, Stühle und Bänke zum Sitzen, sagte, daß es eigentlich nicht zu viele gescheite Leute geben könne und daß Hamburg technische Fächer brauche, sonst würde es den Anschluß verpassen. Als Weichmann antwortete, Hamburg habe den Hafen, habe die Werften und eine Universität sei genug, sagte ich, daß der Hafen noch einmal ganz ungeahnte Bedeutung erlangen könne, als Einfuhrhafen für Kunststoffe aus Japan. Dort gäbe es nämlich 320 Professoren für Makromolekulare Chemie, in Deutschland seien wir allenfalls 30. Ich machte Antrittsbesuche auch - und zwar ganz selbstverständlich - bei den Kammerpräsidenten und beim DGB. Zumindest bei den Gewerkschaften erregte das Aufsehen.

In jener Zeit habe ich gelernt, daß nichts so wichtig ist, wie die persönliche Präsenz nach guter fachlicher Vorbereitung. Es mußten Behelfsbauten her, aber die Baubehörde behauptete, daß man über einem U-Bahn-Tunnel nicht bauen könnte. Ich lernte, was Walzenlast bedeutet und entkräftete das Behördenargument. Die Arbeit in der Hochschulspitze brachte viele Berührungen mit politischen und wirtschaftlichen Gremien. Ich machte die Entdeckung, daß sich viele politische Vorgänge gut verstehen lassen, wenn man die zu betrachtende Gesellschaft als Reaktionskessel mit vielen Parallel- und Folgereaktionen sieht. Endotherme und exotherme Reaktionen, Konzentrationen, Stoßzahlen und Aktivierungsenergien haben im Sozialverhalten ihre Entsprechungen. Politik wirkt katalytisch, sie muß Reaktionswärmen rechtzeitig abführen, sonst kommt es zu Explosionen, sie darf nicht zu viel Wärme entnehmen, sonst schläft die Gesellschaft ein.

1972 war endlich die Vizepräsidentschaft zu Ende. Die Forschung lief gut. Um den Wunsch der Mittelständler nach Rektifikationskompetenz zu befriedigen, dachte ich an eine kleine Raffinerie zum Demonstrieren und Lernen. Aber irgendwie war das ja einfallslos; es gab das alles schon. Andererseits machten wir Kunststoffe und teilweise hatten deren Produktionen Verdoppelungszeiten von nur 4 Jahren. Es war vorherzusehen, daß in Kürze das Volumen der Kunststoffproduktion das Volumen der Stahlproduktion übersteigen würde. Warum also nicht Kunststoffe verschrotten? So entstand das „Hamburger Pyrolyseverfahren". Das Hamburger Pyroloyseverfah-

ren hat den Nachteil, daß es keine „feine" Chemie ist. Wir brauchten aber auch die Anerkennung der „feinen" Kollegen; ohne wissenschaftliche Reputation, und die besteht in der Anerkennung durch die scientific community, kann man keine Bildungspolitik machen. „Feine" Chemie ist heutzutage u. a. die Bestimmung einer Kristallstruktur. Sie wird als finaler Beweis akzeptiert, obwohl Reaktionen meistens in Lösung ablaufen und dort die Strukturen ziemlich anders sein können. Glücklicherweise erhielten wir einmal schöne Kristalle. Die Kristallstrukturanalyse, die ja im wesentlichen von einem Apparat und einem Rechenprogramm durchgeführt wird, brachte erstaunlich verzerrte Bindungswinkel. Das war ein Phänomen. Das brachte viel Aufmerksamkeit und Beachtung und Wertschätzung bei den Kollegen ein. Aber wir können allenfalls etwas dafür, daß der Kristall isoliert wurde. Daß in dem Kristall verzerrte Bindungwinkel auftreten, dafür können wir nichts, die sind gottgewollt. Natürlich haben wir den Kristall nur isolieren können, weil wir ein Gebiet akribisch beackert haben. Akribisch beackern, das ist die wissenschaftliche Leistung. Sie wäre unbeachtet geblieben, hätten wir nicht die verzerrten Bindungswinkel gefunden. Es kam ein Ruf nach München. Ich habe schließlich abgelehnt, weil ich am Horizont die Gründung der TU in Hamburg sah.

Wissenschaftlich beachtlich bedeutet aber nicht wirtschaftlich bedeutsam. Wirtschaftlich bedeutsam wurde eher das Hamburger Pyrolyseverfahren. Ein Mittelständler wollte es realisieren und diese Zusammenarbeit gab tiefe Einblicke in mittelständlerisches Denken. Kühnheit und Risikobereitschaft steht da im Vordergrund, die Erwartung, ein Schnäppchen zu machen und die Angst von den „Großen" vereinnahmt zu werden. Vertrauen und Mißtrauen bei der Kooperation stehen nebeneinander. Zu Recht übrigens. Vom BMFT oder Verbänden abgestellte „Projektbegleiter" sind stets interessiert, vergessen aber nicht die Interessen der sie entsendenden Firma, sie identifizieren sich nicht mit dem Projekt und sollen dies auch nicht; das führt dazu, daß sie kritisch hilfreich, aber nicht uneingeschränkt und nicht uneigennützig hilfreich sind. Für mehr als fünf Jahre dauernde Entwicklungen ist die Kapitaldecke von Mittelständlern zu klein. Dann kauft ein „Großer" die Entwicklung auf, honoriert großzügig, aber übernimmt die Federführung und weiß alles besser. In veränderter Form wird dann die Pyrolyse wieder aufgegriffen, es wird zunächst eine Nische für sie gefunden, man erfährt: „Sie waren einfach zu früh" und wenn die Pyrolyse dann gebaut wird, weiß man nichts mehr von den Erfindern. Dies lastet schwer auf der Zusammenarbeit. Immerhin brachte das schließlich den Förderpreis der europäischen Wissenschaft ein und das Institut hat von den Fördermitteln gut gelebt, ist gut ausgestattet, auch in Bereichen, die nichts mit der Pyrolyse zu tun haben.

Die insgesamt beschriebene Situation, Hochschulpolitik, wissenschaftlicher Erfolg, Unternehmerinteresse an den Forschungsarbeiten, prädestinieren dann offensichtlich für den Wissenschaftsrat. Dort war mir die Förderung der Forschung und die Forderung nach universitärer Dienstleistung ein besonderes Anliegen. Wir betrachten dazu ein Bild: Die große Fläche bedeutet die Umgebungsgesellschaft. Ein klei-

ner Teil der Bevölkerung, etwa gegen 5 - 10 % strömte in diesen Tertiärbereich ein und wirkte aus ihm auf die Umgebungsgesellschaft zurück. Der Tertiärbereich selbst war strukturiert durch die dominante Figur des Hochschullehreres HL, dessen zwiefältige Aufgabe Forschung F und Lehre L hieß, wobei in der Vergangenheit weder eine Festlegung von Anteiligkeit, geschweige denn die Prioritätenfolge zur Diskussion stand.

Mit der Ausweitung des Tertiärbereiches, bestimmt durch die zunehmende Zahl von Studierenden, erfährt der Tertiärbereich auch qualitativ eine tiefgreifende Veränderung. Bis zu 25 % eines Geburtenjahrgangs sollen jeweils in den Tertiärbereich einströmen. Damit kann die Vermehrung der Hochschullehrer nicht nur nicht Schritt halten, die Vermehrung kann auch nicht ohne qualitative Veränderung der Hochschullehrer und ihrer Erwartungshorizonte erfolgen; denn die adäquate Ausweitung frei bestimmter Forschung kann deshalb nicht gelingen, weil Forschung, Entwicklung und Umsetzung in Praxis zwar nicht in der einzelnen Person, wohl aber im Gesamtsystem in einem vernünftigen, am Gemeinwohl orientierten noch zu bestimmenden, aber nicht nur politisch zu setzenden Verhältnis stehen müssen.

Ich schrieb damals: „Forschung, die Weiterentwicklung der Wissenschaften, kann nur gedeihen, die Humusschicht nur abgesichert werden, auf einem Hintergrund breiter - als ökonomisch dargestellter - wissenschaftlicher Arbeit. Deshalb sind - so meine ich - unsere hohen Schulen der Zukunft als Bereiche öffentlicher Forschung und wissenschaftlicher Dienstleistung zu konzipieren. Der Bereich wissenschaftlicher Dienstleistung ist dabei über Forschung, Entwicklung, Anwendung und Kontrolle zu erstrecken. Das Hineinwachsen und Teilnehmen an diesem Wissenschaftsbetrieb ist Studium." (Siehe DUZ 17/73).

Die Vorstellung bei Weichmann hatte gefruchtet. Hamburg eröffnete die Perspektive, eine TU zu gründen. Das bewog mich, einen Ruf nach München abzulehnen. Sie wurde vorbereitet von einer bürgerschaftlichen Enquete-Kommission, deren Vorsitzender ich war; die bürgerschaftlichen Vorschläge wurden verfeinert durch eine von dem Universitäts-Mathematiker Biallas und FDP-Senator eingesetzte Kommission des Senates. Der Mathematiker Ansorge war Vorsitzender, ich war Mitglied.

1978 berief mich Biallas zum Gründungspräsidenten. Die Konzeption der TU versuchte, alle Schwächen der Universität zu vermeiden. Ihr Erfolg sollte Anlaß sein, auch in der Universität die politisch eingeleiteten Fehlentwicklungen zu korrigieren. Die TU wurde gegründet für Forschung und Dienstleistung für die Region - auch für die Ausbildung von Studenten.

Vier Wochen nach der Übernahme des Gründungspräsidentenamtes rief mich der Wahlsieger Klose von einer Vortragsreise zum World-Rubber-Congress aus Oslo nach Hamburg. Wir kannten uns kaum. Ohne Umschweife frug er, ob ich bereit sei,

das Amt des Senators für Wissenschaft zu übernehmen. „Sie haben die Gelegenheit, das, was nicht läuft und worüber Sie sich bei mir beschweren möchten, selber durchzusetzen", war seine Anrede. Einen Termin, um sich Beschwerden über einen Senator anzuhören, wenn ich ablehnte, bekäme ich von ihm nicht. Mein Hinweis auf Erpressung störte ihn wenig. Er gab mir 24 Stunden. Ich flog wieder nach Oslo, hielt meinen Vortrag, formulierte ein 40-Punkte-Programm, telefonierte dieses durch, er akzeptierte, ich hatte keine Wahl, Klose hielt Wort. Wir hatten nicht eine einzige Differenz in Sachen Bildungspolitik. Ich durfte als Parteiloser dennoch in der Fraktion vortragen, es wurde abgestimmt, mal einstimmig, mal mit Mehrheit in meinem Sinne, und es wurde gehandelt. Im Gründungssenat arbeiteten Vertreter der Hamburger Studenten und Vertreter der Handelskammer neben Hamburger und auswärtigen Hochschullehrern einträchtig zusammen. Sehr früh wurde das Hamburger-Institut für Technologietransfer gegründet, als Verein getragen von der in Gründung befindlichen TU, ebenso die ZEWU, in der Klempnermeister von Hochschullehrern über die Trends in Energie-, Trinkwassertechnik und Umwelttechnik informiert werden. Dies ist Technologietransfer an KMU's. Eine glänzende Zusammenarbeit, die noch anhält und wichtig ist für die Resonanz der TU in der Bevölkerung.

Die Senatorenzeit hatte aber auch bittere Seiten: Stolzenberg-Skandal, vergrabene Giftgasgranaten inmitten der Stadt; Deponieskandal Georgswerder, unerlaubte (und unwissentliche) Dioxinablagerungen; Kollegen, die die Deponie explodieren sahen, Sanierungsexperten, die meinten, mit „Dioxin" könne man nun richtig „Power" machen; Überschreitung, brutale Überschreitung von Grenzwerten durch Unternehmungen, auch der Chemie; und zu alledem noch die Brockdorf-Entscheidung, Verhandlungen, vertrauliche, geheime und offene mit Energieerzeugern und Kraftwerksbauern, durchsetzt von vielen Fehlinformationen von Seiten der EVU's. Alles hing mit Energie oder mit Chemie zusammen und ich sagte meine Meinung. Immer wieder die merkwürdige Meinung von Wissenschaftlern, der Senat und insbesondere der Wissenschaftssenator sei für die Akzeptanz verantwortlich. Die Wissenschaftler empfanden wenig Verpflichtung, sich zu bekennen.

In vielen Situationen wiederholte ich die Erfahrung, die ich als Rektor und Vizepräsident gemacht hatte: Persönliches Erscheinen ist wichtig, allerdings zerfleischend. Geht der Senator in eine Behördenbesprechung, so zwingt er die andere beteiligte Behörde, mindestens den Staatsrat beizuziehen. Und dann wird - entgegen der Behördenplanung - entschieden, das ist der Sinn der Sache. Es ist lähmend bei unserem Regierungshandeln, daß zu oft auf sogenannter Arbeitsebene verhandelt wird und anschließend „das Haus" prüft. In der nächsten Sitzung geht alles wieder von vorne los.

Aus jener Zeit stammen auch die Forderungen nach mehr Selbstkontrolle der Wirtschaft. Es würde die Akzeptanz der Technik unheimlich steigern, wenn Werkstore mit einem Emblem versehen wären: „Dieser Betrieb unterliegt der Selbstkontrolle

der Deutschen Chemischen Industrie. Für Schäden, die dieser Betrieb trotz aller Vorsorge verursacht, haftet die Deutsche Chemische Industrie kollektiv." Die Eigenüberwachung ist viel wirksamer als der TÜV.

Fürchterlich sind beim Regierungsgeschäft die Auseinandersetzungen mit dem Finanzressort. Sie werden insbesondere dann fürchterlich, wenn das Geld stärker als vorhergesehen verknappt, aber die Leistungen, die nun gar nicht mehr erbracht werden können, unverändert als politische Großtat und vom Bürger einzufordern, verkündet werden. Nach meinen Erfahrungen hilft dagegen nur Brutalität, auch die Brutalität des Rücktritts. Schlimm sind die Positionskämpfe auch zwischen Bund und Ländern. Zwar überschlagen und überschlugen sich Bund und Land im Loblied auf Desy. Aber als es um Hera ging, haben beide bei einer Gesamtsumme von mehr als einer Milliarde wegen 30 Mio. DM furchtbar gestritten und das Projekt fast torpediert. Es ging um die Anrechnung ausländischer Beiträge auf Bundes- und Landeszuschuß. Nach einer wirtschaftlichen Analyse des HWWA war der Vorteil für Hamburg 300 Mio. DM, die durch 30 fehlende Mio. DM gefährdert waren. Beim Finanzressort ging es um das Prinzip der Bund-Länder-Finanzierung. Ich machte dann für den Senat eine Zusage, die ich eigentlich nicht hätte machen dürfen; ich habe das überlebt, wenn auch mit Schrammen, aber die Entscheidung war damit für Hera gefallen.

Während meine Kontakte zur Hamburger Wirtschaft sich intensivierten, wurden sie zur Chemischen Industrie protokollarisch angehoben, aber damit auch inhaltsleerer. Das war schmerzlich, aber insoweit auch folgerichtig. Das Senatorenamt ist ein Fulltime-Job, der Freistunden im Labor nicht zuläßt. Dies ist letztlich der Grund, warum ich zuerst nach vier und richtig dann nach sechs Jahren zurücktrat. Kurz vor Beginn der Senatorenzeit war uns im Labor ein merkwürdiger Befund begegnet. Ein von mir als äußerst sorgfältig eingeschätzter Mitarbeiter wiederholte Experimente meiner Habilitation und bestätigte sie. Ein anderer bekam immer wieder, aber schwankend, abweichende Resultate. Dies führte zu der Entdeckung, daß Wasser als Verunreinigung eingeschleppt, einen homogenen Katalysator aktiviert, von dem bekannt war, daß er auch mit Spuren von Wasser unter Selbstzerstörung reagieren würde. Der Wassereinfluß wurde von der Industrie patentiert, die Patente schließlich wieder um 1980 herum fallen gelassen. Zu diesem Zeitpunkt, ich war schon Senator, fanden wir dann heraus, daß das Wasser nicht aktiviert, sondern daß sozusagen die Zerstörungsprodukte des Katalysators viel aktiver waren als der ursprünglich eingesetzte Katalysator. Die Zerstörungsprodukte sind Alumoxan. Das hochwirksame Katalysatorsystem ist das alumoxanbasierte Metallocen. Die Industrie zeigte daran aber nur ein sehr zurückhaltendes Interesse. Es blieb mir nichts übrig, als persönlich eine Patentanmeldung zu formulieren und einzureichen.

Der Fall muß erwähnt werden, weil sicher durch eine professionelle Bearbeitung der Patentanmeldung ein umfassenderer Schutz hätte erreicht werden können. Er muß erwähnt werden, weil hier die Hochschule durch ihre Grundlagenforschung - wir

suchten nämlich gar keine Verbesserung des Katalysators, sondern wollten die vielfältigen Nebenreaktionen aufklären und von dort her verstehen, wie der Katalysator eigentlich wirkt - also weil hier die Hochschule durch ihre Grundlagenforschung einen sehr bedeutenden Beitrag zur industriellen Chemie geliefert hat. Erst als wir durch Besuche von Japanern und Amerikanern im Institut bemerkten, wie andere hellhörig geworden waren und ich darauf alarmierend hinwies, übernahm die BASF das Patent und ließ Auslandsanmeldungen durchführen - die aber an den Text der deutschen Erstanmeldung gebunden sind. In einer kürzlichen Presseinformation wird mitgeteilt: (07.03.96) P 162:

„Darüber hinaus besitzt die BASF das erste Patent, das die Verwendung von methylaluminoxanaktivierten, unsubstituierten wie auch substituierten Zirconocenen als Polymerisationskatalysatoren für Ethylen und Propylen absichert (US 4 404 344). Die BASF beabsichtigt, von ihren Rechten aus diesem frühen Patent in Zukunft aktiv Gebrauch zu machen."

Es hätte die Zusammenarbeit zwischen Hochschule und Industrie noch mehr gefördert, wenn in der Zeit, in der die Hochschule unablässig der mangelnden Aufmerksamkeit für wirtschaftliche und industrielle Notwendigkeiten bezichtigt wird und die **Innovationsunfreude** beklagt wird, z. B. die zitierte Pressekonferenz den Hinweis enthalten hätte, daß dieses erste Patent von einer Universität und sogar der Hamburger Universität entwickelt wurde. Immerhin wird erwartet, daß aufgrund der auf diesem Patent basierenden Entwicklung 50 Mio. Tonnen Polyolefine bis zum Jahre 2005 zusätzlich produziert werden (dann jährlich). Aber der Hamburger Bürgermeister, der die Kosten der Universität beklagt und darunter leidet, daß diese so groß sei und außerdem auch noch mäßig - wobei er immer sagt, daß damit andere Fachbereiche gemeint seien, so zuletzt vor dem Wissenschaftsrat beim Empfang vor vierzehn Tagen - der erfährt doch nicht, daß es seine, die Hamburger Universität war, die hier einen glücklichen Griff, wenn schon nicht für die Hansestadt, dann aber doch für die Volkswirtschaft getan hat - aufgrund der ihr gemäßen Grundlagenforschung. Ich erwähne dies in Anwesenheit der Vorsitzenden des Wissenschaftsrates, um dem Eindruck entgegenzuwirken, daß in der Universität nur geschlafen würde und in der aus den Erfahrungen der Universität gegründeten neuen Technischen Universität nur innoviert würde. Und - das muß hinzugefügt werden - die Hamburger Universität hat die Bedeutung für die industrielle Produktion erkannt, die deutsche Industrie zunächst nicht.

Kürzlich wurde als allgemeine Erfahrung mitgeteilt: „Wenn - wie im Falle der Chemie - große etablierte Industriefirmen bestimmte Märkte beherrschen, besteht eine gewisse Gefahr, daß der Transfer neuer, innovativer Entwicklungen in ein Produkt behindert ist" (Wagemann, Nachrichten aus Chemie, Technik und Laboratorium, 2, 1997).

Je älter Professoren werden, desto mehr werden sie in Beiräte und Beratungsorgane berufen. Beratungsorgane beraten die Regierungen, unabsichtlich vielleicht sogar einmal falsch, aber bemüht, es richtig zu tun. Sagt ein Beratungsorgan etwas nur umstritten Richtiges, oder etwas Richtiges zu scharf, wobei ja die Aussage von einem „Rat" gemacht wird, indem der eigentliche Fachvertreter kein Diktatrecht hat, dann ist der betroffene Fachvertreter nicht gerade Pressionen, wohl aber schon recht deutlichen Unfreundlichkeiten ausgesetzt, wenn es sich etwa um ein Thema wie Chlorchemie handelt. Die Chlorchemie ist in vielen Bereichen unentbehrlich, das ist unstrittig. Es gibt viele natürliche, äußerst nützliche chlororganische Verbindungen, das ist unstrittig. Es gibt auch bemerkenswert viele chlororganische Verbindungen, die unbeabsichtigte Nebenfolgen ausgelöst haben, auch dies ist unstrittig. Was ist nun daran schlimm, wenn ein Rat sagt, man müsse es bei dieser Sachlage als Herausforderung empfinden, die Chlorchemie zu überwinden?

Wenn ein Verfahren der Chlorchemie, wie beispielsweise die Ethylenoxidproduktion, durch ein katalytisches Verfahren substituiert werden kann und das katalytische Verfahren wirtschaftlicher ist, so findet die Substitution weltweit statt, ohne daß jemand mit der Wimper zuckt. Ich verstehe die Aufforderung des Rates als Aufforderung, billigere, die Chlorchemie substituierende Verfahren zu finden und die Chlorchemie in dem bis dahin unerläßlichen Umfang zu nutzen.

So wie ich die Selbstkontrolle der Wirtschaft vorgeschlagen habe, sollte auch eine Selbstkontrolle der Wissenschaft funktionieren. Die Akademien sollten berufen sein, kontroverse Mehrheits- und Minderheitsstandpunkte kommentiert darzustellen und sie sollten dies so kompetent machen, daß die Medien sich danach richten und nicht nach jedem Wichtigtuer.

Als ein Abstellraum in Hamburg zu einem Chemieskandal hochgeputscht wurde, hat der Fachbereich industrieübliche Sicherheitsleitlinien eingeführt und ein im Hochschulgesetz nicht vorgesehenes Entscheidungsorgan, das sich Betriebs- und Sicherheitsdirektorium nennt. Seine Mitglieder erfuhren in Unternehmen der Chemischen Industrie ein mehrwöchiges Sicherheitstraining. Inzwischen sehen Senat und Bürgerschaft diese Entscheidungsorgane als sinnvoll an.

Demokratie funktioniert durch die kontrollierte und zeitlich vernünftig begrenzte Delegation von Verantwortung, Macht und Vollzugsgewalt. Dabei sind Gesetze und Spielregeln „eisern" zu befolgen. Beide können geändert werden, aber so lange sie nicht geändert sind, gelten sie.

Im Forschungsbericht der Bundesregierung heißt es:

„Wachstum und Beschäftigung von morgen werden nicht mit dem Wissen und den Verfahren von gestern erreicht. ... Bildung und Wissenschaft, Forschung und Tech-

nologie rücken damit ins Zentrum einer Politik, die Zukunft möglich machen will. In einer (unserer) Zeit ... ist Wissen zum wichtigsten aber auch vielfältigen und schnellebigen 'Rohstoff' geworden.

Gerade auch technisch-wissenschaftliches Wissen muß heute bereits mit Blick auf die Problemlösung und vorgesehene Anwendung gewonnen werden. Innovationen werden eine größere Erfolgschance haben, wenn die potentiellen Anwender der FuE-Arbeiten selbst schon im Hinblick auf das zukünftige Marktpotential selbst mitgestalten können; damit ist auch die Interdisziplinarität von Forschung und Entwicklung gefragt."

Das ist alles wohl wahr, aber wie kommt denn der so ersehnte Innovationsprozeß nun in Gang? Wagemann berichtet in einem Beitrag „Wie neue Technologien entstehen": Mit der Bereitstellung ausreichender Mittel für die Forschung allein ist es nicht getan. Es müssen Plattformen für die Partnerfindung bei der Projektkoordinierung bereitgestellt werden, und eine geeignete kompetente Projektbegleitung muß zu einem raschen Transfer in die industrielle FuE beitragen.

Chemiker - so heißt es in einer Anzeige des VAA vor wenigen Wochen - arbeiten für eine gute Gegenwart und eine bessere Zukunft. Alle, die in der chemischen Industrie tätig sind - von der Forschung bis zur Produktion - sind keine Brunnenvergifter, sondern Menschen, die das Beste für die Zukunft wollen; für sich und ihre Familien, für alle. Wir sprachen - und wir sagten dies mit Überzeugung - von der dienenden Funktion der Chemie, der Technik für die Menschen. Die Mitteilung „chemical companies exist to make money for the owners" überrascht keinen ökonomisch denkenden Menschen, die Härte, mit der gelegentlich „share holder value" durchgesetzt wird, aber schon. Auch der Präsident der Forschungsgemeinschaft beklagt: „Die Industrie fährt ihre Forschungsabteilungen mit rasanter Geschwindigkeit zurück und gibt jungen Menschen keine Beschäftigungschancen mehr." Damit unterbleibt aber auch der personale Technologietransfer, und der Stau hat schlimme Rückwirkungen auf die Motivation zur Arbeit in der Universität und auf die Berufswahl.

Wie geht es voran, wie kommt es zum gemeinsamen Projekt?

Die Großunternehmen werden nach der Phase ihrer tiefgreifenden Umorganisation, die derzeit in vollem Gange ist, Forschungsergebnisse suchen und kaufen, und zwar bei ihren eigenen Service-Forschungszentren, bei den von ihnen ausgemachten „centers of excellence", vor allem aber durch ihre Repräsentanten und „Späher" überall auf der Welt. Persönliche Bindungen und Ergebnistransfers von Forschern zu einem und nur einem Unternehmen werden sich minimieren. Hochschullehrer werden mehr Zeit aufwenden müssen, um „spähende" Besucher zu empfangen, zu bedienen, zu informieren und zuvor sorgfältig zu selektieren und ihre Mitteilsamkeit festzulegen. Es gibt auch die Meinung, daß es Sache der Hochschulen sei - wenn sie

denn aus öffentlichen Mitteln so üppig alimentiert werden wollen - die Entwicklungs- und Anwendungsmöglichkeiten ihrer Forschungsergebnisse zu verdeutlichen. Dies setzt Entwicklungseinrichtungen voraus, über die die Hochschulen im allgemeinen nicht verfügen, weshalb die Entwicklungen dort auch meistens nicht bis zu diesem Punkt getrieben werden (können). In einer anderen Situation sind die Großforschungszentren und auch die Fraunhofer-Gesellschaft. Eine Verbesserung der Zusammenarbeit bis hin zur Nutzung notwendiger Einrichtungen sollte daher organisiert werden. In Einzelfällen ist es auch schon geschehen.

Sicher werden die finanzschwachen politischen Beobachter nicht nur auf den Umfang des Transfers sehen (und ihn neuerdings als Qualitätsmerkmal akzeptieren), sondern auch die Frage stellen, in welchem Umfang aus nationalem Budget finanzierte Forschung gefördert werden soll, um international arbeitende „global players" wettbewerbsfördernd zu unterstützen. Schutzrechtsfragen gewinnen an Bedeutung.

Meines Erachtens wären Universitäten gut beraten, wenn sie aus ihren älteren Professoren, die ja nach der Emeritierung meist keinen eigenen Arbeitskreis mehr haben, aber noch Reputation, einen „brain trust" bildeten, der nicht etwa für die Forschungsplanung, sondern für den Forschungs-Ergebnis-Verkauf, für Schutzrechtsberatung, nationale und internationale Fachkontakte in Anspruch genommen werden könnte. Ein solcher brain trust könnte die Arbeitskreise und Arbeitseinheiten beraten, intern und extern Partner vermitteln und stellte auch eine Plattform im Sinne von Wagemann dar.

Es muß ja immer auch an Finanzierung gedacht werden. Man könnte sich ja vorstellen, daß die emeriti zunächst einmal ohne Zusatzbezahlung bereit wären. Kommen sie beispielsweise zu einer Schutzrechtsempfehlung, so wäre diese in schwierigen Fällen natürlich von einem Patentanwalt auszuarbeiten, der dies meines Wissens nicht ohne Honorar tun darf. Dafür wäre Risikokapital bereitzustellen. Gibt es keinen Interessenten für das Schutzrecht, muß man es fallen lassen und das Kapital ist verloren. Gibt es Interessenten, so könnte man verkaufen und dem Erfinder ein Drittel des Erlöses geben. Ein Drittel wäre dem Risikokapitalfonds zuzuführen, ein Drittel erhält die Universität. Ein Drittel für den Erfinder ist ja besser als nichts. Man müßte so etwas einmal 10 Jahre lang probieren und dann sehen, ob sich so angelegtes Risikokapital verzinst und die Universität reich wird oder ob damit der Beweis geführt wird, daß sich Forschung wirklich nicht rentierlich gestalten läßt.

Wagemann weist auch noch darauf hin:

„Wenn - wie im Falle der Chemie - große etablierte Industriefirmen bestimmte Märkte beherrschen, besteht eine gewisse Gefahr, daß der Transfer neuer, innovativer Entwicklungen in ein Produkt behindert ist. Eine viel schnellere Umsetzung in ein Produkt kann durch die Forscher selbst im Rahmen von Forschungsunterneh-

men gewährleistet werden. Dann müssen aber Mittel für die Unternehmensgründung bzw. die Finanzierung von Risikokapital bereitgestellt werden."

Im erwähnten Forschungsbericht betrachtet die Bundesregierung „die Forschungs- und Technologiepolitik als integralen Bestandteil einer breit angelegten innovationsfördernden Politik, die auf eine Verbesserung der Zusammenarbeit zwischen Wirtschaft und Wissenschaft und die Förderung günstiger Rahmenbedingungen und kooperativer Netzwerke des Innovationssystems abzielt." Es wird weiter festgestellt: „Im marktwirtschaftlichen Zusammenhang spielen für den Technologiediffusionsprozeß vor allem kleine und mittlere Unternehmen eine wichtige Rolle."

Meines Erachtens ist der oben erwähnte „brain trust", der ja wiederum in Fachsektionen überregional sich verbinden könnte, geeignet, auch das Problem der Förderung der KMU anzugehen.

Die KMU sind dadurch ausgezeichnet, daß sie eine kurzfristige Lösung meist auch erst kurzfristig erkannter, oft sehr spezieller Probleme suchen. Gleichzeitig suchen sie Vertraulichkeit, denn sie wissen, daß eine Problemformulierung oft schon eine halbe Problemlösung ist. Diese Problemlösung wollen sie für sich allein. Zumindest wollen sie einen Vorsprung vor der Konkurrenz. Wissenschaftlich forschende Institutionen und Personen sind nicht geeignet, sich um solche Problemlösungen zu kümmern, wenn sie nicht sehr ähnliche Lösungen schon durchgeführt haben oder zufällig im Besitz einer adäquaten Problemlösung sind. Wie können hier Problemträger und Problemlöser zusammenkommen?

Indem ein „brain trust" im oben beschriebenen Sinne, quasi anonym das Problem des Problemträgers zur Kenntnis nimmt, bei der Problemformulierung hilft und sodann einen ihm - dem brain trust - bekannten Problemlöser entweder unmittelbar vermittelt oder die Problemlösung via Internet ausschreibt und so einen Problemlöser findet. Damit nähmen die Universitäten vorweg, was die Bundesregierung mit der Helmholtz-Gemeinschaft will: Das vorhandene ausgezeichnete Know-how und Potential einer breiten wirtschaftlichen Nutzanwendung zugänglich zu machen.

Ich erinnere, daß ich schon eingangs darauf hingewiesen hatte, daß ein so stark expandierter Tertiärbereich sich neben der Forschung auch der zweck- und zielorientierten Dienstleistung zuwenden müsse. Wir müssen uns auch die Frage stellen, wieviel Forschung im Hinblick auf mögliche Innovationen brauchen wir? Auch die Bemerkung des Forschungsministers in der Woche, daß nicht jeder, der ein Reagenzglas halten könne, ein Forscher sei, muß bedacht werden. Wenn sich auch keine kausale Beziehung zwischen nichtvorhersehbaren Forschungsergebnissen und Anwendung herstellen läßt, so wird es doch eine statistische Relation geben, über die beispielsweise der Forschungsrat beim Bundeskanzler befinden muß, also die Politik. Daher scheint es mir angebracht, über die Verteilung von Forschungsgeldern nach einem Verfahren zu beschließen, das vor Jahren von der DFG einmal in

Vorschlag gebracht wurde, vielleicht implizit auch benutzt wurde, aber offengelegt werden sollte: Es werden die Ziele, um derentwillen Forschung betrieben wird, festgelegt und bewertet. Dieses bewertete Ziel ist der Zielvektor. Forschungsprojekte werden nun je nachdem, was sie zur Erreichung eines bestimmten Zieles beiträgen können, z. B. zwischen 1 und 10 bewertet. Dies ist der Projektvektor. Der Zielvektor wird mit dem Projektvektor multipliziert. Damit hat man einen Wert für die Wünschbarkeit des Projektes. Nun gibt es Projekte, die sehr wenig kosten. Sie erhalten einen Kostenfaktor 1. Offensichtlich muß über Projekte, die viele Millionen kosten, letztendlich politisch entschieden werden. Bei einer Million ist der Kostenfaktor etwa 0,5, bei 10 Millionen 0,3, bei 100 Millionen 0,1 und bei einer Milliarde konvergiert er gegen Null. Die Kurve für den Kostenfaktor legt eine Finanzkommission fest. Natürlich erhalten bei der Qualitätsbewertung in der Qualität hervorragende Projekte einen Qualitätsfaktor 1, schlechte einen Qualitätsfaktor 0, für den Bereich dazwischen kann man eine Sprungkurve oder eine sigmoidale Kurve festlegen. Die Summe über die Produkte aus Zielvektor*Projektvektor*Kostenfaktor*Qualitätsfaktor ergibt eine Prioritätszahl für das Projekt.

Das Verfahren wurde 1970 auf einem DFG-Kolloquium von Carsten Bresch dargestellt. Die Mittel werden jetzt in der Reihenfolge der Prioritätszahlen verteilt. Das Verfahren trägt der Erkenntnis von Herrn Rüttgers Rechnung: „Nicht jeder, der ein Reagenzglas halten kann, ist schon ein Forscher", aber auch dem Bedarf nach Humus-Forschung. „Forscher sollen auch die Möglichkeit haben, als 'Käuze' in ihrem Labor zu arbeiten".

Danach sollte der zur Forschung berufene - die Menge legt der Forschungsrat fest - nach geprüfter Qualität so ausgestattet sein, daß er Humusforschung betreiben kann. Zusätzliche Mittel sollen die erhalten, die auf Gebieten arbeiten, deren Ergebnisse für eine Reihe von verschiedenen Anwendungsbereichen von Relevanz sein können (solche Gebiete definiert man beispielsweise durch Delphi-Befragungen).

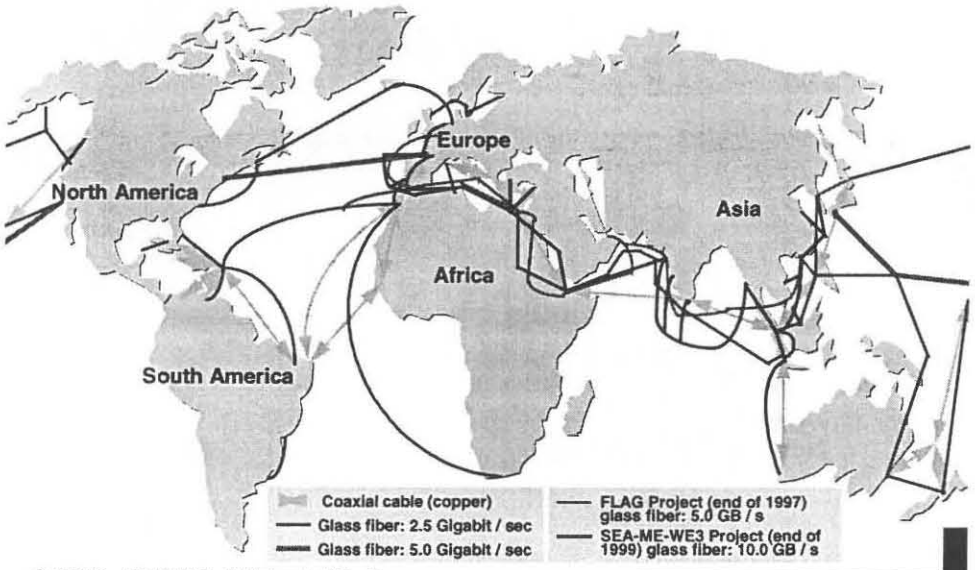
Es wäre doch interessant und mit dieser Anregung will ich schließen, die Delphi-Befragung über die Zukunftserwartungen der Wissenschaftler mit dem Ergebnis einer Bevölkerungsbefragung über die Erwartungen der Bevölkerung an die Wissenschaft zu konfrontieren. Möglicherweise erwarten Durschnittsmenschen, die die Wissenschaft bezahlen, von dieser ganz anderes als die Wissenschaftler meinen liefern zu müssen. Mich beispielsweise würde schon sehr interessieren, ob die Menschen, die gegen ein atomares Endlager sind, vielleicht die Transmutation gefördert haben möchten, damit nun einmal entstandene und entstehende radioaktive Abfälle nicht gelagert werden müssen, sondern beseitigt werden können. Vielleicht entstünde dadurch sogar Aufbruchstimmung.

# Rolle der Information im Wandel der Strukturen

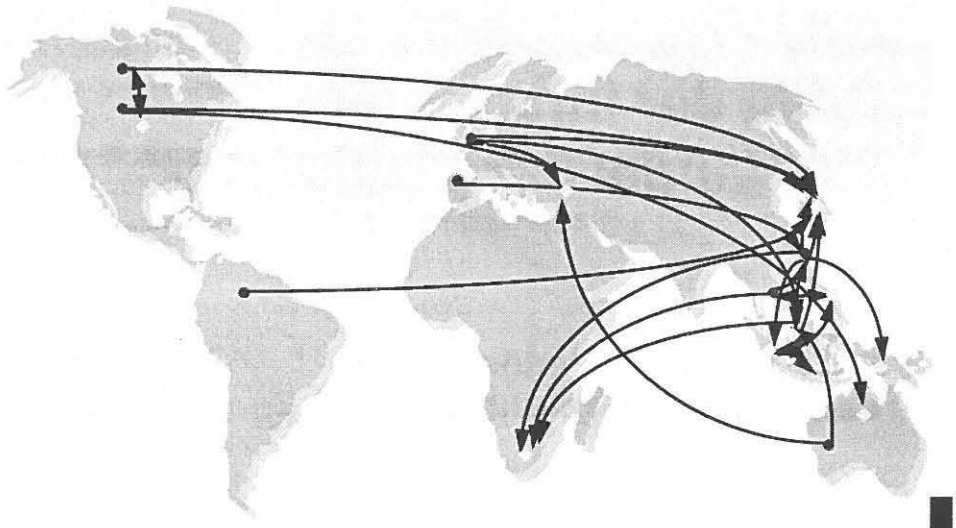
**Prof. Dr. Hasso Plattner**
**Vice Chairman, SAP AG**



## The Worldwide Data Highway

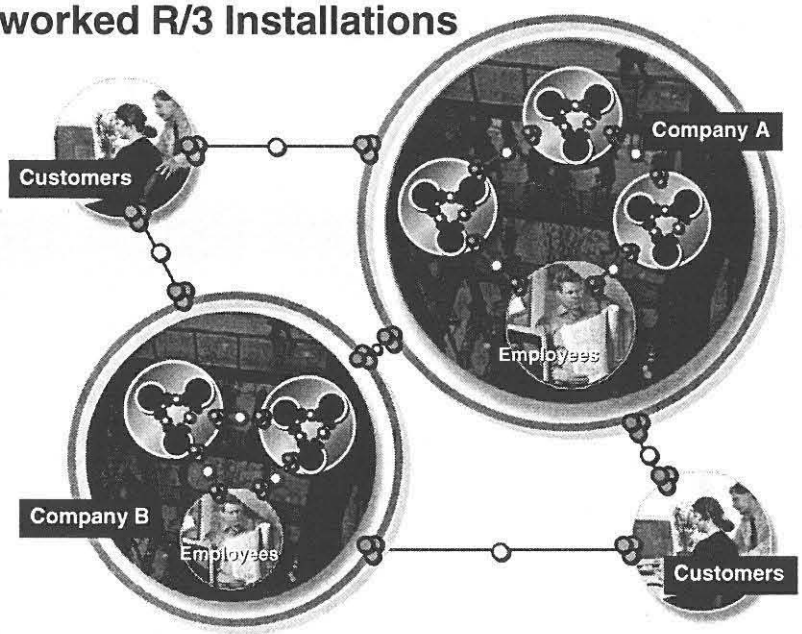


## Global Customer Network: Toyota

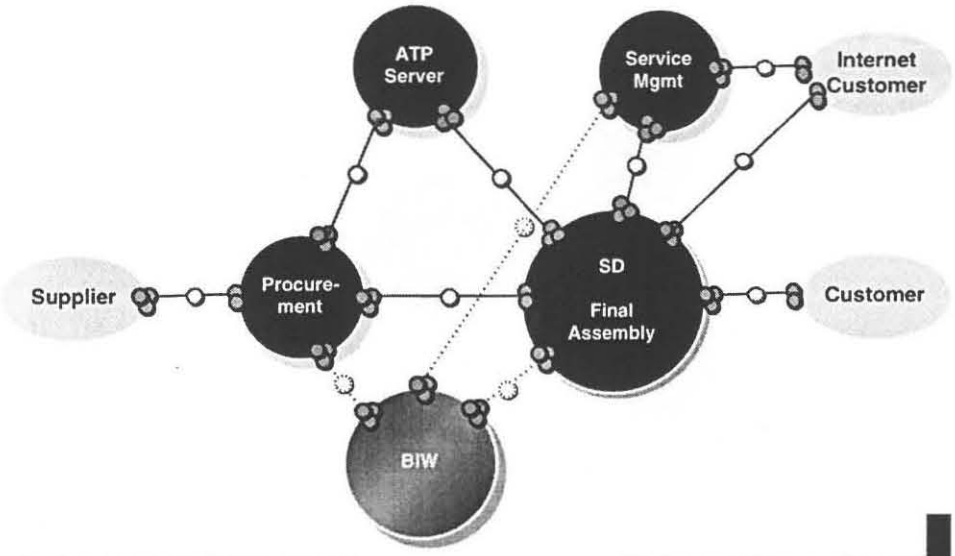




## Networked R/3 Installations

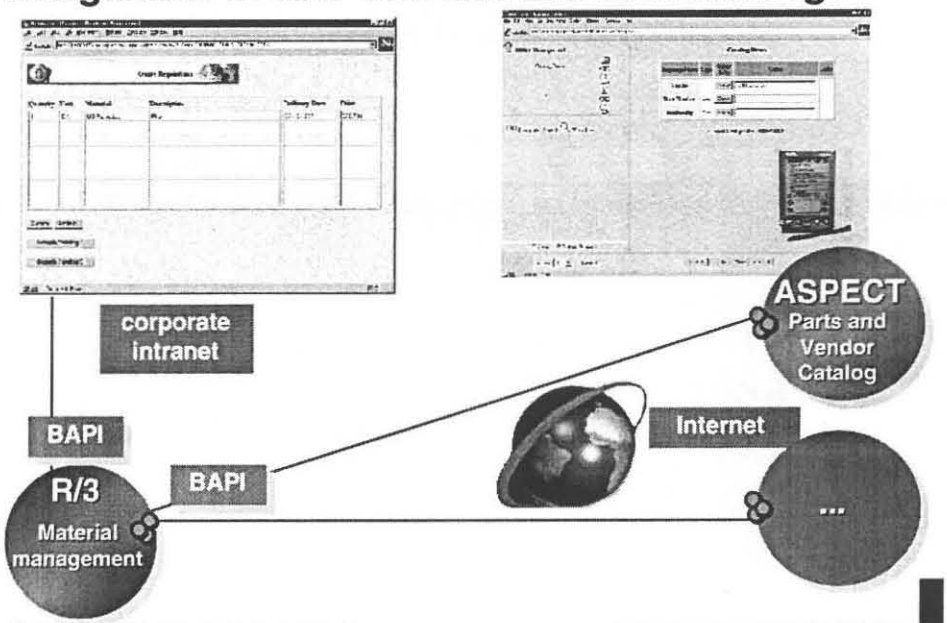


## PC Industry

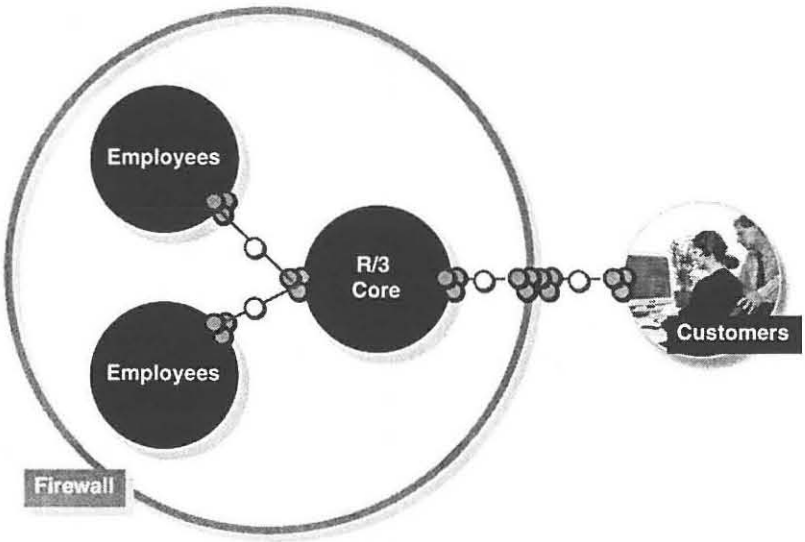





## Integration of SAP R/3 and external catalogs

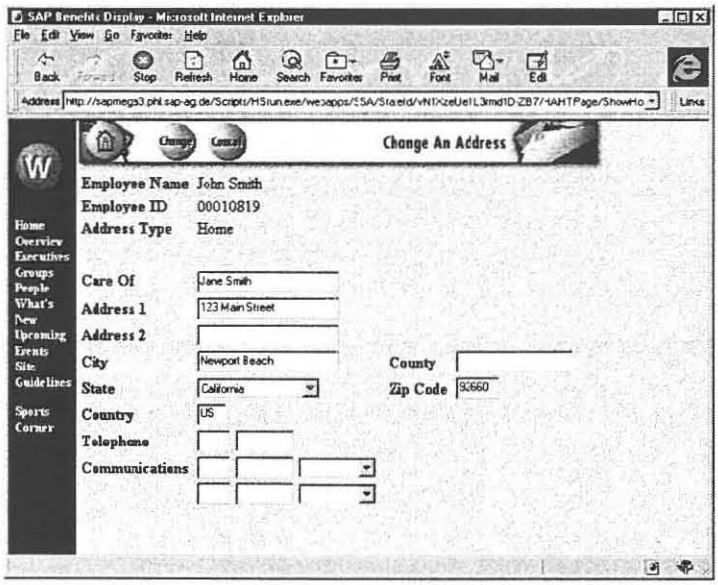


## Cooperating Components






## Change Address



## Employee Directory

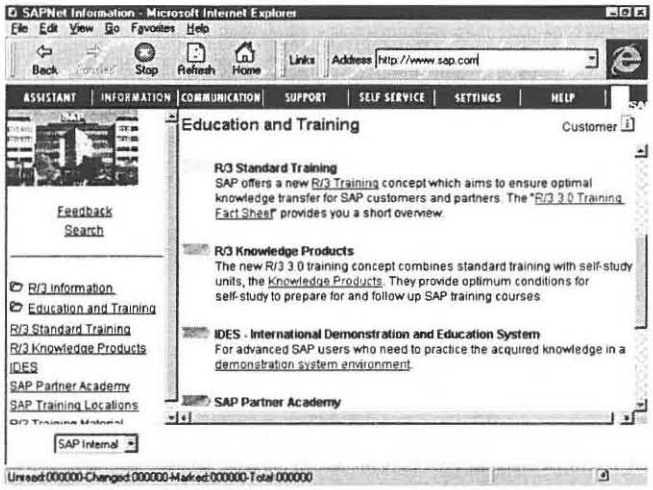



## SAP*Net* - Scalability of Information

- Information Pool for SAP, customers, partners and public audiences
- All about SAP from one source
- Assistant: Personalized information
- Global indexing
- Communication Channel
- Self Service Opportunities
- Online-Support
- Content: Product documentation, training material, event booking, marketing collaterals, discussion forums, news, support information, consulting hints, ...


- Laptop
- Local Server
- Global Internet

# SAP*Net* - Training Area



Prof. Dr. Klaus Michael Meyer-Abich



Mai 1997

# Ist biologisches Produzieren natürlich?
# Kulturelle Grenzen der Biotechnik[1]

Ist biologisches Produzieren natürlich? Ich sehe dafür durchaus eine Chance, obwohl sich die unbedingten Befürworter wie die unbedingten Gegner der Biotechnologie tendenziell darüber einig sind, diese Frage zu verneinen, weil auch eine sozusagen biologische Produktion allemal Technik bleibe und somit nicht natürlich sein könne. Dieses Einvernehmen ist dann die gemeinsame Basis, auf der die einen dafür und die andern dagegen sind. Nun verdient die Biologisierung der Technik, wie sie sich als ein Wegweiser künftiger Innovationen abzeichnet, ganz gewiß eine gründliche Auseinandersetzung in der politischen Öffentlichkeit. Der Mühe wert und in unser aller Interesse ist diese aber doch nur dann, wenn sie auch darüber geführt wird, welche Fragen den Streit wert sind und uns auf möglichst richtige Wege bringen könnten. Dazu möchte ich einen Beitrag leisten.

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[1] Vortrag zum 25jährigen Bestehen des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung in Karlsruhe am 3. Juni 1997

Selbstverständlich will ich mit dem biologischen Produzieren nicht darauf hinaus, daß jede technisch produktive Umsetzung biologischen Wissens insoweit auch bereits natürlich sei. Die - dringend gebotene - öffentliche Auseinandersetzung darüber, ob wir mit den neuen Biotechniken besser leben würden als ohne sie, sollte aber meines Erachtens nicht aus einer Entgegensetzung von Natur und Technik geführt werden. Denn Technik kann ein Beitrag zur *Kultur* sein und die Entgegensetzung von *Natur und Kultur* ist einer der Fehler, die uns in die Naturkrise der wissenschaftlich-technischen Welt hineingeführt haben. Überlegungen der Praktischen Naturphilosophie ergeben statt dessen: *Kultur ist der am ehesten spezifisch menschliche Beitrag zur Naturgeschichte.* Dabei verstehe ich unter Kultur den Inbegriff der Lebensentwürfe einer Gesellschaft, d.h. ihren Lebenszusammenhang oder das, was sie zusammenhält. In diesem Sinn war die frühere Agrikultur nicht nur ein sowohl kultivierter als auch technischer Umgang mit Pflanzen - bereits das Anlegen von Feldern ist eine Kunst oder Technik -, sondern zugleich die Kultur der Gesellschaft, deren Lebensgrundlage die Agrikultur war. Wer demgegenüber unter Kultur nur den Kompetenzbereich von Kulturdezernenten versteht, wird mit der These, Kultur sei der am ehesten spezifisch menschliche Beitrag zur Naturgeschichte, nicht viel anfangen können.

Ich denke also, wir Menschen sind nicht dazu da, um die Welt wieder so zu verlassen, als seien wir gar nicht da gewesen. Wie für alle Lebewesen gehört es auch zu unserer Natur und zu

unserm Leben, Veränderungen in die Welt zu bringen. Dies legitimiert natürlich nicht die zerstörerischen Lebensformen, auf die wir uns eingelassen haben. Aber erst dann, wenn wir die menschliche Weltveränderung grundsätzlich bejahen, können wir uns der entscheidenden Frage zuwenden, *welche* Veränderungen dem menschlichen Dasein angemessen sind und welche *nicht*. Auf diese Frage gibt es eine Antwort aus der naturphilosophischen Anthropologie, welche in allgemeiner Form lautet: *Dem menschlichen Dasein in der Natur angemessen ist das, wofür wir unserer Natur nach gut sind.* Und wenn man dann genauer wissen möchte, wofür wir gut sind, kommt heraus: um *Kultur* in die Welt zu bringen (Meyer-Abich 1997).

Der Gegensatz, auf den es für die Technikbewertung ankommt, besteht danach weder zwischen Natur und Technik noch zwischen Natur und Kultur, sondern zwischen kultivierter und unkultivierter Technik. Diesen Unterschied zu machen ist nun gewiß viel schwieriger als den zwischen Natur und Technik, und wir werden hier in der Regel nicht mit eindeutigen Entscheidungen rechnen können. Schwierige und unsichere Antworten auf die richtigen Fragen sind aber immer noch wesentlich besser als einfache Antworten auf falsche Fragen. Und es liegt auf der Hand, wie wenig unserm Verhalten in der Natur heute noch anzusehen ist, daß wir eigentlich ein Kulturvolk sind. Die meisten Menschen haben wohl ein Gefühl dafür, daß z.B. die industrielle Landwirtschaft keine Agrikultur in dem Sinn mehr ist, wie es hierzulande noch am Anfang des vorigen Jahrhunderts eine Kulturlandschaft gegeben hat. Dieses Grundgefühl gilt es zu differenzieren und außer der Landwirtschaft auch auf die industrielle Wirtschaft insgesamt zu beziehen.

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Wenn Technik ein Teil der Kultur und Kultur im weitesten Sinn unser Beitrag zur Naturgeschichte sein kann, sollte unser technisches Handeln im Einklang mit der - geschichtlichen - Ordnung des Ganzen der Natur stehen. Statt die kultivierte - pflegende - von der unkultivierten - zerstörerischen - Technik zu unterscheiden, können wir die kultivierte Technik also auch *eine naturgemäße Technik* und ihr Gegenteil nicht naturgemäß nennen. Woran aber erkennt man, ob eine bestimmte Technik naturgemäß ist oder nicht?

Die Natur ist das Ganze, von dem wir ein Teil sind. Dem Ganzen der Natur gemäß ist eine Technik allenfalls dann, wenn sie nicht zu Lasten des Ganzen betrieben wird. Diese Bedingung wird von der gegenwärtigen industriellen Wirtschaft weitgehend nicht erfüllt. Wir wirtschaften (1) zu Lasten der außermenschlichen Natur - das Artensterben und die anthropogene Klimaveränderung sind die bedeutendsten Beispiele. Wir wirtschaften außerdem (2) zu Lasten der Dritten Welt, indem wir vor allem zu ihren Lasten die Klimaveränderung verursachen, und (3) zu Lasten der Nachwelt. Hier lebt also ein Teil der Welt zu Lasten des Ganzen, d.h. jedenfalls nicht naturgemäß und außerdem unwirtschaftlich, weil die Kosten durch die Erträge nicht gedeckt werden. Um dies zu ändern, müßten wir uns vergegenwärtigen, daß die außermenschliche Natur zunächst einmal *mit* uns in der Welt ist, sie mit uns und wir mit ihr, nicht *um* uns - der Mensch in der Mitte - oder gar nur *für* uns. Die Grundbedingung für eine naturgemäße Technik ist also, daß Tiere, Pflanzen und die sogenannte unbelebte Welt als unsere *natürliche Mitwelt* behandelt werden und nicht nur als Ressourcen für die Menschheit bzw. - genauer gesagt - für Teile

der Menschheit. Kann es eine Technik geben, die im Umgang mit der natürlichen Mitwelt das Grundverhältnis des Mitseins wahrt, ohne die industrielle Wirtschaft aufzugeben? Ich sehe dazu durchaus Möglichkeiten, nicht zuletzt in der Biotechnologie.

**Heuristik des naturgeschichtlich Bewährten**

Die naturgemäße Technik beginnt damit, daß wir uns nicht erst im wirtschaftlichen Handeln, sondern bereits im technologischen Denken zunächst einmal vergegenwärtigen, was schon da ist, was sich also in der naturgeschichtlichen Entwicklung bereits bewährt zu haben scheint. Die im Verlauf der Naturgeschichte entstandenen und schon anderweitig ausprobierten Prozesse haben den von uns erdachten technischen Prozessen voraus, daß sie das Ganze der Natur in Millionen oder Hunderten von Millionen Jahren offenbar erheblich weniger gefährdet haben, als es diese bereits nach wenigen Jahrzehnten oder Jahrhunderten tun. Die naturgeschichtlich entwickelten Prozesse können uns heuristisch insoweit zum Vorbild dienen. Wir sollten deshalb zunächst einmal feststellen, was im Ganzen der Natur sozusagen schon üblich ist, bevor wir neue Ordnungen einführen, die wir für besser halten. Keineswegs aber ist damit gesagt, daß es solche besseren Ordnungen gar nicht geben könne, weil naturgeschichtlich überall schon die besten Lösungen gefunden seien.

Heuristisch wegweisend ist beispielsweise, daß die Natur bei der Synthese und beim Abbau von Stoffen Hochtemperaturprozesse vermeidet, daß sie ihre enzymatischen Abbauprozesse nicht durch zu große Mengen oder zu hohe Konzentrationen toxischer Substanzen - z.B. Chlororganika - überfordert etc. (vgl.

Sturm/Fliege 1994). Und hätten wir uns die Fähigkeit der Natur, mit Stoffen zu arbeiten, die für die Dauer des Bedarfs sehr stabil gegen Zerfall, danach aber leicht abzubauen sind, nicht schon längst zum Vorbild nehmen sollen? Holz ist das bekannteste Beispiel. Demgegenüber erinnere ich mich noch gut an eine Äußerung aus den 50er Jahren, welche besagte: Wenn es das Holz noch nicht gäbe und es heute jemand erfinden würde, bekäme er dafür noch nicht einmal ein Patent. So viel besser, meinte man damals, seien die Kunststoffe.

Naturgeschichtlich bewährt sind auch die Photosynthese, die geschlechtliche Fortpflanzung und die organische Entwicklung im Gegensatz zum technischen 'Fortschritt', der neuerdings meistens 'Innovation' heißt. Nach dem heuristischen Paradigma des naturgeschichtlich Bewährten wäre die heutige Biotechnologie wohl zum großen Teil nicht erfunden worden, an ihrer Statt aber andere, teilweise vielleicht auch gentechnische Verfahren der biologischen Technik. Schädlingsresistenz statt Herbizidresistenz ist ein Beispiel für eine bekannte Alternative. Dabei soll wiederum keineswegs alles als bewährt im Sinn von 'relativ unschädlich' gelten dürfen, was - wie man so sagt - 'auch in der Natur vorkommt'. Zur Bewertung von Biotechnologien wird dies Argument gelegentlich ins Feld geführt. Beispielsweise ist der bloße Hinweis, daß Prozesse der jetzt in vitro praktizierten Art des horizontalen Gentransfers auch in vivo stattfinden (Pühler 1994), zunächst ohne jeden legitimatorischen Gehalt. Nach dem heuristischen Kriterium des naturgeschichtlich Bewährten wäre über das bloße Vorkommen hinaus vielmehr die Art dieser Bewährung und ihre Vergleichbarkeit z.B. mit Freilandversuchen zu überprüfen. Auch hier aber dient das heuristische Kriterium

nur der Eingrenzung grundsätzlich diskutabler Lösungen, nicht der Rechtfertigung einer von ihnen.

Uns die naturgeschichtlich bewährten Vorgänge in der technologischen Entwicklung heuristisch zum Vorbild zu nehmen, ist auch deshalb angemessen, weil sie nicht nur naturverträglicher sind als die meisten industriewirtschaftlichen Prozesse, sondern durchweg eleganter, intelligenter und weniger gewalttätig bzw. energieintensiv. Daß ein so vielseitig befähigtes Wesen wie der Mensch mit einer Energiezufuhr von durchschnittlich ca. 100 Watt auskommt, wohingegen ein - sozusagen um viele Größenordnungen dümmeres - Auto etwa den tausendfachen Energieumsatz hat, zeigt diesen Unterschied. Eine Maus braucht rund 6 Watt und selbst ein Elefant nur etwa 600. Die technische Entwicklung ist in der Mikroelektronik und auch in der Biotechnologie mittlerweile auf dem Weg zu einer in diesem Sinn naturgemäßeren, weniger gewaltsamen Technik. Es versteht sich, daß die geringere Energieintensität für diese Entwicklung nur ein Ziel unter anderen ist, die besonders in der Biotechnologie noch der näheren Bestimmung bedürfen.

**'Der Natur' nachahmen**

Die Heuristik des naturgeschichtlich Bewährten kann das technische Ingenium auf grundsätzlich naturgemäße Wege bringen, liefert dazu aber nicht die näheren Bestimmungen. Ich sehe außerdem keinen prinzipiellen Grund, warum nicht auch eine Technik, die in der Naturgeschichte keinerlei Vorbild hat,

trotzdem naturgemäß im Sinn des Kriteriums der Mitweltlichkeit sein könnte. Dafür Entscheidungskriterien anzugeben erfordert allerdings umfassende naturphilosophische Überlegungen (vgl. Meyer-Abich 1997), deren Richtung ich hier nur kurz andeuten kann. Ich mache dabei von einer Unterscheidung Gebrauch, die Goethe für die Kunst getroffen hat. Sie auf die Technik zu übertragen, bezieht diese zugleich auf ihre neuzeitlichen Anfänge zurück, in denen Kunst und Technik sich noch nicht auseinanderentwickelt hatten.

Ein Künstler, so heißt es u.a. in den „Wanderjahren", kann die Natur nachahmen, also z.B. eine Blume oder einen Sonnenuntergang abmalen. Dies ist nicht die höchste Form der Kunst, aber doch ein Einstieg und ein Übungsfeld. Die Natur nachzuahmen entspricht für die naturgemäße Technik der Heuristik, uns zunächst einmal zu vergegenwärtigen, was naturgeschichtlich schon da ist, bevor wir Veränderungen in die Welt bringen. Auch dies ist als ein Einstieg und ein Übungsfeld gemeint. In der Kunst nun hat Goethe die höhere, schöpferische Form als 'Stil' bezeichnet und diesen so charakterisiert, daß der Künstler nicht mehr *die* Natur nachahmt, sondern *der* Natur: Die Künste im eigentlichen Sinn ahmen nicht *die* Natur nach, nämlich „nicht das ..., was man mit Augen siehet", sondern *der* Natur, indem sie „auf jenes Vernünftige zurückgehen, aus welchem die Natur bestehet und wornach sie handelt" (1829, HA VIII 463). Wer also *die* Natur nachahmt, orientiert sich an den *Dingen der Natur*, wer *der* Natur nachahmt, nimmt sich die *Natur der Dinge* zum Vorbild - nicht das Geschaffene, sondern die schöpferische Kraft, die es hervorgebracht hat und auch noch anderes hätte hervorgebracht haben können oder in der Zukunft hervorbringen könnte. Philosophisch ist dies die Unterscheidung

von natura naturans, der schaffenden Natur, und natura naturata, den sichtbaren Dingen.

Wollten wir nun auch in einer naturgemäßen Technik nicht nur *die* Natur nachahmen, sondern *der* Natur, so wären wir nicht mehr an das naturgeschichtlich bereits Bewährte gebunden. Daß wir es bisher in einem Übermaß gerade so halten zu dürfen gemeint und es uns damit zu leicht gemacht haben, bedeutet nicht, daß diese Art des technischen Ingeniums grundsätzlich disqualifiziert ist. Wir sollten uns aber wohl auch in der Technik erst einmal mehr darin üben, *die* Natur nachzuahmen, wenn es um das biologische Produzieren geht, und uns erst später und viel vorsichtiger zutrauen, dann auch *der* Natur nachzuahmen. Goethe selbst hat diesen Schritt jedenfalls nicht gescheut, als er sich beispielsweise hinsichtlich der Urpflanze vorstellte: „Mit diesem Modell und dem Schlüssel dazu kann man alsdenn noch Pflanzen ins Unendliche erfinden" (1816/17, HA XI 375). Auch Goethe war also jedenfalls nicht grundsätzlich gegen die Erfindung neuer Pflanzen.

Indem die Kunst *der* Natur nachahmt, sucht sie eigentlich das zu tun, was diese selber tun würde. Warum tut sie es nicht selber? Sie tut es selber, indem sie ein Lebewesen hervorgebracht hat, den Menschen, dessen besonderer Beitrag zur Naturgeschichte u.a. gerade das künstlerische und das technische Handeln sind. So kann - wieder in Goethes Worten - „die allgemeine Natur unter der besonderen Form der menschlichen Natur produktiv handeln" (HA XII 469), d.h. sozusagen biologisch produzieren. Die Natur „treibt sich mit uns fort" (HA XIII 45), *sich* mit *uns*.

Unter welchen Umständen tut sie es wirklich? Nach dem gegenwärtigen Verhalten der Industriegesellschaften droht der Versuch der Natur zu mißlingen, sich *durch Menschen* fortzutreiben. Die Natur hat uns aber auch mit dem Vernunftvermögen ausgestattet, und es spricht alles dafür, davon einen erheblich weitergehenden Gebrauch zu machen, als wir es bisher tun. Folgten wir dabei Goethe, was ich für richtig halte, so käme es darauf an, „daß wir uns, durch das Anschauen einer immer schaffenden Natur, zur geistigen Teilnahme an ihren Produktionen würdig machten" (HA XIII 30 f). Wir werden dieser Teilnahme an der Produktivität der Natur sicherlich nicht würdig, wenn wir zu Lasten des Ganzen leben und die übrige Welt wie einen Sack voll Ressourcen verwirtschaften. Aber wir *könnten auch als mündige Erdenbürger in der Gemeinschaft der Natur* das zu tun suchen, wofür wir unserer menschlichen Natur nach gut sind: *Kultur* in die Welt zu bringen, durch die Teilnahme an der Produktivität der Natur, zu der wir gehören. So wie die antiken Kunstwerke „als die höchsten Naturwerke von Menschen nach wahren und natürlichen Gesetzen hervorgebracht worden" (1816/17, HA XI 395) sind, wäre die Natur dann selbst das Maß der Technik. Wenn wir uns immer schon daran gehalten hätten, brauchten wir heute keine Umweltgesetze und -behörden. Wenn wir uns in Zukunft daran hielten, würden wir andern Ländern kein schlechtes, nicht verallgemeinerungsfähiges Vorbild mehr bieten. Das 'biologische Produzieren' durch eine naturgemäße Technik wäre dazu ein guter Weg.

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# Wissenschaftliche Evaluierung der Politik - Schiedsrichter oder Spieler ? Das Beispiel der Schweizer Technologiepolitik

Referat von Prof. Dr. Hans Sieber, Direktor des Bundesamtes für Konjunkturfragen im Eidgenössischen Volkswirtschaftsdepartement und Präsident der Kommission für Technologie und Innovation anlässlich des Festaktes zum 25-jährigen Bestehen des Fraunhofer-Insituts für Systemtechnik und Innovationsforschung ISI am 3. Juni 1997 in Karlsruhe

## Grundzüge der Schweizer Technologiepolitik und die Beiträge des ISI

- Ich freue mich, Ihnen, meine Damen und Herren des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung zum 25-jährigen Institutsjubiläum meine herzlichen Glückwünsche auszusprechen. Seit gut fünf Jahren besteht eine enge Zusammenarbeit zwischen dem ISI und dem von mir geleiteten Bundesamt, welchem u.a. die Federführung bei der Umsetzung der Schweizerischen Technologiepolitik obliegt. Ich darf der Institutsleitung sowie den Mitarbeiterinnen und Mitarbeitern an dieser Stelle Dank und Anerkennung für den wertvollen Beitrag zur Konzeption und Evaluierung der Umsetzung wichtiger Massnahmen der Schweizerischen Technologiepolitik aussprechen.

- Technologiepolitik zählt heute zu einem der am gründlichsten analysierten Bereiche der Schweizer Politik. Während mehr als fünf Jahren wurde die Technologiepolitik tiefgehend ausgelotet und begründet. In diesem Zeitraum hat eine parlamentarische Kommission eine eigentliche 'Motorenrolle' bei der Formulierung und Gestaltung dieses Politikbereiches übernommen. Ich erwähne dies deshalb, weil ein solches Engagement im wohltuenden Gegensatz steht zu der in der Politik heute vielfach vorherrschenden 'Kurzatmigkeit'.

- Wir haben die Technologiepolitik auf drei Beine abgestützt:

  - Erstens, **innovationsfreundliche Rahmenbedingungen** als mit Abstand wichtigstem Stützpfeiler: Diese bestehen aus einer wettbewerbsfreundlichen, marktwirtschaftlichen Ordnung, einer gut ausgebauten Forschungsinfrastruktur sowie einem leistungs- und anpassungsfähigen Bildungssystem.

Was nützt es beispielsweise, durch technologiepolitische Förderprogramme die Effizienzpotentiale in der Bauwirtschaft auszuschöpfen, wenn diese dann durch langwierige staatliche Bewilligungsverfahren aufgefressen werden, konkret: wenn einem Baugesuch bei durchschnittlich fünf Stunden Bearbeitungsaufwand durch die Baubehörden monatewährende Liege- und Transportzeiten gegenüberstehen.

- Der zweite Pfeiler unserer Technologiepolitik ist das **Leitbild der Diffusion**. Das heisst, technologiepolitische Massnahmen haben die möglichst rasche **Verbreitung** und Anwendung von neuen Technologien resp. neuesten technologischem Wissen durch eine Vielzahl von Unternehmen zu begünstigen. In einem Kleinstaat mit begrenzten personellen und finanziellen Ressourcen ist dies nach meiner Überzeugung der einzig gangbare Weg.

  Zwar gehört die Schweiz, gemessen an den Ausgaben für FuE, zu den forschungsintensivsten Ländern der Welt. Pro Kopf der Wohnbevölkerung wird in der Schweiz mehr Geld in FuE investiert als in den meisten anderen Ländern. Dies ist aber nur ein relativer Vorteil. Denn mit rund 10 Mrd Franken übertreffen die gesamten FuE-Ausgaben der Schweiz im Inland nur knapp die FuE-Ausgaben einzelner weltweit operierender Grosskonzerne.

- Ein dritter Pfeiler unserer Technologiepolitik ruht in unsem **ganzheitlichen Ansatz**: Seit Anfang der 90-er Jahre arbeiten wir konsequent an einer ganzheitlichen Vorgehensweise in unseren technologiepolitischen Aktivitäten. Mit dem sogenannten **MTO-Ansatz** - Mensch,Technik, Organisation - haben wir dazu beigetragen, den 'Paradigmenwechsel' von einer technologiegetriebenen FuE-Förderung zu einer umsetzungsorientierten Förderpolitik zu beschleunigen. Dies war auch für mich persönlich ein Lernprozess, wurde doch dieser Richtungswechsel insbesondere an unseren Ingenieurschulen anfänglich alles andere denn begeistert aufgenommen. Ich denke, die wirtschaftliche Entwicklung der letzten Jahre hat uns darin bestätigt, dass komplexe, zunehmend turbulentere Situationen nicht mit einfachen Massnahmen zu bewältigen sind. Neben Mensch, Technik und Organisation sind vermehrt auch die Faktoren Markt und Umwelt miteinzubeziehen,

etwa im Sinne einer an Innovations- und Lebenszyklen ausgerichteten Förderpolitik.

- Unsere Sondermassnahmen zur Förderung neuer Technologien im Fertigungsbereich, das sog. CIM-Aktionsprogramm von 1990-1996 war die bisher komplexeste technologiepolitische Fördermassnahme in unserem Land. Hier haben wir erstmals ein **strategisches Controlling** eingeführt; als ein Novum unserer Technologiepolitik. Die Wahl zu dessen Durchführung ist auf das ISI gefallen wegen seiner Kompetenz und hohen wissenschaftlichen Reputation. Seitdem hat das ISI wiederholt wesentliche Beiträge der Beratung bei der Politikgestaltung und der Politikevaluation geleistet. Ich erwähne die Mitwirkung bei der vertieften Zielanalyse der Schweizerischen Technologiepolitik im Jahr 1995, die soeben abgeschlossene begleitende Evaluierung des CIM-Aktionsprogrammes, aber auch die laufenden Arbeiten zur Wirkungsanalyse der Fördertätigkeit der von mir präsidierten Kommission für Technologie und Innovation (KTI).

## Chancen und Grenzen einer wissenschaftlichen Evaluierung der Politik

- Die Kernfragen der Evaluierung lauten üblicherweise:

  Ist die Durchführung einer Massnahme zu rechtfertigen (Marktversagen, technologischer Rückstand) ? Sind die Zielsetzungen erreicht worden (Wirksamkeit) ? Welches sind die Nebenwirkungen ? Ist die Massnahme effizient organisiert und ausgeführt worden (administrative Effizienz) ? Diese Fragen werden heute mit einer breiten Palette von Methoden (Methoden-Mix) beantwortet.

- **Die Evaluierung staatlicher Massnahmen hat Hochkonjunktur, jedenfalls in unserem Lande.** Ich nenne einige **Gründe** hierfür:

  – Die zunehmende Verbreitung der Evaluation technologiepolitischer Massnahmen steht in engem Zusammenhang mit den technologiepolitischen In-

terventionen der Europäischen Union und der wachsenden **Kritik an der Durchführungseffizienz**.

- Sodann besteht die **Verpflichtung zur Transparenz** über die Verwendung öffentlicher Gelder gegenüber den Steuerzahlerinnen und Steuerzahlern. Genügte früher das formelle Controlling, d.h. die gesetzeskonforme Verwendung und buchhalterisch saubere Abrechnung, so wird seit einigen Jahren vermehrt die Frage nach der Wirksamkeit (Effektivität) öffentlicher Ausgaben sowie der Effizienz der Verwaltung dieser Mittel gestellt. Die Beantwortung dieser Fragen stellt sich umso dringlicher in wirtschaftlich schwierigen Zeiten bei leeren öffentlichen Kassen. Im Verteilungskampf um knappe öffentliche Mittel gerät die Technologiepolitik wie andere Politikbereiche unter wachsenden Legitimationsdruck.

- Legitimationsdruck besteht für die Technologiepolitik aber auch aus **ordnungspolitischen Gründen**. In unserem Lande wird - womöglich häufiger als anderswo - der ordnungspolitische 'Zeigefinger' warnend gegenüber einer staatlichen Technologiepolitik erhoben, vor allem, wenn sie als staatliche Industriepolitik verstanden wird. Diese Position besagt stark vereinfacht: Die beste Technologiepolitik ist, wenn der Staat keine Technologiepolitik betreibt. Entsprechend gab es während langer Zeit starke Kräfte, welche einer Technologiepolitik des Staates grundsätzlich ablehnend gegenüberstanden. Verständlich wird eine solche Haltung, wenn man etwa berücksichtigt, dass beispielsweise die forschungsintensiven Grossunternehmen der schweizerischen Chemischen Industrie ihre Forschungs- und Entwicklungsausgaben praktisch vollständig aus eigenen Mitteln finanzieren; wenn man ferner in Rechnung stellt, dass 4/5 der FuE-Ausgaben in unserem Lande von der Privatwirtschaft finanziert werden - in Deutschland sind es zwischen 40 und 60 %. Allerdings hat sich in den letzten Jahren diese Auseinandersetzung namentlich im Zusammenhang mit der allmählichen Annäherung an die Europäische Union etwas entschärft. Gleichwohl muss die Technologiepolitik in dieser Konstellation ihre Leistung immer wieder bestätigen, unter anderem auch durch unabhängige Evaluationen.

- Auf der psychologischen Ebene ist der Ruf nach Evaluation auch als Ausdruck einer wachsenden Skepsis, um nicht zu sagen **Vertrauenskrise gegenüber der Politik** zu deuten, insbesondere wenn sie von einer zentralen Instanz (in der Schweiz von „Bern", in Europa von „Brüssel") ausgeht. In der Schweiz ist dies insbesondere spürbar seit dem Nein des Volkes gegen den Beitritt zum Europäischen Wirtschaftsraum EWR vom 6. Dezember 1992.

- Schliesslich entsteht ein gewisser Druck zur Evaluierung der Politik auch aus der Entwicklung **moderner Managementkonzepte.** Ich erwähne das **New Public Management**, den Einzug moderner Management-Methoden auch in die öffentlichen Verwaltungen. Durch Benchmarking, sprich: Evaluationen, muss sich die öffentliche Verwaltung in ihrer Leistungsfähigkeit immer wieder beweisen. Inzwischen gibt es kaum einen Politikbereich, der nicht in irgendeiner Form evaluiert wird. Gelegentlich scheint mir eher zuviel des Guten gewollt zu werden, wenn z.B. die Evaluierung einzelner Massnahmen nicht mehr genügt und die massnahmenübergreifende Evaluierung gefordert und durchgeführt wird, gewissermassen die Evaluation der Evaluation. Immerhin hat der Schweizerische Nationalfonds (das Pendant zur Deutschen Forschungsgemeinschaft) ein eigenes Forschungsprogramm „Wirksamkeit staatlicher Massnahmen" (NFP 27) lanciert.

- **KMU-Orientierung der Technologiepolitik**: Ich darf sagen, dass wir uns in der Schweiz insbesondere den kleinen und mittleren Unternehmen, den KMU, verschrieben haben; dies eine weitere Besonderheit unserer Technologiepolitik und füge sogleich hinzu, dass zwischen KMU in der Schweiz und Deutschland strukturelle Unterschiede bestehen. Über 90 % der Betriebe in der Schweiz haben weniger als 100 Beschäftigte; 75 % der in unserer Wirtschaft Beschäftigten arbeiten in KMU. Wenn wir also etwas für die grosse Masse der Betriebe und Beschäftigten tun wollen, dann liegen hier wichtige Ansatzpunkte. Missverstehen Sie mich nicht. Es geht mir nicht darum, Gross und Klein gegeneinander auszuspielen, weiss ich doch um die gesamtwirtschaftliche Bedeutung einer guten Durchmischung von "global players" und einer Vielzahl agiler Klein- und Mittelbetriebe in einer Volkswirtschaft. Dennoch ist nicht zu übersehen, dass einer sozusagen natürlichen Symbiose zwischen den F+E-Abteilungen von Grossunterneh-

men und den Forschungsinstituten an unseren Hochschulen rein grössenbedingte Nachteile, aber auch mentale Barrieren vieler KMU in ihrem Zugang zu Forschungsstätten gegenüberstehen. Umso wichtiger erscheint mir, den KMU die Hand zu reichen, die Zugangsbarrieren zu den Forschungs- und Bildungsstätten - auch in den Köpfen - abzubauen und den KMU die neutralen Vermittlungs- und Moderatorendienste des Staates in der Technologiepolitik anzubieten. Weil es **den** typischen Mittelständler nicht gibt, sondern eine schier unüberschaubare Masse höchst unterschiedlicher KMU, liegt hier eine weitere Notwendigkeit zur ständigen Überprüfung der Zielerreichung durch Evaluierung auf der Hand.

- Neben diesen guten Gründen für eine vermehrte Evaluation der Politik werden aber zunehmend die **Grenzen der Evaluation** sichtbar:

  - Ich nenne erstens die „**Zahlengläubigkeit**" der Politik, der Glaube an die Quantifizierbarkeit politischer Massnahmen resp. des Verwaltungshandelns. Heute steht aus naheliegenden Gründen das Kriterium „Anzahl geschaffener Arbeitsplätze" im Vordergrund. Die Evaluation muss die „Zahlen" liefern als Beweis für die Wirksamkeit staatlichen Handelns.

  - **Qualitative Effekte** geraten deswegen eher etwas in den Hintergrund, weil sie bestenfalls indirekt greifbar sind. Dies obwohl Technologiepolitik heute sehr viel mit sogenannten **'weichen Faktoren'** zu tun hat, in denen das Potential, der Humus für Innovationen liegt - ich erwähnte bereits unseren ganzheitlichen Ansatz. Die Rede ist von den Effekten auf die Motivation der beteiligten Personen, ihrem Willen und ihrer Bereitschaft, etwas zu verändern und dem Glauben an den Erfolg, der bekanntlich Berge versetzen kann. Im Veränderungsprozess erweisen sich gerade solche weichen Faktoren oft als die härtesten Hindernisse.

  - Zu den qualitativen Wirkungen gehört auch der **Erfahrungszuwachs**, das nur in den Köpfen vorhandene Wissen ('tacit knowledge'), das selbst dann positiv zu werten ist, wenn sich ein Projekt einmal als Fehlschlag herausstellen sollte.

- Ein Kennzeichen heutiger Politik ist ihre zunehmende **Kurzatmigkeit und Ungeduld**, eng verbunden mit einer starken Personifizierung und ihrer Ausrichtung auf die Medien. Tendenzen, die auch für die Wirtschaft gelten. Die Zeithorizonte in der Politik sind zwar immer noch etwas länger, aber gleichwohl mehr und mehr auf rasche Wirksamkeit und schnelle Resultate ausgerichtet. Es scheint fast so, als müssten wir, nachdem wir ein Samenkorn in die Erde versenkt haben, es jeden Tag herausreissen und nachschauen, ob es schon Wurzeln geschlagen hat. Technologiepolitik und die komplementären Bereiche der Forschungs- und Bildungspolitik sind dagegen auf mittel- und langfristige Wirkungen orientiert. Technologiepolitik hat sehr viel mit dem **Aufbau von Netzwerken** zu tun und ich meine damit ausdrücklich **nicht** Computernetzwerke. Die Massnahmen und Projekte zielen auf Veränderung von Unternehmenskulturen, Zusammenarbeitskulturen, Veränderungen in den Köpfen. Wir haben die Erfahrung gemacht, dass solche Prozesse drei bis fünf Jahre dauern, bevor Resultate sichtbar werden.

- Zum Thema 'Kurzatmigkeit' gehört auch, dass die **Zeitspanne zwischen dem Abschluss einer technologiepolitischen Massnahme und dem Abschluss ihrer Evaluation ebenfalls kürzer werden**. Die Wirkungen gerade einer umsetzungsorientierten Technologiepolitik sind auf diese Weise schwer zu ermitteln. Bekanntlich werden die Resultate sehr guter öffentlich geförderter FuE-Projekte nicht immer sofort umgesetzt. Die Gründe hierfür sind bei den Unternehmen zu finden, deren strategische und operativen Entscheidungen oft so komplex sind, dass eine rasche Umsetzung auf dem Markt im Massstab 1:1 kaum erwartet werden darf. Angesagt wären darum Langzeitbeobachtungen, aber die scheitern in der Regel an den damit verbundenen Kosten. Und je mehr Zeit vergeht, desto schwieriger wird die Zuordnung von Ursache und Wirkung.

- **Technokratisches Politikverständnis**: Weit verbreitet ist ein technokratisches Verständnis von Politik, der Glaube an eine quasi ingenieurmässige Umsetzung staatlicher Aktionen und an die Steuerungsfähigkeit der öffentlichen Administration. **Kausalzusammenhänge sind gerade in der Technologiepolitik schwer festzumachen**. Die Zielgenauigkeit insbesondere der

komplexeren technologiepolitischen Massnahmen, z.B. unserer Aktionsprogramme, ist vielschichtig und auf Breitenwirkung angelegt. Ich benutze hier gern das Bild des Steins, der ins Wasser geworfen wird und in alle Richtungen Wellen wirft.

- **'Bottom-up-Ansatz'**: Es steht einer Demokratie gut an, dass nicht die Verwaltung, die Beamten kraft eigener Kompetenz bestimmen, wo es langgeht. Die Mitwirkung der Bürger an der Gestaltung und Umsetzung ist gefragt. Technologiepolitische Aktivitäten verstehen sich darum als Angebote: Der Staat kann den „Pferden" die „Tränken" - Unterstützungsleistungen für FuE - aufstellen, „saufen" müssen diese jedoch selbst. Im Rahmen unserer vor allem auf kleine und mittlere Unternehmen KMU ausgerichteten technologiepolitischen Massnahmen haben wir gelernt, die KMU abzuholen. Ein solches Abholen ist nicht ganz einfach in einem Land, in welchem bei der Wirtschaft - ich erwähnte es bereits - generell eine gesunde Skepsis gegenüber staatlichen Eingriffen besteht, und seien sie auch noch so gut gemeint. Bei uns wird zuweilen heftig darum gerungen, wieviel 'top-down' vorgegeben werden darf und wieviel 'bottom-up' von den Industriebedürfnissen angestossen wachsen muss. Umso wichtiger ist die Evaluierung, um zu erfahren, was schlussendlich wirklich herausgekommen ist. Und ebenso wichtig ist das Kommunizieren der Resultate und die Lehren, die von den technologiepolitischen Akteuren daraus gezogen werden.

- **Kosten**: Die Evaluation technologiepolitischer Programme ist teuer. Eine Untersuchung, die von Ihrem Institut durchgeführt wurde zeigt, dass Evaluationen der Förderung industrieller Innovationen zwischen 200'000 DM und 5 Millionen DM kosten[1]. Aufgrund dieser nicht zu vernachlässigenden Kosten und bei leeren öffentlichen Kassen sind die meisten Evaluationen gezwungen, ihren Anforderungskatalog einzuschränken. Nicht alles, was wünschbar wäre, kann evaluiert werden, manchmal sogar nicht einmal alles, was sinnvoll wäre.

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[1] Kuhlmann, S.; Holland, D.; „Evaluation von Technologiepolitik in Deutschland: Konzepte, Anwendungen, Perspektiven"; Schriftenreihe des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung, Physica-Verlag, Heidelberg: 1995

**Spieler oder Schiedsrichter**

**oder:**

**das nicht immer ganz einfache Verhältnis von Evaluatoren und technologiepolitischen Akteuren**

- Ein mir persönlich 'heiliger' Grundsatz ist die **„Trennung von Spielern und Schiedsrichtern"**. Damit bin ich in mehr als 10 Jahren an vorderster Front der Schweizer Technologiepolitik immer gut gefahren. In der geographisch und bevölkerungsmässig kleinräumigen Schweiz kennt in der „Szene" schnell jeder jeden, egal um welches Gebiet sich handelt. Gerade in der Technologiepolitik und der wirtschaftsnahen Forschung und Entwicklung haben die Sachkenner fast immer auch eigene Interessen. Das Problem der 'zwei Hüte', der sauberen Trennung von öffentlichen und privaten Interessen ist allgegenwärtig und nicht immer eineindeutig lösbar.

- Umso wichtiger wird die **Unabhängigkeit der Evaluatoren**. Diese kann kraft innerer Haltung und Charakterstärke gewährleistet sein, aber auch durch äussere Unabhängigkeit, das 'Nicht -Eingefilzt-Sein' in die oft komplizierten Interessensgeflechte. Für uns ist dies ein ganz wesentlicher Grund, weshalb wir in der Schweiz gern die Dienste des ISI in Anspruch nehmen, nicht nur wegen der unbestritten hohen fachlichen Qualifikation, sondern auch wegen des Standortes in Deutschland. Denn bekanntlich trifft auch auf die Evaluation zu: Der Prophet gilt nichts im eigenen Land !

- Der beste Garant für die Gewährleistung der geforderten Unabhängigkeit ist die **Rolle des Wissenschaftlers**, die ihm eigene intellektuelle Disziplin und Methodik sowie die Verankerung in der internationalen Wissenschaftlergemeinschaft, flankiert von institutsinternen Machanismen der 'checks' und 'balances' durch die leitenden Wissenschaftler und Institutskollegen.

- Politik ist per se die **Auseinandersetzung über Interessen**. Die Evaluatoren werden zwangsläufig damit konfrontiert. Dies beginnt bereits bei der Formulierung des Auftrags, geht über die Datensammlung und gilt ganz besonders für die Auseinandersetzung über die Resultate der Evaluation und den daraus zu

ziehenden Schlussfolgerungen. Dass Wissenschaftler sich bei diesem „Zusammenprall der Kulturen" nicht immer ganz wohl in ihrer Haut fühlen, ist verständlich.

- **Über den Umgang mit Misserfolgen**: Innovationen sind typischerweise risikobehaftete Tätigkeiten. Also werden immer auch Fehler gemacht, Flops erzeugt, Geld 'in den Sand' gesetzt. Dies ist vielleicht die Kehrseite des 'Made in Switzerland' resp. 'Made in Germany', unserer Null-Fehler-Kultur, welche das Versagen in Geschäft und Beruf schnell mit gesellschaftlicher Ächtung bestraft. Es kommt natürlich auf die Fehlertoleranz einer Gesellschaft resp. ihrer politischen Verantwortlichen an, wie sie mit Fehlschlägen umgeht, die immer auch mit Innovationen einhergehen. Die Evaluation kann und muss auch diese zum Vorschein bringen, auch wenn dies die Akteure besonders schmerzt. Allerdings sollten wir uns vor Schuldzuweisungen hüten und aus Fehlern Lehren für die Zukunft ziehen.

- In unserer heutigen **Informations- und Meinungskultur** machen vor allem schlechte Nachrichten Schlagzeilen. Beide Seiten, Auftraggeber und Evaluatoren, müssen darum gewappnet sein, in solche Auseinandersetzungen verwikkelt zu werden. Entspricht es doch der allzu menschlichen Erfahrung, dass zunächst der Überbringer einer schlechten Nachricht geprügelt wird, womit die Evaluatoren in das „Kreuzfeuer" geraten können. Allerdings muss ich gerade zur Ehrenrettung der Medien sagen, dass die Technologiepolitik im allgemeinen wohlwollende Aufmerksamkeit findet, beschäftigt sie sich doch mit der Gestaltung von Zukunft und Fortschritt.

- Es gilt heute als 'State of the art', dass länger dauernde Massnahmen durch eine **begleitende Evaluierung** auf ihre Wirksamkeit hin untersucht werden. Im Verlauf der Massnahmen kommt es zu wiederholten Rückmeldungen an den Auftraggeber und eventuell die Betroffenen. Wir haben zur Halbzeit des CIM-Aktionsprogrammes anlässlich des Zwischenberichtes festgestellt, dass das Feedback des ISI mittelfristig positive Veränderungen und Kurskorrekturen, kurzfristig aber auch heftige Emotionen und politische Manöver auf lokaler und regionaler Ebene ausgelöst hat. Hier geraten die Evaluatoren sehr schnell in

die **Rolle von Spielern**, zumindest wird ihre Unabhängigkeit auf eine spannungsreiche Bewährungsprobe gestellt.

- Auch der Auftraggeber muss sich an die eigene Brust klopfen. Die Politik bekundet zunehmend Mühe mit differenzierten Äusserungen. Wissenschaftliche Aussagen sind immer an Randbedingungen geknüpft, die ihren Gültigkeitsbereich markieren. Politik zeichnet sich dagegen aus durch **Vereinfachungen, Verkürzungen, möglichst holzschnitt- und schlagwortartige Erklärungen**. Vielleicht sind Wissenschaftler nicht immer glücklich darüber, wenn beispielsweise nur eine oder zwei Aussagen aus einem umfangreichen Bericht in den politischen Ring geworfen werden.

- Hierzu gehört, dass auch die Verwaltung gerne die Evaluatoren dazu benutzt, Ansprüche der verschiedenen „Kundengruppen" in der Politik und bei der Wirtschaft unter Verweis auf das Urteil unabhängiger Evaluatoren abzuwehren. Ich habe Verständnis dafür, dass Wissenschaftler über solche **Instrumentalisierungen** nicht gerade froh sind.

- Politik gestaltet das Morgen und beschäftigt sich nur ungern mit dem Gestern. Dem muss auch die Evaluierung Rechnung tragen. Es ist gut und notwendig, die Erfolge und Fehler der Vergangenheit zu kennen. Wichtiger noch ist es, **für die Zukunft zu lernen**. Darum ist die Evaluierung der Politik schlussendlich immer nach vorne gerichtet und die Evaluatoren übernehmen die **Rolle von Beratern**. Die Beratung ist in der Regel willkommen, wenn nicht sogar ausdrücklich erwünscht. Bildet sie doch ein gutes Gegenmittel zur allfälligen 'déformation professionelle' der technologiepolitischen Akteure, indem sie die Aussensicht in das oftmals „eherne Gehäuse der Bürokratie" (Max Weber) einbringt.

- Aus Sicht des Auftraggebers möchte ich zugleich an die Adresse der Wissenschaftler vor einer allfälligen Selbstüberschätzung warnen. Eine **'Verwissenschaftlichung der Politik'** wird es letztlich auch bei einer Vielzahl von Evaluierungen nicht geben. Der Einfluss der Evaluierung auf die Politikgestaltung bleibt eher indirekt. Zu viele Faktoren kommen hier zusammen. Vielleicht ist es zulässig, einen Vergleich mit der Chaosforschung anzustellen. Diese untersucht bekanntlich Phänomene, wo aus einer chaotischen Situation

mehr oder weniger spontan Ordnungen und Strukturen entstehen, die sich dann wieder im Chaos auflösen. Letztendlich kann man sagen **'all depends on people'**, und deren Handeln ist immer noch am schwierigsten vorhersehbar.

- Zum Schluss meiner Ausführungen möchte ich aus meiner persönlichen Sicht das Fazit ziehen, dass ich den Beitrag der wissenschaftlichen Evaluierung ausserordentlich schätze, auch wenn die Resultate nicht immer nur Positives und Schmeichelhaftes zum Vorschein bringen. Speziell hat sich zwischen meinem Amt und dem ISI eine gute Zusammenarbeit entwickelt, auch auf der persönlichen Ebene, insbesondere und gerade in der gegenseitigen Kenntnis und im Respekt vor den jeweiligen Sensibilitäten.

- Sind nun die Evaluatoren Schiedsrichter oder Spieler bei der Evaluation technologiepolitischer Massnahmen ? Auf den ersten Blick scheint die Antwort einfach. Natürlich sind sie primär Schiedsrichter. Aber wir sind uns alle bewusst, dass im Prozess der Evaluation an Sie immer auch verschiedene Spieler-Rollen herangetragen werden, sei es als Berater oder als Überbringer unbequemer Botschaften. Solche Spieler-Rollen können auch ohne Ihr eigenes Zutun an Sie herangetragen werden, etwa wenn versucht wird, Sie als Advokat für die eine oder andere Seite in die Auseinandersetzungen um Interessen hineinzuziehen, aus denen Politik nun einmal besteht.

  Es bleibt Ihrer persönlichen Stärke überlassen, wie Sie solche Situationen lösen. Zentral ist und bleibt die Unabhängigkeit des Urteils, gestützt auf einen erprobten „Werkzeugkasten" an Methoden und die mit jedem Auftrag zunehmende Erfahrung als Referenzmassstab.

**Evaluation zwischen Wissenschaft und 'Kunst'**

- Ein Politikwissenschaftler hat - wohl aufgrund solcher Erfahrungen - die Evaluationsforschung zutreffend im Spannungsfeld zwischen wissenschaftlicher Disziplin und **praxisorientierter Kunst** verortet. Trotz erheblicher methodischer Fortschritte bleibe ihr immer ein Rest an Einzigartigkeit[2].

- Ich wünsche dem ISI, insbesondere den Damen und Herren, die sich mit der Evaluation der Politik beschäftigen, auch in Zukunft Freude und Erfolg in der Perfektionierung dieser Kunst.

- Und eine letzte Bemerkung: Die wissenschaftliche Evaluierung der Politik hält den Politikern und der Verwaltung einen nützlichen Spiegel vor. Ob jedoch eine Politik gut oder schlecht ist, darüber entscheidet in einer Demokratie in letzter Instanz das Volk an der Wahlurne.

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[2] Balthasar, A., Knöpfel, C., „Umweltpolitik und technische Entwicklung", Helbing & Lichtenhahn, Basel und Frankfurt am Main, 1994, S. V

15.05.1997

# Podiumsdiskussion

Sieben Jahre nach der deutschen Einigung: Innovationssystem - wohin?
Aus Anlaß des 25-jährigen Bestehens des ISI Karlsruhe.

**Vier Fragen als Provokation vom Moderator**

1. Das Innovationssystem nach der Einheit - haben wir eines, hatten wir vorher eines, brauchen wir in Zukunft ein „System"?

2. Die Probleme Deutschlands sind die Folge eines globalen Wertewandels: Unsere überkommenen Werte (z.B. Solidität, Beharrlichkeit, Berechenbarkeit) sind kein Fundament mehr - können wir umschalten?

3. Innovation findet in den Köpfen statt - ein leerer Bauch setzt Energien frei, ist das effizienter als alle Strukturen?

4. Wir leben im Dilemma zwischen nur langfristig lösbaren Defiziten (z.B. Bildungssystem, Industriestruktur) und kurzfristigen Entscheidungshorizonten (z.B. Wahlperioden, Shareholder value) - Gesellschaftssystem wohin?

**Introduction (second day)**
*Frieder Meyer-Krahmer*

Ladies and Gentlemen, dear Colleagues and Friends,

Welcome to our 25th anniversary celebration and our International Symposium on Technology, Economy and Policy. First let me give some brief sketches and highlights of the development of ISI from 1972 - 1997. You will find an extensive description of the development of the research program, the context of foundation and development of the institute in the Jubilee Report. One reason for the foundation of ISI in 1972 dealt with the idea of establishing a think tank or advisory research group in the field of technology policy for the use of the Federal Ministry of Research and Technology. In the meantime the situation changed steadily, today our clients are broadly distributed. Most clients are public authorities on the regional, national and European levels as well as industry. Presently the degree of diversity is high which is also a means of our independence.

Research activities in the beginning were mainly focused on technology transfer, small and medium-sized enterprises, systems research in energy and environment and technology assessment. Compared to the beginning of the seventies the focus of ISI's research within recent years was oriented more on innovation than on R & D, more on the soft assets of firms, sectors, countries and national innovation systems than on hard technologies, more on globalisation, international competitiveness, European and regional issues than on national developments and more on prospective studies than on an analysis of the past. ISI has placed great emphasis on an international orientation right from the beginning. An important step in this strategy was the establishment of the Six Countries Programme. Helmar Krupp, many colleagues and I myself pushed internationalisation very much so that today we have a great number of co-operation partners and a very differentiated European and worldwide network (see fig. 1)


Fig. 1: European Cooperation Partners of ISI

An important institutional environment is the Fraunhofer Society which ISI belongs to. In the beginning ISI was confronted with much scepticism from this engineering and natural science environment. ISI still may be a bird of paradise within the FhG although it is now a well accepted one. For us the integration within the FhG has significant advantages: an easy access to the technology of our 47 specialized institutes as well as the general reputation of the Fraunhofer Society.

The beginning of the seventies was a period of enthusiasm for political reforms in Germany. It was popular to use the term "technical progress" - as economists usually do instead of "technical change". Governments were perceived as major players to influence, redirect and control technical change. The book "Limits to Growth" became world famous but there was no book on limits of government influence (outside liberal economic concepts). A strong belief existed in the visibility of new concepts promoting technical change and innovation through government programmes. At present a loss of illusions can be observed regarding government influence on innovation. Today we believe more in the learning capacity of a society as a whole and in

the government as one player among others than in the technocratic vision of government control. Semi-public or private authorities, organizations and firms became increasingly important partners of collaboration for us in this respect.

Our present situation is ambivalent. Without being cynical the present challenges are favourable for an institute such as ISI: priority-setting because of financial scarcities, problems-solving through interdisciplinarity, systemic thinking, identification of future developments paths as well as innovation barriers. We are faced with a lively demand for our research. On the other hand we are also confronted with severe problems. In particular the tendency to short-term projects and decreasing opportunities for long-term applied research (new methods or concepts) pushes us in the wrong direction. This is a general and dangerous trend, also elsewhere as far as I know, e. g. from our colleagues of SPRU where I am a member of the scientific advisory board. My personal vision as counter strategy is to establish very close relations with small university groups. A network between small discipline driven university groups and a larger center of interdisciplinary applied research like ourselves offers a better balance between long-term application-oriented research and (often short-term) applied research.

The main aim of these one-and-a-half-days is the discussion of major research issues and the future agenda of research in these areas. We asked clients, observers, but primarily our research colleagues and members of our staff to present their views. Most of these colleagues belong to organisations we collaborate with. Through this selection we want to emphazise two different aspects: first, we want to stress the importance of the inclusion of global aspects and international conditions and consequences into careful investigation. The second aspect is to make visible how strongly the international network of ISI has been developed within the last decades, which is reflected in the list of our speakers. E. g., a long-standing collaboration exists between the Science Policy Research Unit (SPRU) and ISI. Both institutes belong to the network of European innovation research institutes together with MERIT, IKE, BETA, PREST and many others such as the University of Leyden from which Antony van Raan is present. A close cooperation exists for more than ten years with Fumio Kodama and other Japanes organisations, especially NISTEP in the field of Delphi foresight. Finally, we cooperate with MIT in the field of international R & D strategies of multinational enterprises and the consequences for national systems of innovation.

The list of issues is broad and selective. It is selective because the issues have to be relevant: energy and natural resources, systemic innovations, production, unemployment, long-term perspectives and new roles of technology policy. It is broad because we are interested particularly in getting different views on a possible future agenda of research in these areas.

# 21-Century Energy Strategies Based on Environment-Driven Innovation

Robert H. Williams
Princeton University
Princeton, New Jersey 08544

Presented at the

*25th Anniversary Conference of the*
*Fraunhofer Institute for Systems and Innovation Research*

Karlsruhe City Festival Hall
Karlsruhe, Germany
3-4 June 1997

undp

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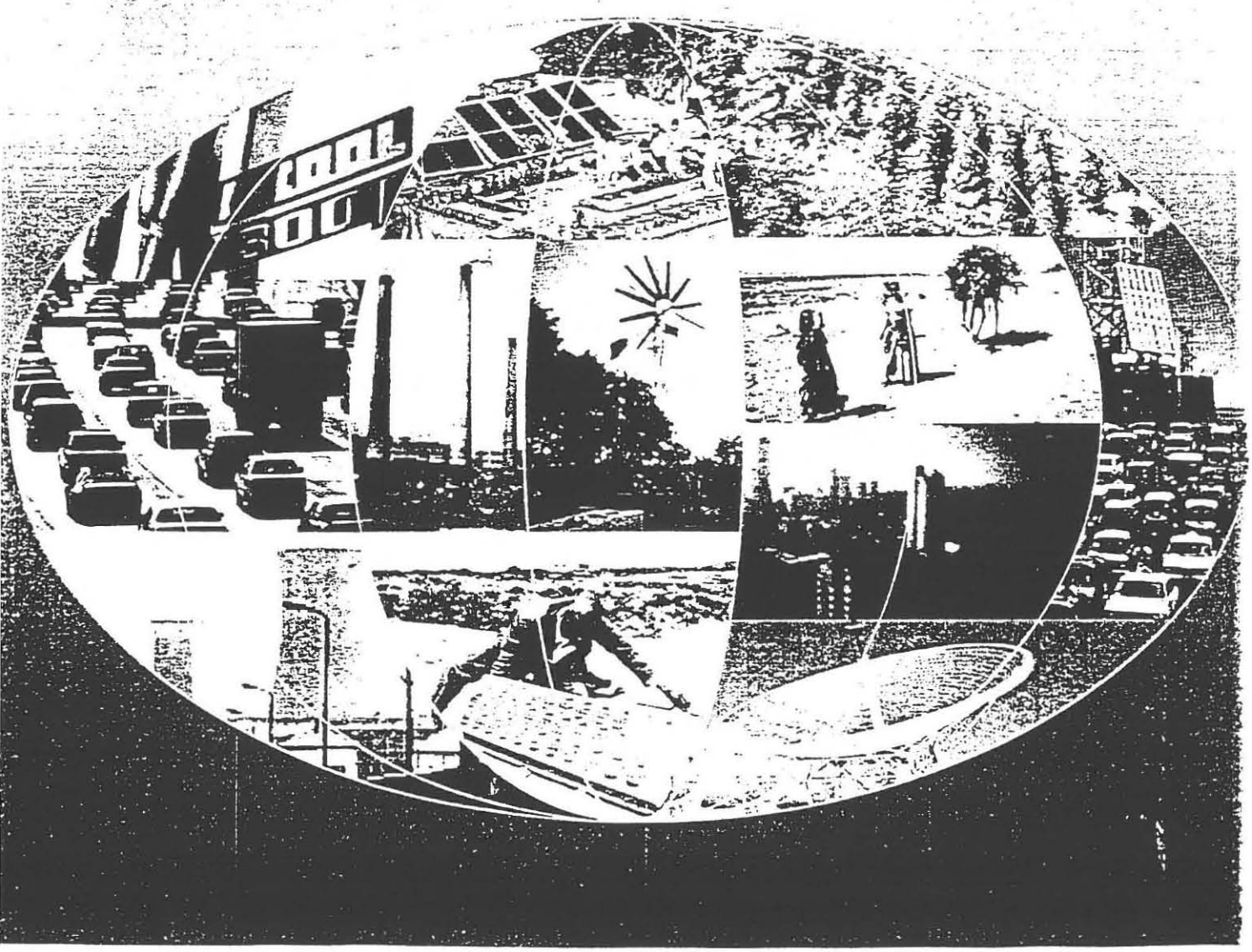
# ENERGY AFTER RIO

## PROSPECTS AND CHALLENGES



# *ENERGY AFTER RIO: PROSPECTS & CHALLENGES*

Amulya K. N. Reddy, Robert H. Williams, Thomas B. Johansson

1997

This report was prepared by the UNDP (*through its Energy & Atmosphere Programme)*, as an input to the 1997 UN Review of Rio (*which is examining international progress in sustainable development since the 1992 UN Conference on Environment and Development*).

The report examined linkages between energy and other major global issues:

Social Issues (*poverty, gender disparity, population, undernutrition & food)*
Environment (*health, acidification, climate change, land degradation)*
Economy (*investment challenges, foreign exchange impacts of energy imports)*
Security (*energy trade & national security, nuclear energy & nuclear proliferation*)

and concluded that continuation of the present course is unsustainable because of aggravation of serious problems in these areas.



The report also explored a wide range of technological options in an attempt to identify and articulate energy strategies that prospectively could ameliorate problems in many of these areas *simultaneously* at energy service costs comparable to costs for conventional energy—thus offering good prospects for being consistent with sustainable development goals.

The report concluded that there are good prospects for so doing, but that

**THIS COULD NOT BE ACHIEVED WITHOUT A HIGH RATE OF TECHNOLOGICAL INNOVATION IN THE GLOBAL ENERGY SYSTEM!**

# MAJOR TECHNOLOGY CLUSTERS CHARACTERIZING 21st CENTURY ENERGY STRATEGIES FOR SUSTAINABLE DEVELOPMENT

- **Increased Efficiency of Energy Use.** Some examples:

  —Whole building energy strategies (*integrating shell improvements, energy consuming equipment, energy-producing equipment*)
  —Advanced industrial process technologies (*e.g., iron & steel*) will be especially important for developing countries
  —Fuel cells offer quantum leap in efficiency in transport applications

- **Renewable Energy**

  —Intermittent renewables for electricity (*wind, photovoltaic, solar thermal*)
  —Biomass for electric power and fluid fuels (*hydrogen, methanol, ethanol*)
  —solar gasification/reforming of carbonaceous feedstocks to produce hydrogen

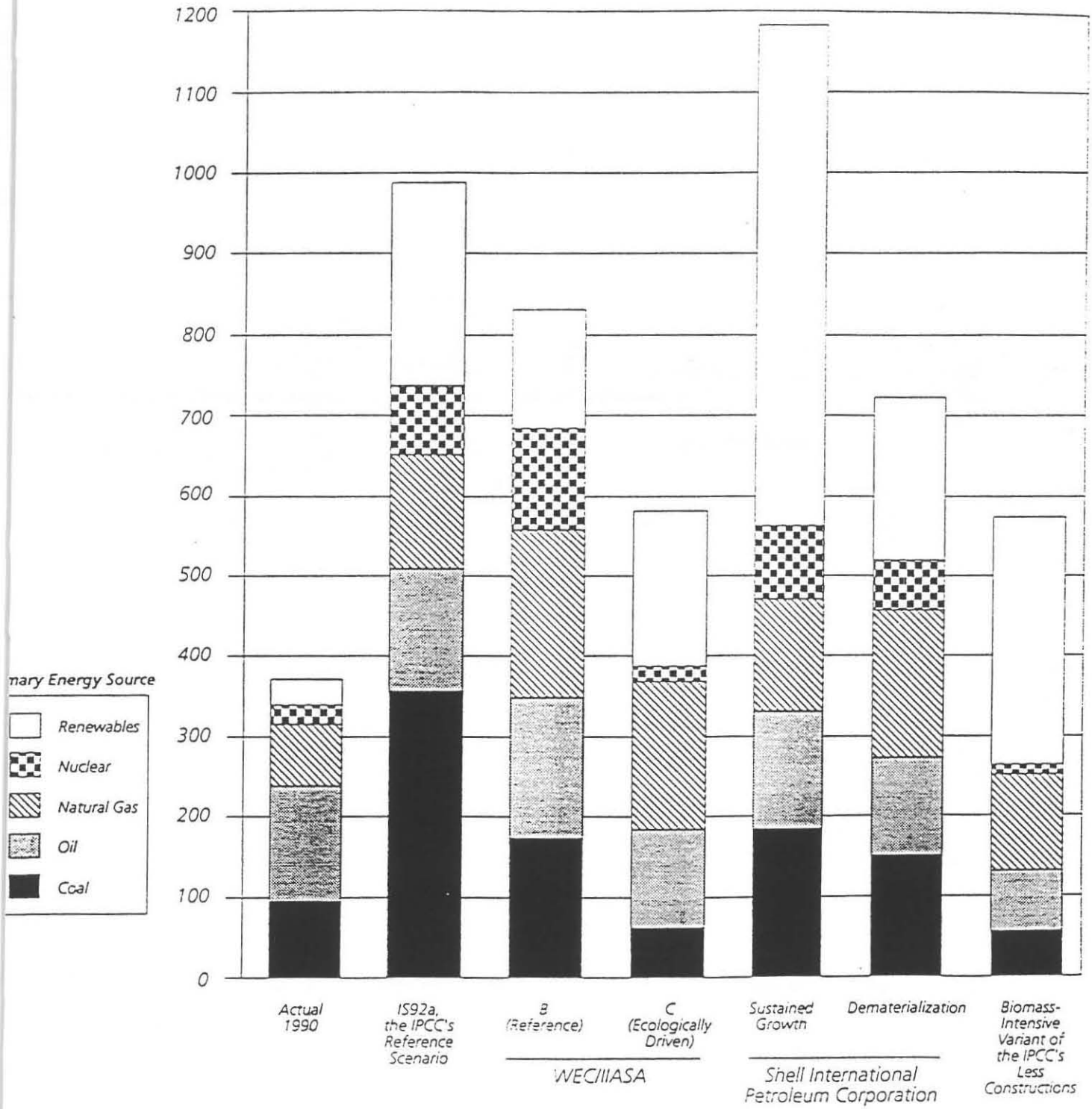
- **Fuels Decarbonizaton and $CO_2$ Sequestration**

  —Production of $H_2$ or H-rich fuels from carbonaceous feedstocks
  —Storing the separated $CO_2$ (*e.g., in depleted gas and oil fields, saline aquifers*)

**KEY ASPECT: TECHNOLOGIES WITH HIGH LEVELS OF "INHERENT CLEANLINESS" ARE EMPHASIZED**

## ALTERNATIVE SCENARIOS FOR GLOBAL COMMERCIAL ENERGY USE IN 2050

(EJ per year)



# PROSPECTIVE MARKET DYNAMIC FOR FOSSIL ENERGY/RENEWABLE ENERGY COMPETITION

**—While Remaining Fossil Fuels Will Still Be Abundant in 2nd Quarter of Next Century, Shift to Smaller and Smaller Oil and Gas Fields Will Make It Difficult to Continue Increasing Global Productive Capacity.**

**—Shift to More Marginal Fossil Fuel Resources Will Also Pose Greater Environmental Challenges.**

**—Rate of Cost-Cutting for RETs May Begin to Outpace Rate of Improvement of Fossil Fuel Technologies, Which Are Relatively Mature.**

- **Modular Characteristic of Most RETS Makes Them Good Candidates for Cost-Cutting via Organizational Learning (*"learning-by-doing"*).**
- **Many Generations of Marginal Improvements in Technology Possible in Short Periods.**
- **Inherent Cleanliness Makes It Possible to Avoid Large Investments in Cleanup Technology.**

# INNOVATION, THE ECONOMY, & PUBLIC SECTOR SUPPORT FOR R&D

## Economic Importance of R&D:

*Innovation is the single most important source of long-term economic growth.*

*Total economic return on investment in R&D is much higher than for other investments.*

*Societies with high wage rates can sustain high rates of economic growth only if they are continuously on the technological frontier.*

## Rational for Public Sector Support of R&D:

*Private firms underinvest in R&D because they cannot appropriate the full benefits of these investments.* (Imitators are free-riders.)

*Some innovations needed to reduce costs not reflected in market prices.* (Reducing negative externalities is a public good.)

# ENERGY & THE ENVIRONMENT

## Environmental Concerns are Becoming Major Determinants of the Energy System

*Environmental protection strategies that rely on tightening end-of-pipe controls are becoming ever more complicated and costly*

*Coping with the long-term consequences of the atmospheric buildup of GHGs may require deep reductions in GHG emissions from the energy system*

## Population and Economic Growth in the Developing World are Expected to Lead to Large Increases in Energy Requirements and Especially Severe Environmental Challenges

## Responding to Increasingly-Severe Environmental Challenges without Jeopardizing Long-Term Economic Goals will Require Radical Changes in the Energy System

# DEFENSE → ENVIRONMENT AS DRIVER FOR TECHNOLOGICAL INNOVATION?

**In the 1950s, 1960s, Military R&D, Defense Procurement were Important Sources of Civilian Technologies:**

*Semiconductors, computers, jet engines, air frames, etc.*

**But the Cold War is Over...And the Flow of Technology from Military R&D, Defense Procurement to the Civilian Economy Has Been Much Slower in Recent Times**
(*the slowdown began well before the ending of the Cold War*)

*Increasingly, the flow has been from the civilian to the military sector.*

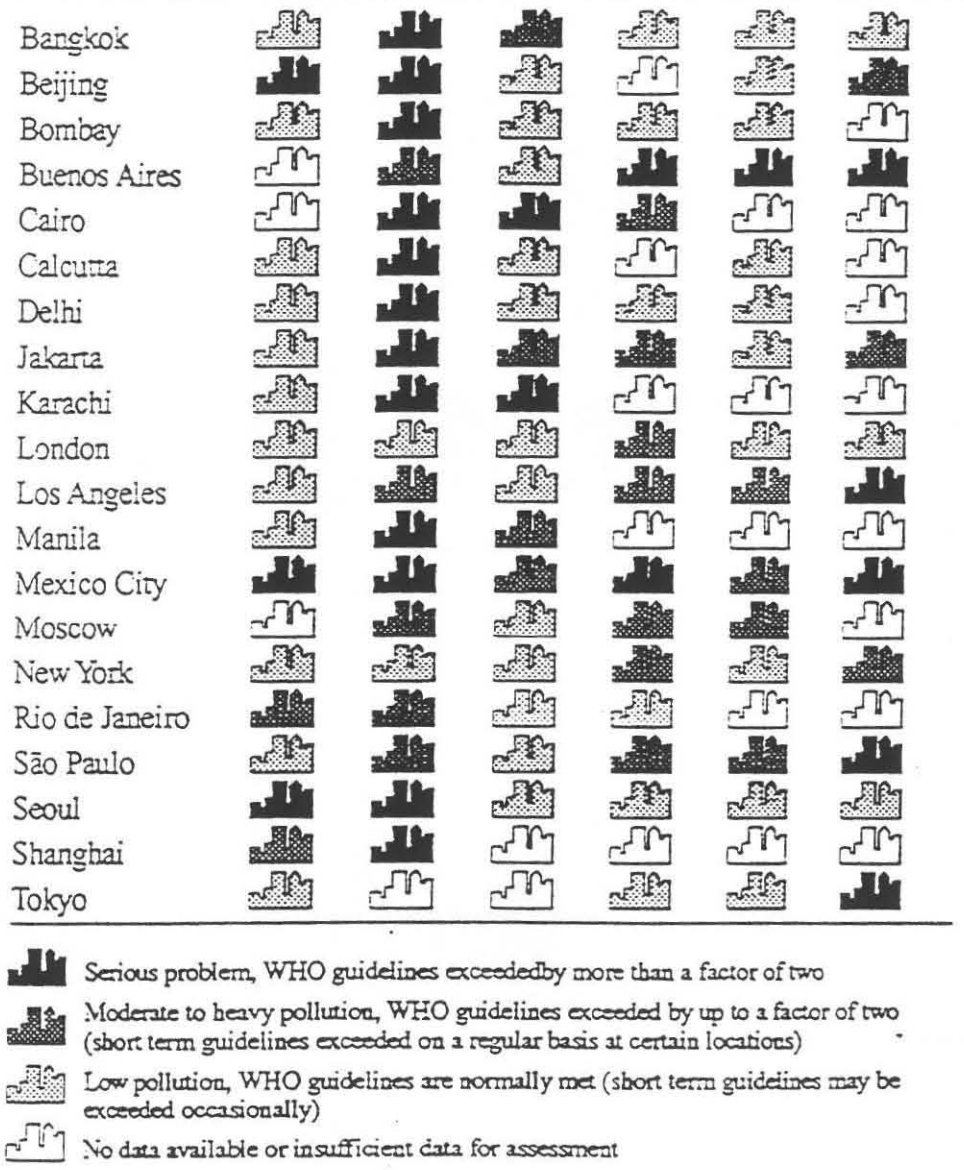
**Will There Be New Drivers for Innovation?**

**Will Environment Be an Important Driver?**

*If the Pursuit of Advanced, "Inherently Clean" Technologies*
*Is Not Chosen as the Preferred Strategy*
*for Meeting Growing Environmental Concerns,*
*We Can Expect Ever More Intrusive Environmental Regulations*

**Chip Bok**
Akron Beacon Journal
Creators Syndicate

# OVERVIEW OF AIR QUALITY IN 20 MEGACITIES[a]

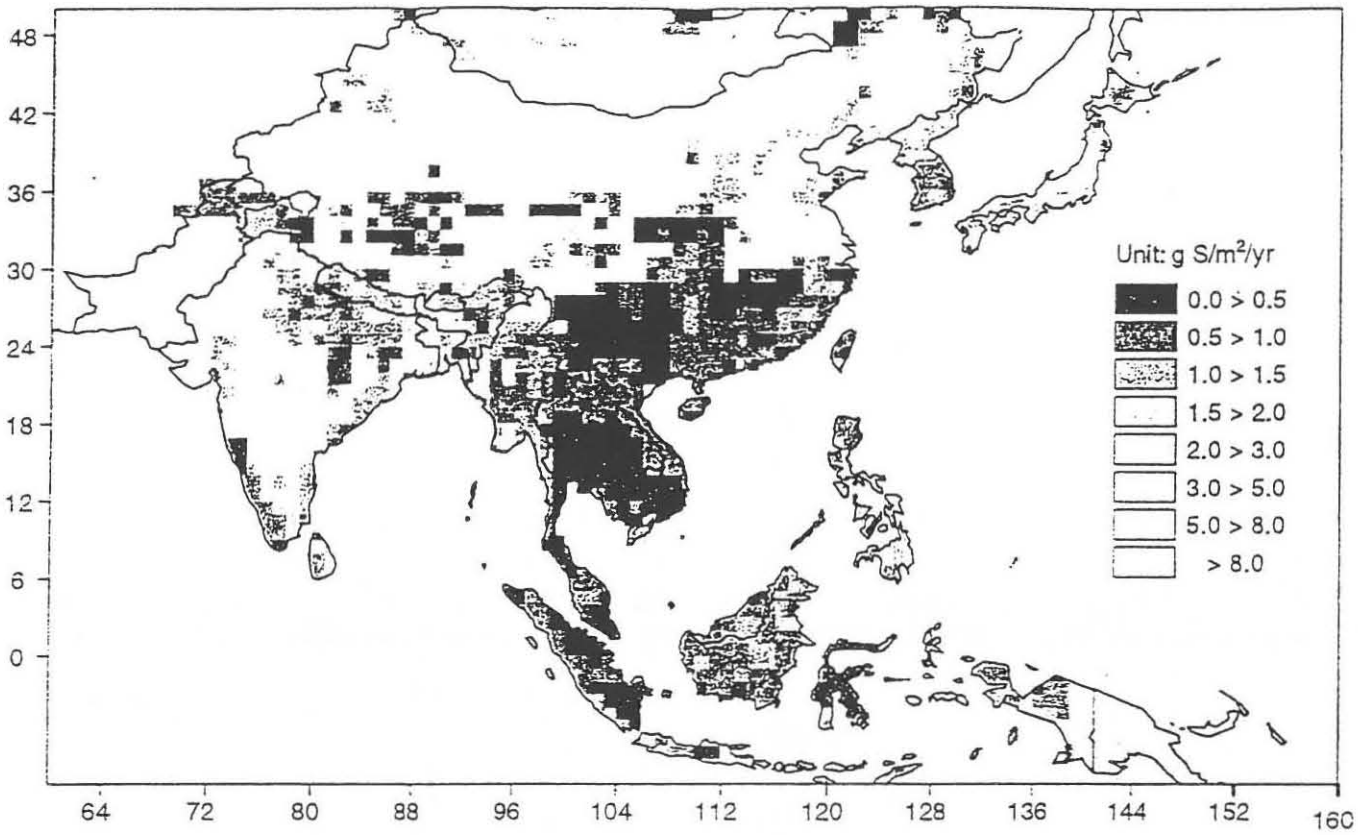


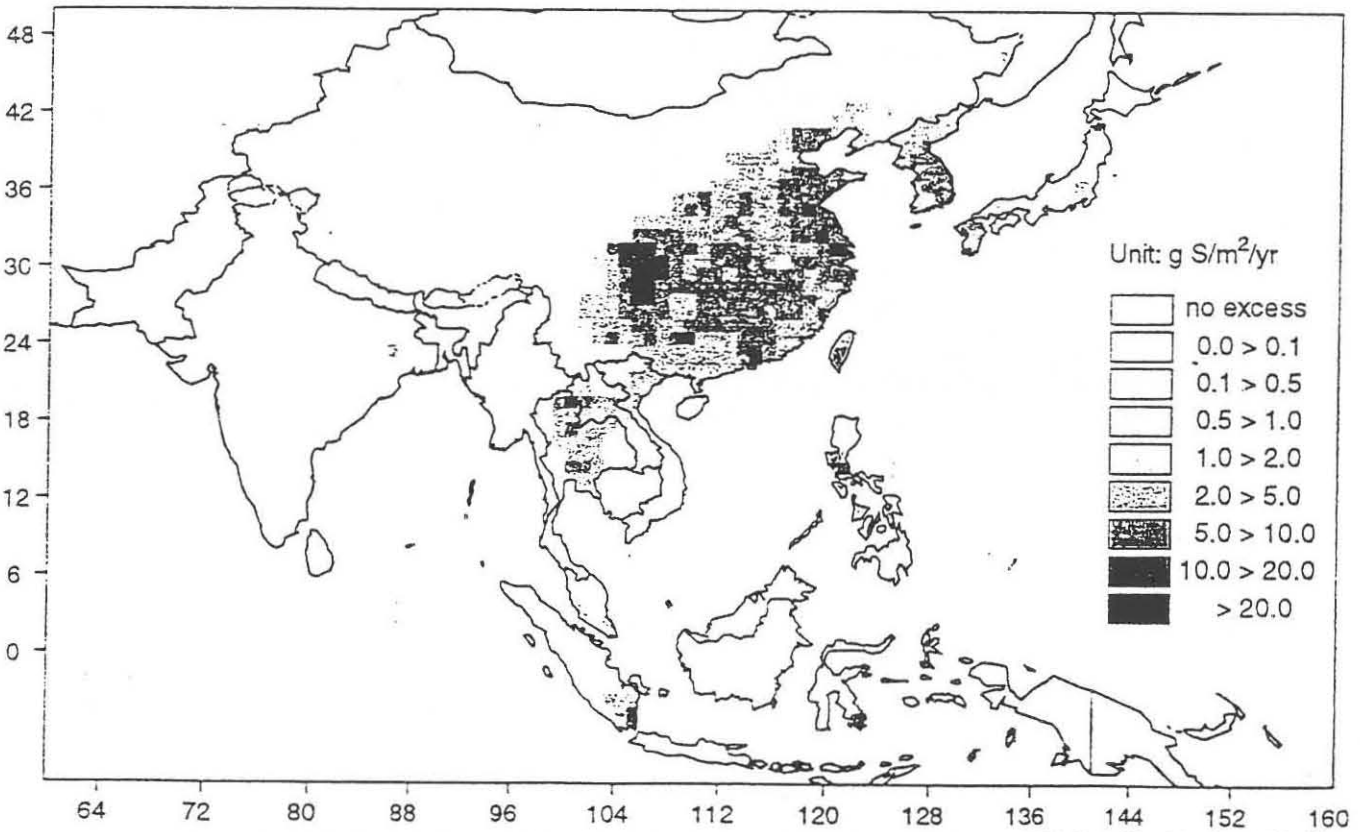

[a] Based on a subjective assessment of monitoring data and emissions inventory.

Source: *Urban Air Pollution in Megacities of the World.* Blanckwell Publishers, Oxford, 1992.

# ESTIMATED CRITICAL LOADS FOR ACID DEPOSITION IN SOUTH & EAST ASIA

*(in grams S per $m^2$ per year)*




# EXCESS SULFUR DEPOSITION ABOVE CRITICAL LOADS, FOR LDC COAL USE UP 3X, 1990-2020

*(No $SO_x$ Controls)*

# PROSPECTIVE GROWTH IN THE ENERGY MARKET POWER OF THE RAPIDLY INDUSTRIALIZING COUNTRIES

**—Most Growth in Energy Demand Will Be Accounted For by Developing Countries.**

**Most Developing Country Energy Demand Growth Will Be Accounted for by the Large, Rapidly-Industrializing Countries** (*e.g. China, India, Indonesia, Brazil, Mexico*).

**—Most Rapidly Industrializing Countries Have Aspirations to Become Major Economic Powers.**

**—To Do So, These Countries Will Have to Undergo Major Structural Reforms** (*including restructuring of the electrical and other energy sectors*) **to Be Able to Hold Strong Competitive Positions in the Increasingly Integrated Global Economy.**

**—Once These Structural Reforms Have Been Carried Out in the Energy Sectors** (*these reforms are already underway*) **Developing Country Energy Markets Will Become "Buyers' Markets," and Developing Countries Will Be Able to Demand and Get from Foreign Vendors the Kinds of Energy Technologies They Believe They Need.**

**—As Long As Wage-Rate Differentials Persist between Industrialized and Rapidly-Industrializing Countries, Industrialized Countries Will Have Only New Products to Offer Competitively, so that They Will Have to Stay on "Innovation Treadmills" to Maintain Market Positions.**

# PROSPECTIVE DEMAND FOR "ENVIRONMENTAL ENERGY TECHNOLOGIES" IN RAPIDLY INDUSTRIALIZING COUNTRIES

**Once Energy Markets in Developing Countries Have Been Transformed into Buyers' Markets, These Countries Will Give Priority to *"Environmental Energy Technologies,"* i.e., Energy Technologies Characterized by a High Degree of Inherent Cleanliness and Safety, Because:**

- **Environmental Problems Are Rapidly Becoming Severe, Especially in Densely Populated Urban Areas, and This is Reflected by Growing Public Concerns.**

- **Regulations Mandating End-Of-Pipe Controls on Energy Technologies Designed Orginally without Environmental Concerns in Mind Are Likely to Be Only Partially Effective at Best in Meeting Environmental Goals, Even If Regulatory Agencies Succeed in Becoming Powerful Government Bodies.**

- **In Most Developing Countries It Will Take Decades to Evolve Environmental Regulatory Agencies into Powerful Government Bodies.**

- **Thus in the Prospective Buyers' Energy Markets of the Developing World One Can Expect Strong Demand for Renewable Energy and Other Environmental Energy Technologies.**

## Proposed Measures for Accelerating the Pace of Innovation in the Energy Sector and Directing Innovation to Sustainable Development Objectives

1. *Expanded public- and private-sector R&D in industrialized countries on energy technologies that meet sustainability objectives.*

2. *Promotion of capacity-building for energy technology assessment in developing countries*—to better inform the energy-planning process about opportunities for meeting sustainable development objectives with alternative energy technologies.

3. *Cooperative energy R&D between industrialized and developing countries*—to improve the prospects that energy technology developed in industrialized countries for developing country markets will be well-matched to developing country needs, and facilitate the process of technology transfer.

4. *Programs for accelerated commercialization that "buy-down" the prices of commercially ready advanced energy technologies that are compatible with sustainability objectives*—in those countries that are good prospective theaters for innovation in the energy sector (e.g., where there are good prospects for achieving rapid cost convergence with conventional energy technologies).

# RESEARCH DEVELOPMENT

ON THE INSTRUCTIONS OF

Shell Research

**Shell Research Limited, Sittingbourne, Kent, England**

A rare opportunity to acquire a high calibre Research and Development Centre (60,383 m² on 21.7 hectares) together with an extensive range of adjacent land and assets.

The property is located 2.4 km from Sittingbourne in northern Kent within the south-east region of the UK. The site is close to a high quality motorway network (M2/M20), giving access to London, international airports, the Channel Tunnel, and many of the commercial centres of the UK.

The principal uses arising from the current configuration of the Research and Development Centre are laboratories (27% - 16,298 m²), offices (14% - 8,688 m²) and utility and storage facilities (33% - 19,655 m²).

Other assets include Woodstock Farm (173. ectares), the Woodstock Leisure Club (1,057 m²) set in approximately 6.97 hectares nd Cromer's Wood (26.4 hectares of conservation land let to the Kent Trust for Nature Conservation).

The preferred method of disposal is the sale of Shell's freehold interests in the site. Full vacant possession of the Research Centre is scheduled for first quarter of 1996, although the centre is currently available in part.

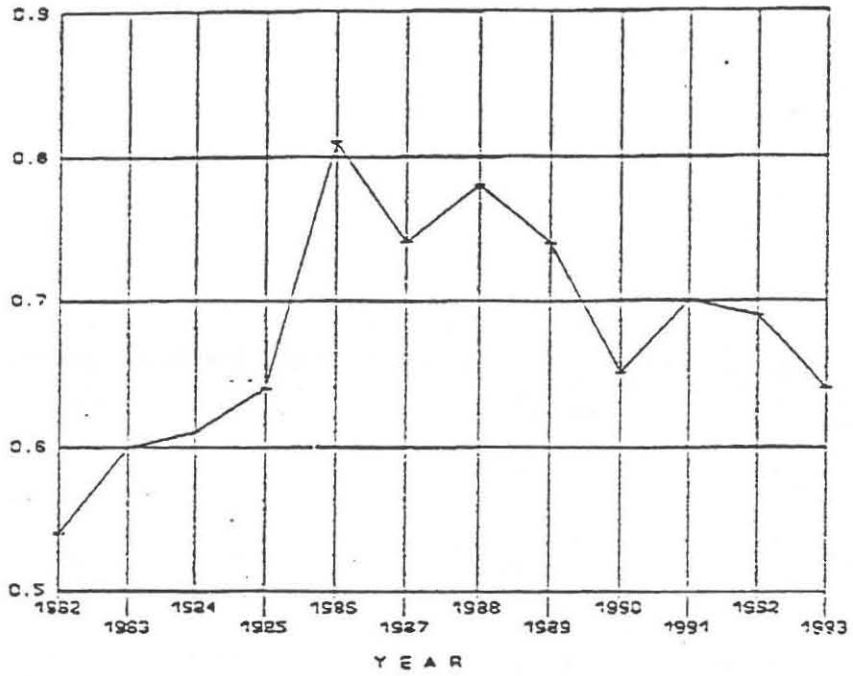
*For further information please contact Graham Hayman*

Knight Frank & Rutley
INTERNATIONAL
0171 629 8171

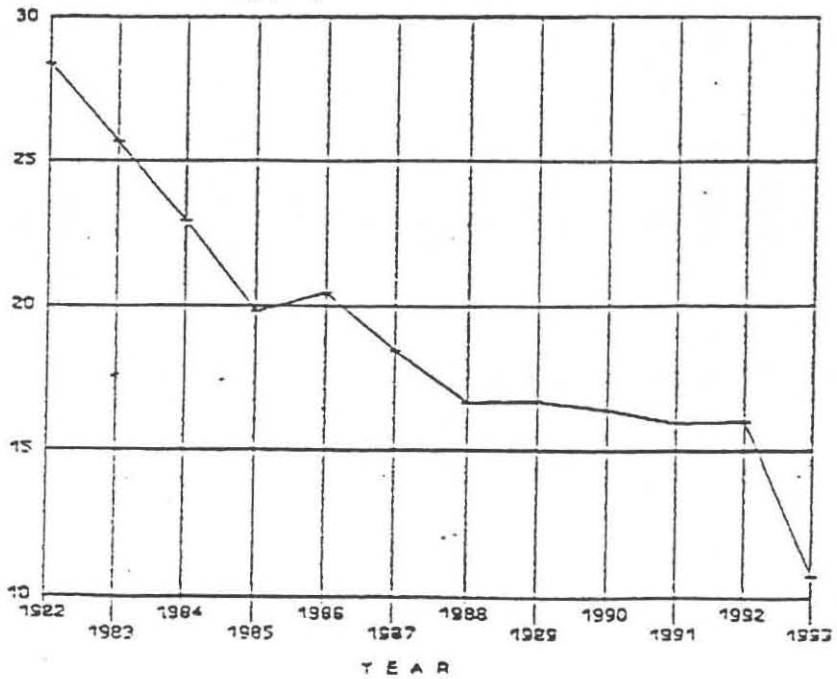
Ad in *The Economist*, March 1995

# TRENDS IN SPENDING ON R&D BY THE MAJOR INTERNATIONAL OIL COMPANIES

*R&D as a Percent of Sales:*




*Long-Range R&D as a Percent of Total R&D:*



# COSTS FOR LAUNCHING NEW ENERGY INDUSTRIES THAT WOULD BE SUPPORTIVE OF SUSTAINABLE DEVELOPMENT GOALS

1. **Successful Roles for Renewable Energy, Fuel Cells, and Related Technologies, As Visualized in the Shell, WEC Ecologically-Driven, & IPCC LESS Scenarios, Require that these Energy Industries Be "Kickstarted," via Public Sector Support for R&D and Commercialization Incentives.**

2. **The World Energy Council has Estimated that the World-Wide Costs** *(for the public plus the private sectors)* **for Launching, Over the Next 1-2 Decades, a Range of Solar Energy Industries is:**

   - **~ 8 Billion US$ for R&D.**
   - **~ 7—12 Billion US$ for Initial Incentives to Support Initial Deployment Until Manufacturing Economies of Scale Are Realized.**

3. **A US Industrial Study (Penner, 1995) Estimated that the Total Investment Required to Commercialize in the US Over a 5-10 Year Period 4 Different Fuel Cell Technologies for Stationary Applications is ~ 2 Billion US$.**

4. **For Comparison, the Investment Rate for the Energy Supply Industry is ~ 400 Billion US$/year at the Global Level.**

# PROMISING MARKET INSTRUMENTS FOR ACHIEVING COST-CONVERGENCE BETWEEN RENEWABLE & FOSSIL ENERGIES IN A RESTRUCTURED, COMPETITIVE ELECTRIC INDUSTRY

1. **Renewables Non-Fossil Fuel Obligation** (*UK*)

2. **Renewable Portfolio Standard** (*US*)

3. **Renewable Energy Resource Development Concession** (*Proposed*)

Fraunhofer Institute
Systems and
Innovation Research

# Shrinking Natural Resources and Environments Under Stress - Pressures for Systematic Innovations

E. Jochem, Fraunhofer-Institute for Systems and Innovation Research (ISI),
D-76139 Karlsruhe, Breslauerstr. 48

When considering recent literature and the results of conferences on natural resources and the environment, the concerned politician, entrepreneur or scientist is confronted with a broad spectrum of opinions. These may not differ very much from the spectrum of 25 years ago when "limits to growth" was translated into several languages and heavily debated in many countries.

## 1. Contradictory developments

A large part of the broad spectrum of opinions is probably due to a different focus on regional or global developments of natural resources and to different perceptions and underlying assumptions of the natural sciences and economics.

- The case of **environmental pollution in OECD-Countries:** 25 years ago, severe air pollution in regions with heavy industries, polluted rivers - e.g. the Rhine - and biologically dying lakes such as Lake Constance or Lake Eric were of major concern. Swedish lakes became acidic because of the long-distance transport of $SO_2$ emissions from West European power plants.

  Today, air and water pollution in OECD countries has been reduced by 60 % and more (with the exception of $NO_x$ from road transportation) due to the desulphurisation of fuels and treatment of exhaust fumes, improved burners, water treatment, substitution of coal and heating oil by natural gas and nuclear energy, substitution of phosphates in washing powder, and improved or changed industrial processes with far less specific energy or water demand and lower or no emissions.

  The results are impressive: compared to the few hours it took thirty years ago, the collars of white shirts in the Ruhr area of Germany do not get dirty in two days; a few years ago, salmon came back again to the river Rhine where they had not been seen for several decades, and the eutrophication of many lakes has

drastically diminished. So it would seem that market economies can properly manage environmental risks.

- But on a **global scale**, the analysis is not so bright, indeed rather gloomy: over the last 25 years
  - the area of forests was reduced by 17 million hectares per year, which corresponds to the total area of Austria;
  - the losses of fertile topsoil by erosion amounted to 24 billion t per year, which corresponds to the entire arable area used for wheat in Australia;
  - North African States take most of the water required from fossil water reserves for wasteful irrigation of their fields and daily showers for the European tourists while polluting their rivers with the result that this small renewable water resource cannot be used at all. Most North African fossil water reserves will be depleted within the next 25 years.
  - Air pollution has dramatically increased in hundreds of cities in the developing countries and is now having an impact on human health in several ways (respiratory diseases, allergies).

If present trends continue, arable land will be reduced from 0.13 to 0.11 hectare per capita within the next ten years. Pasture and forest area will be reduced on a per capita basis by 20 % from 0.61 to 0.5 and from 0.79 to 0.64 hectare per capita respectively (Worldwatch Institute, 1991). So it becomes quite obvious that the **regional environmental stresses**, which the OECD countries (with a population of 0.9 billion) seem to be able to manage today, will be **one order of magnitude larger in the former Comecon States, Asia and Latin America**. As a first conclusion, the transfer of know how and low emission or resource-efficient technology will be of major importance to avoid unacceptable environmental stresses on regions in former Comecon countries and in developing countries.

## 2. Shrinking global non-renewable resources

Of course, it would be naive not to realize the interdependence of the industrialized and developing countries, the common use of metal ores, fossil fuels, phosphate resources, of the oceans and forests as well as the thin layer of the atmosphere as a cheap sink for greenhouse gases and CFC emissions:

- concerning the extensive use of forests and arable land or pasture in developing countries, the industrialized countries are using a substantial part of these lands by importing timber and pulp for house construction and paper, by importing beef, cereals for feeding cattle, fruits and flowers, coffee, tea, cotton etc. Substantial shares of this area will be needed for food production to meet the domestic demand in the future given an annual population growth of 80 million

in these countries, i.e. an increase equivalent to the German population each year.

- With regard to the extensive use of fossil fuels by the industrialized countries, for road and air transportation in particular, the domestic production of fossil fuels is diminishing in most OECD-countries. Future world production will be concentrated on a few regions in the world with potentially low political stability in many cases (e.g. Near East, North Africa, Russia and CIS for oil and natural gas) and, hence, the uncertain security of supply of oil and natural gas will become a major issue in the next decades.
- A similar dependence can be envisaged for specific metal ores (e.g. tin, copper, gold) and phosphate reserves.
- But the most alarming aspect is the common use of the **atmosphere** as a **sink for greenhouse gas emissions and CFCs**. Since 1870, the balance of the natural greenhouse effect has, to an increasing degree, been disrupted by an increasing growth in the emissions of man-made greenhouse gases, resulting from increased fossil energy use, deforestation, rice and cattle production as well as from CFCs. The atmospheric concentration of $CO_2$ and methane is 30 % higher today than it was 100 years ago. The average temperature achieved by the year 2100 may be about 2 to 4.5°C higher than the pre-industrial level. This increase has never occurred in such a short period of time; it induces a shift in climatic zones of about 600 to 900 km to the poles and huge dislocations for flora and fauna.
  One of the important differences of the greenhouse gases as opposed to traditional air pollutants is their **long lifetime in the atmosphere,** between some 15 and 120 years (for comparison $SO_2$ and dust last only a few days). This means that even if global greenhouse gas emissions could be reduced in the next decades (which is very unlikely due to the industrialization and motorization in developing countries), the greenhouse concentrations would still continue to rise and cause the impacts of climate change such as the increased probability of severe storms, intensified rain falls, rising sea levels and a shift in climatic zones with negative overall effects on agriculture and forestry in a few decades (IPCC, 1996).

Shrinking non-renewable resources have been anticipated since Maltus in the last century; but so far technological progress and the extensive exploitation of public goods have prevented price increases of raw materials and non-renewable energies due to growing scarcity:

- **technological progress in the exploration and production** of raw materials and fossil fuels has compensated for the exhausted reserves of highly concentrated metal ores (such as copper) or of easily producible fossil fuels. Therefore, the prices of many basic materials and oil products remained constant in real terms over many decades during this century, e.g. oil (see Figure 1).

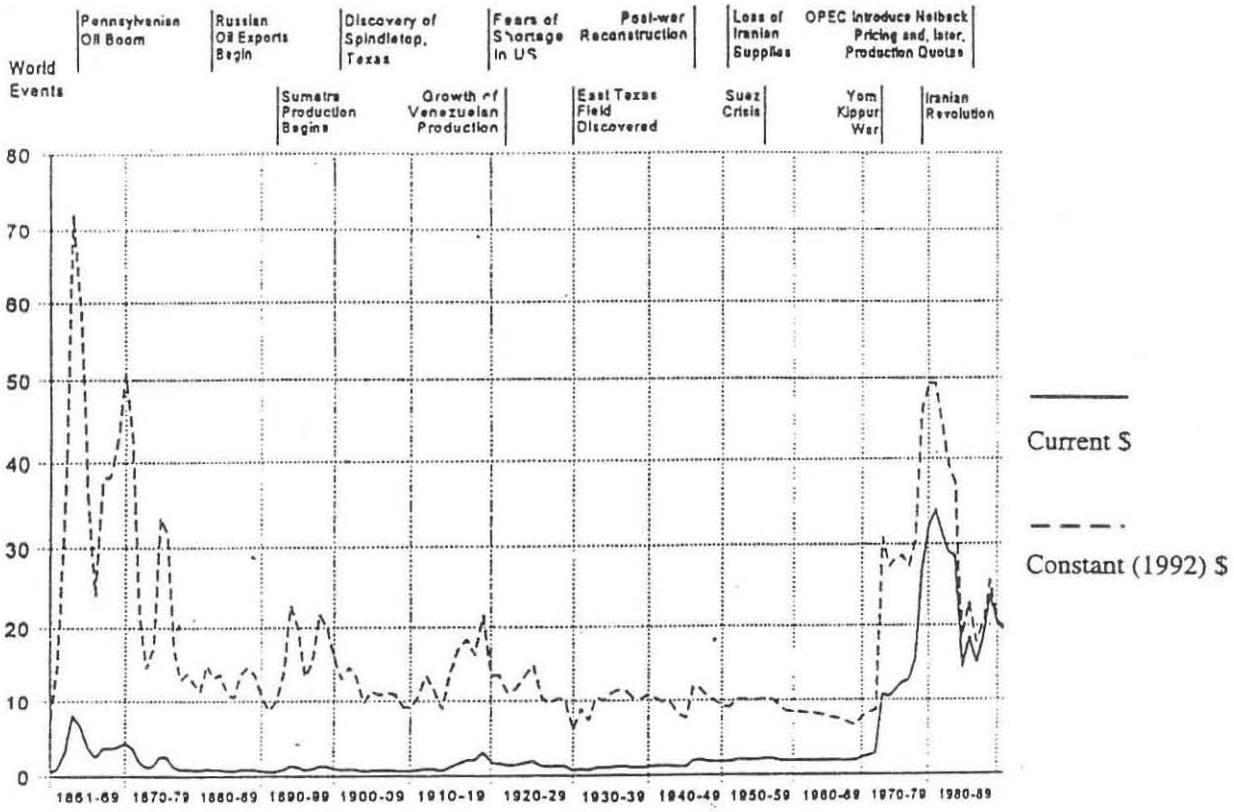



Figure 1: Development of the World Market Price of Crude Oil in the 20th Century (source: BP Statistical Review of World Energy, 1993)

- **Improved efficiency in material and energy** use, **substitution** of scarce materials by more abundant (new) materials, as well as **increased recycling** of waste heat, metals (e.g. steel, aluminium, copper, lead), glass, paper and, most recently, plastics contributed to lower materials and energy intensities of industrialized countries (see Figure 2). These technological and other structural changes (see below) resulted in a stagnating or even decreasing use of primary materials or primary energy in the highly industrialized countries (see Figure 3), at least on a per capita basis.
- Last, but not least, the **costless use of the "Commons atmosphere"** or the **oceans** led to the experience in industrialized countries that - taking the result of a US poll of 1994 - "the environment and the non-renewable resources are of minor importance compared to crime, health care, economy recession, high taxes, unemployment, education, and efficient government" (Bowman 1996).

But in addition, there have been **structural changes towards less material- and energy-intensive economic activities** in OECD-countries. At high levels of affluence, economic activity tends to shift towards less material- and energy-intensive production as a result of several influences: a shift in consumer preferences to more valuable, less material-intensive products, the shift in production to better performance materials, and trends towards an increasing demand for services due to both the growing demand of private consumers and

trends of outsourcing, leasing, contracting, as well as increased needs for consulting and professional training.

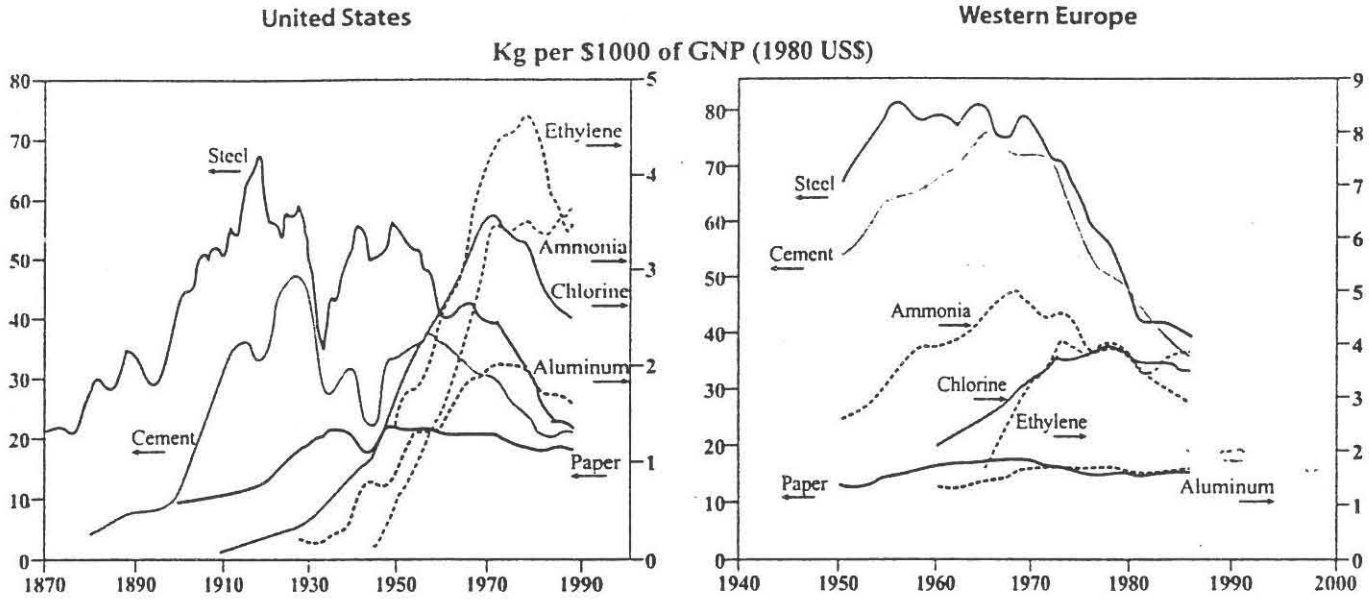



Figure 2: Decreasing Material Intensities and Material Substitution in the USA, 1870 to 1990 and Western Europe (D, F, UK) 1940 to 1986 (sources: CBC, 1996; UNDP, 1997)

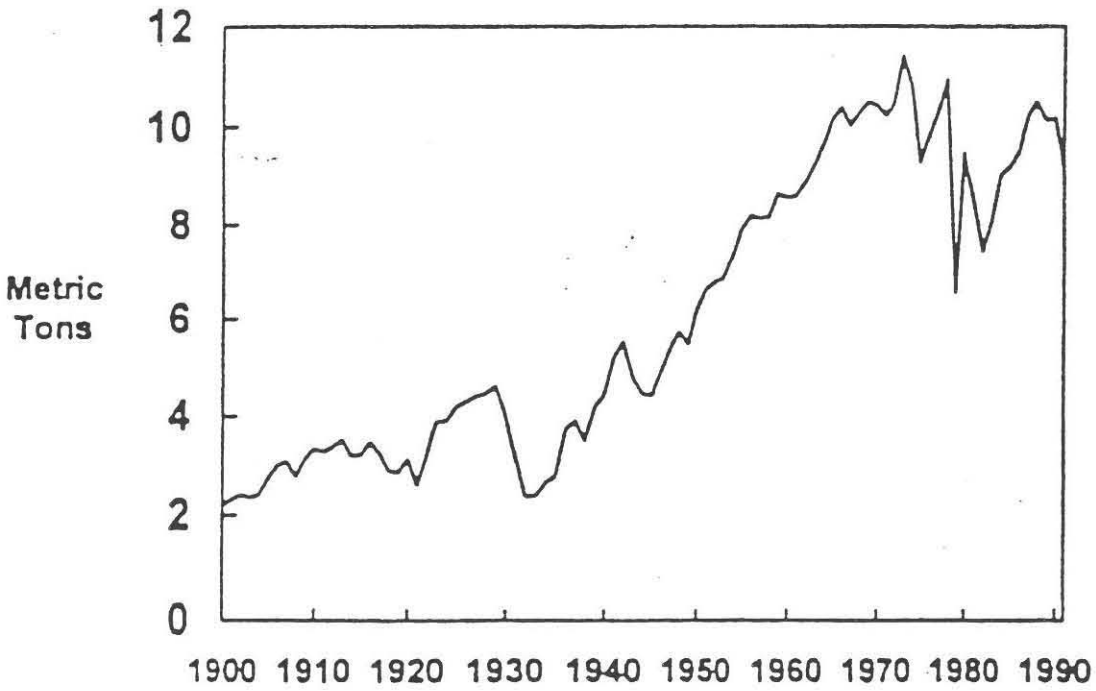



Figure 3: Annual Per Capita Consumption of Physical Structure Materials (Construction Minerals, Metals, Industrial Minerals, Forestry and Animal Products) in the USA, 1900 to 1991
(source: US Bureau of Mines and Bureau of the Census, 1993)

Again, it seems that the experience gained by the present 15 % rich people on the globe over the past 100 years is likely to be extrapolated to the 85 % of the world population or some 6 to 10 billion people for the next 100 years. This extrapolation assumes implicitly an **overall efficiency improvement** of material and energy use of **more than 95 % within 100 years** (or 3 % per year). This would require an innovation rate which is almost twice as high as in the past and which seems to be very difficult, if not impossible to achieve (see also Benardini/Galli, 1993), because the developing countries will undergo the phase of industrialization and motorization with inherent increasing material and energy intensities.

Let us have a closer look at the energy efficiency options on a global level, taking the global per capita primary energy demand relative to 1990 levels as a simple indicator. In the different reference scenarios, the indicator varies $\pm$ 20 % for the year 2020 and $\pm$ 50 % in 2050 (see Table 1). There is not much deviation of the indicator's values between the efficiency scenarios with the lowest values of per capita consumption relative to 1990, levels around 1.0, and those with the highest values of a factor 3. These differences in global per capita energy demand demonstrate the divergent opinions on long-term potentials of energy efficiency. The author supports the view of a very high long-term energy efficiency potential due to basic technological considerations (Jochem, 1991) and, based on his empirical work over the last 25 years, that **the economic energy efficiency potential of the next 15 years will be constant at 20 to 30 %.** This observation corresponds to the constant value of reserves to production ratio of some 30 to 40 years for crude oil and 50 to 60 years for natural gas. The constant values of economic resource potentials are easily understood because they reflect the period of pragmatic decisions of the industries involved on the next investment phase or re-investment cycle.

Table 1: Global Per Capita Primary Energy Demand Relative to 1990 Levels for Different Scenarios, 2020 and 2050

| Sources of literature | Global per capita primary energy demand relative to 1990 levels | |
|---|---|---|
| | 2020 | 2050 |
| **Reference Scenarios** | | |
| - Fukazawa, 1997 | 1.75 | 3.6 |
| - Shell, 1995 | 1.25 | 1.8 |
| - IPCC - IS92a, 1992 | - | 1.5 |
| - Worrell et al., 1997 | 1.25 | - |
| **Efficiency Scenarios** | | |
| - Fukazawa, 1997 | 1.4 | 3.0 |
| - IPCC-LESS, 1996 | 1.2 | 1.6 |
| - Shell, 1995 | 1.15 | 1.1 |
| - Worrell et al., 1997 | 1.0 to 0.75 | - |

But how long can we expect a constant 30 to 40 years reserve to production ratio in the future given the fact of shrinking resources? Fossil fuel resource exhaustion is not a concern for the next century. However, because of the rising global demand for oil products and natural gas, oil plus natural gas production is very likely to peak sometime between 2010 (MacKenzie, 1996) and the middle of the next century (Shell, 1995; WEC/IIASA, 1995). This peaking is envisaged **not** as a response to oil and gas supply exhaustion but rather as a reflection of expected limits on fluid fuel productive capacity, as conventional oil and natural gas resources are depleted and less concentrated resources are developed. The peaking of oil and gas production is even postponed until the end of the next century in high efficiency scenarios with high shares of nuclear energy or renewables (IPCC-less, 1996).

Again the role of the worldwide spread of high innovation rates in efficient energy use, of low cost renewable energy technology, injection of $CO_2$ in partially empty oil and gas fields in order to reduce $CO_2$ emissions and increase the productivity of fossil fuel fields, or of the intensified recycling of energy-intensive materials becomes evident. The differences in the peaks of oil and gas production also demonstrate **the role of energy efficiency in buying time to develop new energy sources**, such as the renewable energies, which means that the steady and full exploitation of economic energy efficiency potentials reduces the future cost of backstop technologies as well as future damages due to climate change.

Besides these techno-economic reasons for the highly efficient use of shrinking oil and gas reserves, the aspect of dependence has to be considered. Asia's dependence on crude oil imports, for instance, is likely to go up from 60 % in 1992 to 80 % by 2010, and its **dependence on Middle East imports** up from 75 % in 1995 to 90 % by 2010 (Fujime 1997). The high dependence of the OECD-countries and Asia on oil imports from the Middle East, which owns two-thirds of the world's oil reserves, represents one potential source of conflict in the world today, also because the political systems involved cannot be regarded as politically stable over the next few decades.

## 3. The Timing of Resource Use and of Innovations - An Important Issue of Global Interrelations and Risky Decisions

If China, India and the large countries of Latin America continue their industrialization and their growth in private consumption in the next decades, world demand for non-renewable natural resources and fossil fuels will increase; the reserve to production ratios of several raw materials are likely to decrease and their prices may tend to go up. These changes will induce

- intensified exploration of undiscovered reserves,

- spur technical progress in extraction technologies with regard to efficiency, lower costs and environmental burdens in order to increase the share of economically producible reserves, and
- further technical progress in the improved efficiency of material and energy uses (as mentioned above).

The pressure on technological innovations will be substantial, but the necessary degree of material intensity improvements and even the direction of important innovations seem to be unclear in many cases. Let us take an example:
the necessity to reduce the $CO_2$ emissions of OECD countries by 50 % or by 80 % by the middle of the next century makes a big difference to the cost-effective investments in the energy infrastructure during the next decades, because grid-based energies (electricity, natural gas, district heat or hydrogen), the building stock and the capital stock of heavy industries as well as the transportation infrastructure have long cycles of reinvestment. In the first case of a 50 % cut of $CO_2$ emissions for Germany, for instance, the widespread use of natural gas and stationary fuel cells would be important elements of a cost-effective energy system in 2050. In the second case of an 80 % cut in $CO_2$ emissions by 2050, however, a widespread use of natural gas and of stationary fuel cells would not enable the reduction target to be met; instead, the country would have to rely much more on renewable energies and on fuel cells in the road transportation sector (see Figure 4).

Because of the **long reinvestment cycles,** the global and national targets as well as the **market boundary conditions have to be set very early**. Whereas the additional energy system costs for reducing $CO_2$ emissions by 80 % or by 50 % by 2050 were calculated to amount to around 3 % of the GDP, a shift from a weak reduction target to an 80 % reduction target sometime between 2010 and 2040 will be much more expensive due to additional necessary investments outside the normal reinvestment cycles of the capital stock.

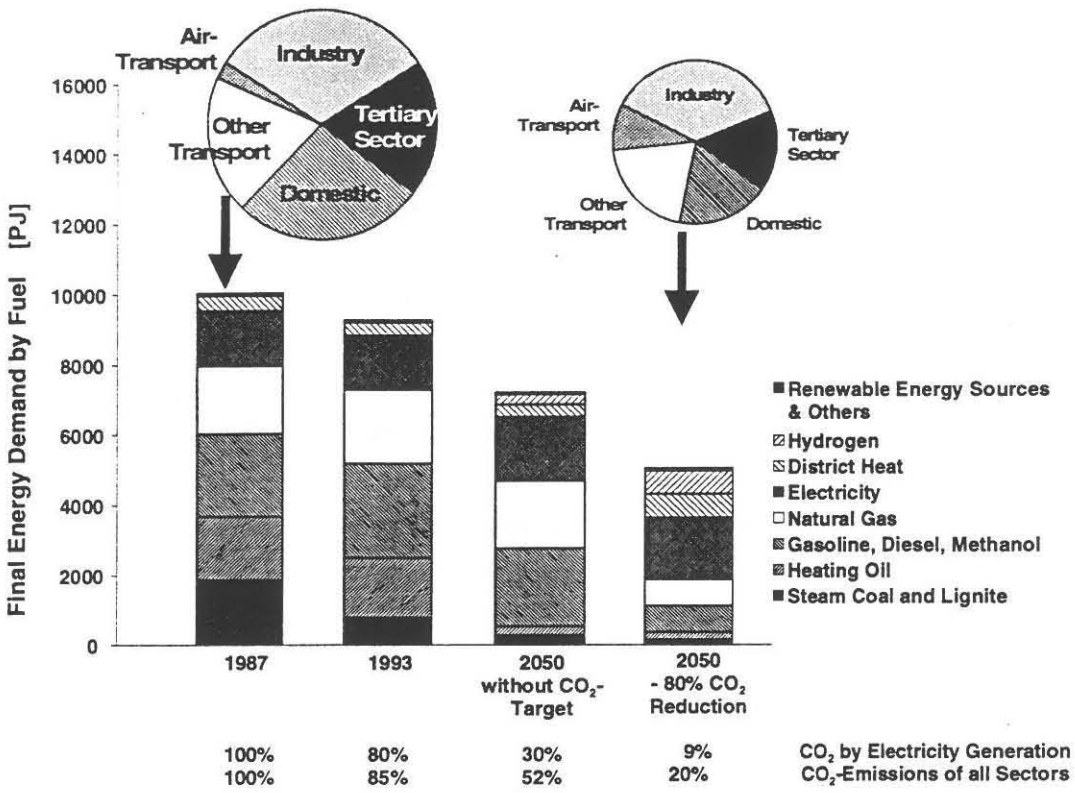



Figure 4: Dependence of Energy Supply on $CO_2$ Emission Reduction Targets for OECD-Countries by the Year 2050, the Case of Germany (source: Tönsing et al., 1997)

## 4. Market Deficiencies in the Long-Term Allocation Of Resources?

The market is one of the possible mechanisms to coordinate individual demand in a society. This mechanism has many advantages, but also its **own limitations**, one of which is the **future allocation of resources**.

The question of shrinking non-renewable resources and over-stressed environments leads to the normative concept of sustainability requesting an equal division of the use of non-renewable resources among present and future generations. Determining a fair discount rate for the cost future generations will have to pay for substituting the use of a natural resource which has already been used today is simply impossible. Neo-classical theories, however, assume that the discount rate is in the order of the rate of interest or return on capital investment (e.g. 3 to 4 per cent yearly) (Norgaard/Howarth 1991). This assumption may be reasonable in short-term considerations of five to 20 years. But given the fact that $CO_2$ emissions remain in the atmosphere for 120 years and can cause severe damages by accumulation, these

accumulation, these discount rates diminish future damages due to climate change by 97.5 to 99.3 % within the 120 years. The neo-classical theory - and practical decision making today - assumes implicitly a technical progress of this order of magnitude to justify this kind of economic evaluation.

On the other hand, the "management rules" of the sustainability concept suggest that "non-renewable resources should only be used to such an extent that a physically and functionally similar substitute in the form of higher efficiency of non-renewable resources or in the form of a renewable resource is made available" (Klemmer, 1996). This "hard sustainability" concept, however, is likely to underestimate future technical improvements and innovations, particularly by material substitution and reuse. But it also demonstrates that

- the decision of **intergenerational justice has to be made in the political arena, and cannot be managed by the market,**
- the justice of distribution among generations is also a question of **intragenerational justice**, e.g. distribution between the North and the South as well as between the poor and the rich, and that
- **sustainability would speed up structural change in industrialized countries** towards less material-intensive production and consumption patterns.

The market economy is, in principle, a suitable mechanism to support processes of change towards a more sustainable development because of its flexibility and potential for innovation. These positive properties, however, are substantially weakened by coalitions aiming to maintain the status quo, by institutional inflexibility and the concentration of capital and companies. In many respects, these factors are determined by traditional behaviour, existing power structures or fears about changing the distribution of wealth, income and influence.

The existing subsidies for natural resources and road transport are a good example of existing power structures: certainly subsidies can be beneficial, particularly if they are sharply focused and limited in duration. But too often, today's harmful subsidies of some 700 to 900 billion dollars per year in the field of water, agriculture, energy and road transportation are defended for the wrong reasons (see Table 2):

- subsidies for drinking water in developing countries are justified on the assumption that poor people cannot pay high prices. Yet the reality is the opposite: water subsidies have tended to benefit the haves. Irrigation is heavily subsidized which invites overuse, misuse and waste.
- Energy is subsidized by some $250 billion per year. The reasons are either no longer valid today (e.g. stimulation of exploration and production to increase

self-sufficiency, protecting employment and investments), or they were ineffective from the beginning (support the poor).

- Road transportation is heavily subsidized in OECD-countries (S85 to 200 billion per year alone in the USA, Japan and Germany) based on reasons of promoting economic development. However, subsidizing road transport has too often encouraged overuse, increasing pollution and congestion.

Table 2: Subsidies for Selected Natural Resources in OECD and non-OECD-Countries

(billion $ per year)

| natural resource, infrastructure | non-OECD | OECD | total |
|---|---|---|---|
| water[1)] | 42 - 47 | n.a. | 42 - 47 |
| agriculture | 10[2)] | 335 | 345 |
| energy | 150 - 200 | 70 - 80 | 220 - 280 |
| road transport | 15 | 85 - 200[3)] | 100 - 215 |
| total | 217 - 272 | 490 - 615 | 707 - 887 |

1) includes subsidies for drinking water and irrigation
2) includes food and input subsidies
3) for the USA, Japan and Germany

(source: Moor/Calamai, 1997)

To conclude, subsidies are often not the right instrument as they give the wrong market signals and lead to the wasteful use of non-renewable resources. They often no longer produce the intended results and they wind up in the pockets of the wrong people, they are economically inefficient and ecologically destructive. Industrialized countries are in the strongest position to take the global lead in moving towards desubsidization.

## 5. Challenges for Politicians and Administrations

So, the **political system has to be more careful about conflicts of distribution** which have been neglected for a long time in favour of present generations (also by increasing public debts). The political system also has to define the visions and targets of the sustainability of natural resources (and of societal resources as well) and to set the boundary conditions which favour a sustainable market order. With regard to democracy and the potential of innovation, the rights of freedom have to be maintained in many respects. But in some instances, new limitations of rights of freedom have to be made, e.g. the rights of property and capital accumulations.

These expectations of the political system seem straightforward, but they are without doubt very demanding - or naive one may say. Politicians of representative

democracies not only depend on the votes of their constituency, but on their convictions and their expectations of tomorrow and the future. If, however, their expectations are dominated by short-term targets of consumerism, increasing income, and by minimizing personal efforts and social engagement, the acceptance of policy measures with regard to sustainability, intra- and intergenerational justice is likely to be small. In this sense, the short-term concentration of market economies and their hedonistic messages of present marketing strategies influence and limit the possibilities of the political system which are also restricted in OECD-countries by a shrinking influence of Christianity and their socially and long-term oriented value system.

The success story of **environmental protection in OECD-countries in the last decades was an easy political task compared with the issue of sustainability**, of the wise use of non-renewable natural resources and the reduction of greenhouse gas emissions. Past achievements in environmental policy were easy because of two reasons:

- at the time when environmental protection policies were discussed and decided, citizens experienced polluted air and water resources, increased rates of bronchitis, warnings about swiming in rivers or dying trees and forests.
- The political system was able to presen the argument that if policy measures were taken, citizens would benefit within a few years or less from the reduced pollution.

Thus, in the case of traditional environmental policy, the voters could comprehend the danger of continuing pollution and the benefits of changed technology and behaviour on the basis of personal experience (see Figure 5).

In the case of reducing greenhouse gas emissions or material intensity, however, the voter does not directly experience global warming and its net damages or the shrinking reserves of non-renewable materials and energies and their increasing prices, because these effects will occur in the decades or even centuries ahead, i.e. far beyond his/her own life expectancy. The negative impacts may be felt in other regions (like North Africa or Mexico) much more than in present OECD countries or Russia. And finally, major damage may be avoided by new technologies in the coming decades at a much lower cost. So why should the voter bother with the issue today?

So the limitations that market economies face with **inadequate possibilities of reaction to long-term scarcities and problems are also the drawbacks of democratic political systems**. It will be, therefore, one major task of governments and members of parliaments to widen the consciousness of responsibility of their citizens and voters in two ways:

- on an inter-generational scale the citizen has to adopt the attitude of a forest owner: he plants the trees he will never harvest. He accepts and supports climate change policy and cautious management of non-renewable resources because of his responsibility for future generations;

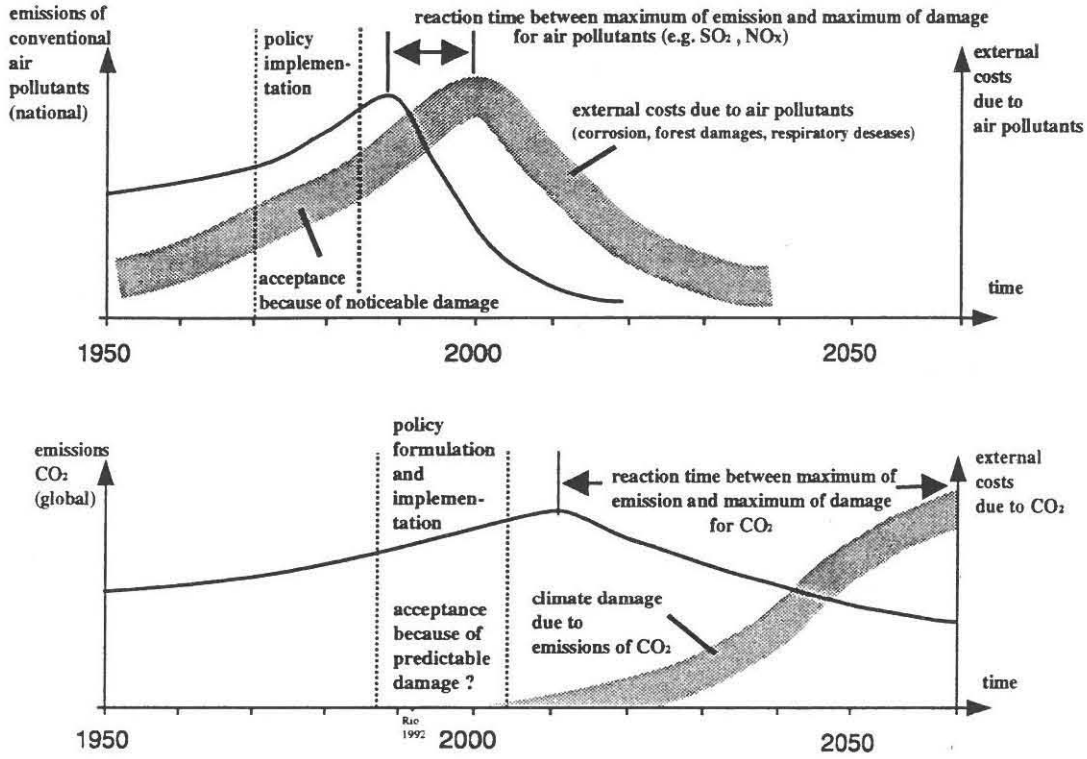



Figure 5: Differences in the Experience of Damages of Pollution and of the Beneficial Impacts of Response Policies in the Case of Traditional Environmental Pollution and Future Climate Change and Shrinking Natural Resources

- on a global scale: the citizen has to adopt the attitude of a world citizen: he does not accept national frontiers as a justification for "pollute your neighbour" - or "free rider" - attitudes and he also does not accept the "prisoner dilemma" as a simple justification for doing nothing in his own OECD village.

The marketing campaign of concerned climate change policy, however, will face intensive competition from the short-term interests of shareholders and of success-oriented managers and salesmen in industry and commerce, increased competition and growing unemployment as well as the induced consumer expectation of instant maximum consumption. One major short-term argument which is linked to the more efficient use of materials and energy and which may convince many voters is the prospect of additional employment and reduced social costs.

In contrast to many arguments of politicians, industrialists and analysts that limiting the risks of rapid climate change by reducing the emissions of greenhouse gases will be very costly, detailed analysis and empirical evidence conclude that just the opposite is true. **Economies benefit, even in the short term, from strategies that promote the efficient use of materials and environmental protection** through the development and faster application of new, more efficient technologies, increased recycling and reuse. Let's take the example of energy.

Policies to improve energy efficiency and to shift the energy supply mix to less carbon-intensive fuels and to advanced technologies - as the previous paper of Bob Williams described - will generate four important kinds of benefits for national economics; such policies will

- quickly generate a substantial number of **additional jobs** because of the following influences: (1) as long as the extra efficiency gains are economic, the saved energy costs can be re-spent for other purposes; (2) in most countries, imported energy is substituted by domestically produced efficiency products, plants and services, (3) resource efficiency investments tend to be more labour-intensive than investments in material and energy supply, the net result being around 100 new jobs per saved PJ (Jochem/Hohmeyer, 1992).
- **Increase exports** of high technology products of efficiency with **above average growth** rates of total exports (Jochem/Hohmeyer, 1992).
- **Reduce the environmental and social costs of energy use** that were previously uncounted in the market prices for fuels and electricity, and finally as a result -
- **spur overall economic growth**.

As there are many "no regrets" and "free lunches", even in highly industrialized countries (IPCC, 1996), as well as large potentials to increase the innovation rate by R&D, the political system could support realizing these economic or innovative potentials on the basis of short-term benefits for society. Here we have to emphasize that so many aspects of efficiency and energy policy cannot be designed or implemented successfully by central governments. The political system has to involve and motivate regional and city authorities, trade associations, the supply and industrial sectors as well as NGOs and citizen initiatives.

## 6. Concluding remarks

Regional environmental stresses and the use of non-renewable resources, which the OECD countries seem to manage today with a population of less than 1 billion people, will be one order of magnitude larger in the developing countries in the first half of the next century. Transfer of know how and of resource-efficient technology to these regions of the world, therefore, needs major political attention and

represents a business opportunity for the capital goods industries in OECD countries.

More efficient use of non-renewable materials by using less material, intensified recycling and reuse as well as by material substitution may be achievable in the next century, but the energy-related greenhouse emissions and the induced climate change seem to be a major threat to mankind in the next century, because the energy system's inertia is huge and many reinvestment cycles are very long.

Traditional economics tends to underestimate the long-term damage of climate change due to a usual discount rate of future cost in the order of 3 to 4 % per year, which is reasonable for time horizons up to 20 years, but which leads to unacceptable evaluations for a period of more than 100 years, the lifetime of $CO_2$ in the atmosphere. Unfortunately, the existing subsidies in the order of $800 billion per year for natural resources and for energy in particular invite the present overuse and waste.

The limitations faced by market economies with their inadequate possibilities of reaction to long-term scarcities cannot be easily corrected by the political system because it is burdened with its own "prisoner" dilemma: the short-term views and targets of the voters. Political campaigns aiming to generate a willingness to invest in creating mechanisms for climate change with insight and foresight are likely to fail when opposed to short-term oriented market campaigns.

Given the fact that many profitable potentials of efficient material and energy use do contribute to additional net employment, to increased exports, reduced social costs and, hence, to additional economic growth with structural changes towards less material and energy intensities, the political system does have convincing arguments for the short and medium term. The question, however, remains as to how intensively the political system still listens to the material- and energy-intensive industries, i.e. the sunset industries of the 20th century, and not to the sunrise industries of the 21st century. It is quite understandable that potential losers try to maintain their positions using any argument, even if it has been proven weak, but it is a dangerous period if a political system does not develop independent insights and adequate, active response strategies, if it does not develop systematic innovations on a national, an OECD-wide and on a global scale. Retreating to a wait-and-see position, even if complemented by investments in "big science" and highly advanced technological monitoring and mathematical modelling, does not buy time and does not guarantee society that safe adaptation schemes to shrinking natural reserves will be found; to sum up: time can be bought by target-oriented research in combination with action. If OECD countries do not take more action today, then there is an extremely high probability that the bill for the next generation will have nothing in common with what today's discount rates or price expectations suggest.

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# COMING CHANGES IN THE INDUSTRIAL SYSTEM: IMPLICATIONS FOR ACADEMIC INSTITUTIONS

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Presented at the

International Symposium on Technology, Economy and Policy

Fraunhofer Institute for Systems and Innovation Research

Karlsruhe

June 4, 1997

Good morning ladies and gentlemen. It is both an honor and a pleasure to have the opportunity to address this distinguished symposium. On behalf of my colleagues at MIT's Industrial Performance Center I would like to congratulate the Fraunhofer ISI on this special occasion. I have been asked to reflect in this talk on the implications of current changes in the world of industrial practice for research. I speak from the perspective of a university, the Massachusetts Institute of Technology, whose *raison d'etre* since its creation nearly 150 years ago has been to engage with the world, especially the world of industry, and which has also, in more recent times, viewed the conduct of research as being integral to the educational experience. This is a perspective from which questions of research, education, industry, and society are intimately connected to each other, in ways in which cause and effect are often hard to disentangle. So instead of trying to do so, I would like rather to offer some general thoughts on the changing nature of the larger system, of which the universities are a component part.

I hope you will forgive my parochialism if I draw these observations mainly from the record of evidence presented by the course of American industrial development over the past decade.

It is remarkable to think, in light of today's optimistic economic climate in the United States, that only a few years ago the prevailing view was that American industry, overwhelmed by foreign competitors, was in rapid and perhaps

even terminal decline. The tone was captured by the title of a best-selling book by the Yale historian Paul Kennedy, the Rise and Decline of Great Powers, which drew ominous parallels between present-day America and the twilight years of lost empires of the past. Pessimism about the economy would later cost George Bush the 1992 Presidential election.

Since then, of course, the good news has poured in. Nearly 10 million new jobs have been added to the American economy since the end of the 1990-91 recession, the unemployment rate today stands at about 5%, and inflation remains at historically low levels. The federal budget deficit has fallen 60 percent from its peak, and as a share of economic output is now the lowest of all the major industrial economies. The stock market is at a record high, and for the last several years the people at the World Economic Forum who try to keep score of these things have voted the U.S. the world's most competitive economy. Even the much-discussed issue of economic insecurity, which as late as March of last year was expected to dominate the 1996 Presidential campaign, had largely disappeared from the political horizon by the time of the November elections.

What happened? How can we explain all this good news, so close on the heels of predictions of irreversible decline? Were things never really as bad as they seemed at the beginning of the decade? Or do we only seem to be doing better because other countries, especially Japan, against which Americans had unfavorably compared themselves for so many years, have lately been looking so much worse? Or has American industry indeed

staged a miraculous recovery? If so, what has been responsible? Is it the cumulative effect of Total Quality Management, re-engineering, and the other new techniques of the so-called managerial revolution? Is it the entrepreneurial energies unleashed by America's dynamic capital markets, personified for many by the brash young multimillionaires of the Internet? Or has it rather been the result of sound fiscal and monetary policies -- a return to macroeconomic stability after nearly two decades of turbulence?

Not all of the news is quite so good, of course. Indeed, despite all of the current optimism, there has been no significant improvement recently in the rate of productivity growth -- the single most important indicator of any nation's economic performance over the long term. For the last quarter of a century U.S. labor productivity has edged up at an average rate of about 1 percent per year. This is the main cause of the disappointingly slow growth in living standards for the majority of Americans over this period. And while not a direct cause, the problem of slow productivity growth has also aggravated the other central problem of the American economy, which to varying degrees is shared by many other advanced economies, namely the increasingly unequal distribution of earning and income. Again, I want to be clear that growing income inequality and low productivity growth are two distinct problems. Our economy is today one in which people at the low end of the educational spectrum are not going to prosper. A rising tide will not lift all boats. But

the lower the tide, the more boats are going to be stranded. Today in the United States our economically stranded population is too large. A significant number of working Americans have been growing poorer in real terms. The causes of this problem are complex, but we are not going to solve it in the absence of stronger growth.

There is no evidence that the wave of corporate restructuring and downsizing during the first half of the 1990s has changed the productivity picture. Even though downsizing has sometimes helped the productivity and competitiveness of individual firms, it has had no discernible effect on the nation's overall productivity growth rate. This is surprising to many, but it should not be. Even if all downsizing actions produced productivity gains for the firms that undertook them -- and they do not, by the way, (a recent survey found that two-thirds of large American companies that had downsized between 1989 and 1994 did not achieve any productivity increases during the period of downsizing, and nearly a third actually experienced a decline) -- a one-time effect at the national level would not be guaranteed. An overall gain equal to the gain by the individual firms would occur only if those whose jobs were eliminated found other work in which they were as productive as before. And you don't have to resort to the stereotype of laid-off auto workers flipping hamburgers to recognize this has not occurred.

There is also no sign that total quality management, re-engineering, and the many other strategies for improving

operational effectiveness adopted by U.S. companies over the past decade have produced a significant overall productivity benefit for the U.S. economy. Once again, this is not to say that these measures did not yield important productivity and competitiveness gains for individual firms. But it is difficult to find any evidence that they have produced a one-time gain in aggregate productivity, let alone a continuing increase in the overall rate of productivity growth.

Even for individual firms, the benefits delivered by the tools and techniques for improving operational effectiveness have often fallen short of expectations. There are many reasons for this, including exaggerated claims by their advocates, and incomplete or faulty implementation by firms. Sometimes, too, different prescriptions have run afoul of each other. Efforts to implement cooperative 'high-performance work systems' have sometimes been undermined by the legacy of damaged trust and battered morale left by downsizing and reengineering efforts. And the organizational requirements of the two most pervasive of these new tools, reengineering and TQM, are so different that it has been difficult for the same organization to pursue them simultaneously.

Our research over the years has made it clear that the most successful firms understand 'best practice' not as a collection of independent techniques but rather as a coherent system of mutually reinforcing processes, practices, and strategies. These firms understand the strength of the

linkages between business elements that other firms see as separable, and recognize the critical importance of aligning these elements with each other.

Beyond this, one of the most striking features of these leading firms -- firms like Hewlett Packard, Levi Strauss, and 3M -- has been their enduring, deep-seated commitment to a handful of basic ideas or beliefs. By embracing and constantly reaffirming these core values, they have been able to communicate clearly and consistently who they are and what they stand for to their employees, their customers, their suppliers, and their shareholders. And this knowledge has helped engender the trust and mutual commitment that have been so important to their success. The latest management ideas, to the extent that they figure in these developments, are consciously and explicitly used and adapted in support of the more fundamental objectives of the firm.

There is another point here that, though straightforward, is often forgotten. For both individual enterprises and aggregate economies, a strategy of improving operational effectiveness is not enough to sustain productivity growth over long periods. Finding ways to do things better -- to improve existing products and services and to carry out existing processes more efficiently -- is a necessary but not a sufficient condition for long-term productivity growth. Business enterprises must also constantly find new markets and develop new products and services and processes. It is often possible to make improvements in operational effectiveness

without major capital outlays. But finding new markets and commercializing new products *always* requires new investment.

Private investment -- and this is, of course, the most important kind -- is more likely to be forthcoming when economic conditions are stable and predictable. Macroeconomic trends at the moment are in a direction to favor increased investment, at least in the United States. But at the micro level the story is a bit different. The three great contemporary driving forces for change -- globalization, deregulation and rapid technological innovation -- are together transforming traditional patterns of microeconomic behavior, and bringing not only new opportunities but also new risks and uncertainties in their wake that conventional macroeconomic stabilitization policies can do little to mitigate.

For many firms, the effect of all this has been to create an environment of essentially continuous change, in which not even the most fundamental questions of strategy and identity remain settled for long. Which markets should they compete in? What products should they make? Who are their competitors? Where ought they to produce? How ought they to organize? Firms must constantly ask these questions because the answers are continually changing.

During periods of rapid change, investment in intangible assets -- knowledge, ideas, skills, organizational capabilities -- take on special importance. The results of

these investments -- ideas for new products and processes, knowledge of new market possibilities, more competent employees, nimbler organizations -- give the economy the flexibility to keep adapting and reconfiguring itself to new supply and demand conditions. They are the lubricants of the economic machinery. But while these kinds of investments are especially important during periods of rapid economic change, it is also during these periods that this sort of investing comes under the greatest pressure. Even under normal circumstances activities such as training, research and development, and the development of new markets pose special problems for investors. Unlike investments in tangible assets like new equipment, buildings, land, and physical infrastructure, investments in intangibles do not create collateral and their returns are inherently more difficult to measure. These same characteristics make them especially vulnerable when uncertainty about the direction of economic activity is high.

Some of the most important questions facing American industry today have to do with these so-called intangible investments. At a time of rapid economic change, when the bonds of loyalty between enterprises and their employees are subject to maximum stress, how will our society come up with the investment needed to upgrade the skills of the workforce? At a time when many companies find it difficult to say with any confidence which markets they will be competing in and who their competitors will be even five years from now, who will finance the R&D activity that will lay the foundation for the new products and services of the 21st century? And at a time

when so much of the energy and attention of our business organizations is still focused on improving efficiency and effectiveness, how will these organizations find the creativity and imagination needed to strike out in new directions? As I said, these are some of the most important issues facing industry today, and each one of them is a worthy subject for academic research.

Economic volatility affects ordinary people as well as profit-seeking firms. The great forces of change at work in the world economy today -- rapid technological innovation, the opening and rapid development of new markets around the world, the progressive lifting of government controls on economic activity -- hold enormous promise for economic growth. Yet the very forces that create this extraordinary growth potential are simultaneously inspiring widespread feelings of apprehension. Every economic change creates losers as well as winners, and for some the price of change will be high. But even many who stand to gain have come to equate change not with opportunity but with disruption and a loss of control over their lives. In democratic societies the fear of economic dislocation may be strong enough to compel governments to act in ways that are intended to reduce economic anxieties and promote social stability but whose actual effect will be to inhibit private investment and growth. In America, and throughout the industrialized world, the fear of rapid economic change has already brought increasingly strident calls for protectionist trade policies, for other forms of what has come to be called 'economic

nationalism', and for more stringent regulation of corporate behavior. To people who are nervous about the future direction of the economy and their place in it, such policies have considerable appeal.

In the U.S. these anxieties abated during the expansion of the mid-1990s, but they never entirely disappeared, and they will gain new force when the economy turns down, as it inevitably will. And at that point the pressure will build on policymakers to do more to relieve the anxiety, whatever the cost in terms of foregone investment and long-term growth. The solution to the problem of productivity growth will therefore turn partly on how much uncertainty ordinary people will be willing to bear before a backlash against the forces of change sets in.

For many, the uncertainty is made tolerable by the expectation of greater material rewards for themselves and their children. But for many others, an improvement in living standards remains a distant and uncertain possibility, whereas the threat of economic dislocation is immediate and real. If the price of protection against this threat is merely the postponement of an already unlikely prospect, it is a price that is likely to seem well worth paying.

Could anything change this calculus? Here I would like to refer once again to recent research on the experiences of successful companies. To some such a connection will seem implausible. The study of why firms succeed and the study of how and why national economies grow are like two parallel but separate conversations. The participants in each are aware that the other exists, and will even eavesdrop on each other

from time to time, but mostly they have little to say to one another. Indeed, some have argued that the less that is said the better. My colleague at MIT Paul Krugman has forcefully reminded us that nations are not firms, and that to speak of the performance of national economies in the language of corporate competitiveness is to confuse two fundamentally different ideas. "The idea that a country's economic fortunes are largely determined by its success on world markets is a hypothesis, not a necessary truth; and as a practical, empirical matter, that hypothesis is flatly wrong." Krugman is quite correct, of course. Still, if one thinks of the firms that have managed to prosper and grow over several decades in spite of frequent, often-radical changes in their economic environment, it is not so far-fetched to imagine that their experiences might contain some lessons relevant to the problem of national economic growth.

One of the most striking features of these companies has been their ability to combine a highly-developed, almost protean ability to transform themselves to take advantage of new technological opportunities or market developments with an enduring, deep-rooted commitment to a handful of core beliefs (different in every case) about their identity and purpose. For the people in these firms, these core ideas have served at once as a powerful motivator, as a credo giving meaning to their individual efforts, and as a framework within which to organize rapidly changing and often confusing information about the external environment. In a sense, these ideas have been the 'glue' that has held these firms together and enabled them to grow steadily over long periods.

The lesson these companies teach is that a strong sense of direction and purpose is critical. The employees of these firms have been left in absolutely no doubt about what is important to their firms and what they are trying to achieve, and how their own individual actions and decisions could contribute to the realization of these more general goals. Throughout these organizations there has been a clear and concrete understanding of core goals and values, and this has had the great benefit of helping employees remain focused on what needs to be done even while almost everything else around them is changing.

In this respect, perhaps, the employees of a company may not be so very different from the citizens of a country. Just as a strong sense of identity and of purpose beyond profit has helped the most successful companies navigate through confusing and unpredictable territory, so too might a shared sense of *national* direction and purpose help advance the prospects for improving a nation's overall growth performance.

Today, though, such ideas barely feature at all in the national conversation about growth, at least in the United States. The debate is dominated instead by discussion of the rate of savings, the rate of investment, the budget deficit, and so on -- macroeconomic abstractions that for most people have no obvious relation to any conception of national identity and purpose. As long as this persists, the analogy with firms suggests that the public's tolerance for the instabilities that are part and parcel of the growth process will be in short supply.

At one time the general alarm over America's declining

competitiveness vis-a-vis Japan and other advanced economies might have provided the missing sense of purpose. The Japanese challenge actually did galvanize significant sections of American industry and the American workforce for the best part of a decade. It elicited a broad-based and vigorous searching for new sources of competitive advantage and an openness to experimentation -- in sharp and welcome contrast to the complacency and myopia that had become the hallmarks of American business practice by the 1970s. But as a vision of what the U.S. economy might become, international competitiveness is hardly the animating force that is needed today. For one, the problems now besetting the Japanese economy would surely disqualify it from such a role in the eyes of most Americans. And in the final analysis the goal of international competitiveness, in addition to its intellectual shortcomings, offers a parched, crabbed view of the nation's economic future. (Is the main point of the U.S. economy really to outperform Japan?)

Today a different economic vision is needed. If people are to be persuaded to embrace change rather than resist it, if they are to be convinced of the need to live with the heightened volatility and ambiguity of the new economy rather than to fight against it, they must see the beneficial possibilities of such a stance. They must have a positive reason to open themselves up to economic forces that will sometimes seem arbitrary and out of control. They must, in short, have a sense of direction and purpose. For many in the workforce, perhaps even the majority, the promise of greater material compensation will not suffice. What is also needed,

I believe, is a coherent vision of the place of work in society and what the work experience itself might become for the majority of contributors to the new economy -- a vision that is almost completely absent from the current debate.

Take the new information technologies, for example. In one view, these are job-destroying, occupation-reshaping, income-polarizing 'agents of change'. But that is only one side of the story. The other view emphasizes the unprecedented opportunity afforded by these technologies to move beyond the production systems of the past, systems which offered intrinsic satisfactions only to people at the top of the pyramid. This aspect of the story highlights the potential of these technologies to eliminate much of the rigid, narrow, repetitive work of today, and more broadly to provide personal and professional satisfaction for a far greater number of workers than ever before. Whether this happy outcome eventually comes to pass will depend not on some uncontrollable technological force but on the exercise of conscious choices. As individuals, and as a society, we may choose to use technology in such a way as to diminish the human contribution -- to pressure, to downskill, or to demean. Or we may choose to use it to augment human capabilities and to enhance the work experience. The key point is that such a choice exists, and is one of the things at stake in the debate about growth. Yet today that choice is hardly acknowledged in the debate today. By separating the question of what economic growth is *for* from the question of how to achieve it, the possibilities of growth are much less likely to be realized. By seeking instead to articulate a vision of what the

workplace can become, and by establishing norms of technological usage on the basis of this vision -- for example, that workers can and should expect to be in control of their working environment, that they should expect not to be displaced by technology, that they should expect their own endeavors to be appreciated, that technology will be used not to compromise but to protect the dignity of work, and so on -- our society stands a far better chance of realizing the full potential of technological advance.

Consider also the implications of an economy in which lifetime careers with a single employer are becoming the exception rather than the rule. To many people a varied career path with multiple employers will seem daunting, a prospect to be endured rather than welcomed. But once again the possibilities need to be more fully articulated. The continuing transformation of the economy is making it possible to imagine a future in which individuals not only take on more responsibility for managing their own careers but also obtain more control over the resources with which to exercise that responsibility. This is the larger implication of current proposals for portable pensions and benefits, individual skill grants, tax-deductible individual training accounts, and the like, and indeed of the movement to give parents greater choice regarding schooling for their children. These new career development and benefit structures, by promoting individual autonomy and private choice, would have the effect of bringing the world of work into closer alignment with our society's individualistic and participatory values. In this view too, these individually-tailored resources would begin to

provide a true alternative to today's social institutions, to 'the standardized offerings of the welfare state on the one hand and the increasingly rare and uncertain embrace of corporate paternalism on the other.'

Taken together, these rights, responsibilities, and resources begin to point towards the notion of a new form of *economic citizenship*, centered on the place of work. I do not claim that these are the only possible elaborations of that concept, or that they are the best of all possible alternatives. I *do* believe, however, that these are the kinds of issues we should be talking about when we debate how to achieve stronger economic growth. The problem of growth remains the central question facing the American economy, and for many other economies around the world. But it is a question that cannot be separated from the challenge of maintaining a healthy relationship between industry and society, a relationship without which neither can survive, let alone thrive. Modern industrial enterprise stands today as a glorious, living monument to society's powers of cooperation, ingenuity and imagination. I would like to suggest that the solution to the problem of growth as we prepare to enter the new century will hinge on the success with which those same powers are applied to the design of the world of work. And that, too, is a worthy subject for academic research.

# The Lasting Challenge of Unemployment and „Sustainability"

Paper presented by Helmar Krupp on the occasion of the
25th anniversary
of the Fraunhofer-Institute of Systems and
Innovation Research (ISI)
in Karlsruhe on June 4, 1997

I propose to share with you a few off-stream considerations about unemployment and sustainability and the dilemmata of the technology policy of the OECD-type societies.

**By way of introduction,**

- let me first summarize a report in a recent issue of „Der Tagesspiegel", a daily newspaper in Berlin: Public subsidies of some 100 million DM will be given by the debt-ridden city of Berlin to the Philip Morris Company for investments to double the present production from 7 to 14 thousand cigarettes per minute. The hope is that 1 200 jobs will be saved, if only for another three years. This has to been seen in the light of a three-year effort on the part of the present German government to enforce cutbacks in the German health system with particular losses to the poor who contribute a disproportional percentage of the smokers.
- Another threat to the poor is an attempt to cut unemployment-related social security payments by another annual 5 billion Deutschmark or so. This may be compared with estimates that the volume of easily traceable tax evasion is of an order of magnitude of 150 billion Deutschmark annually. Commentators warn that money is like a shy deer that would escape across the German border if strict measures against tax fraud were enacted.

With these two examples I want to point to two basic societal problems: On the one hand, basic inconsistencies, **basic societal unsustainabilities**, and on the other hand, **deep dilemmata and risks** where both action and non-action are risky.

I would like to corroberate this by a few more examples from each of the three sectors of the German economy.

**Take agriculture**

Whereas portions of the crop in the European Union are destroyed every year in order to avoid excess supply, attempts are being made, simultaneously to increase agricultural productivity by genetic engineering – the present top priority of public funding in technology policy. This includes the pending introduction of the recombinant bovine somatropic hormone to increase the milk production of cows, although Europe is already „swimming in a sea of milk".

In **manufacturing**, after the era of jobless growth we are entering an era of jobless profit explosion. At the same time and in the same vein, work-related laws are being changed to facilitate the *shedding* of employment. Please notice the terminology used.

Allegedly as a compensation to the creation of a new proletariat of mostly young people under 25 and older ones above 50, large subsidies are being given to start-up companies. They appear to me as candidates for the evolving networks of outsourcing for the ever leaner large corporations. This will lead to what we call the Lopez effect, that is cut-throat competition among small and medium-sized enterprises, as is already common in the automobile industry. Thus, proletarization will be extending to another scale, from that of individuals to that of smaller enterprises – derooting workers still more profoundly.

Current estimates say that the work force in manufacturing may be halved again in the decades to come, because labour productivity is expected to increase by 2 to 3 percent per year.

The picture is the same in the **services**. Here the productivity increase is about to reach 3 to 4 percent annually. The results will be losses in diversity and quality. Already now we can observe the degenerating person-related services in shops and offices, and – correlated with unemployment – the increasing vandalism in public transport vehicles and facilities, in schools, in public parks, graffiti spraying and so on. Some places are better than others to observe all this, Berlin for example, better than Karlsruhe.

I need not describe further details of the accompanying decay of ethical standards and increasing crime rates in all segments of society.

Compared to all of this, a great deal of **technology policy seems to occur on another planet** – in cyberspace so to speak. The gap between the main societal issues and the semantics and projects of current technology policy could not be greater.

In my view misallocated billion-dollar projects of public OECD-technology policy include

- fast breeders, fusion reactors, transmutation of radioactive nuclear waste
- genetic engineering of food, vegetable and animals
- manned space flight
- civilian supersonic planes
- networks for mass-mediatization, intensifying the cycle of self-delusion.

To give just *one* counter-example: Would not billion-dollar projects to increase the productivity of the use of materials and energy and, further, the large-scale use of solar energy with photovoltaics in the forefront, be much more sensible? Curiously, investments in the protection of the environment hardly match the sales of any one of the advertising, tobacco or the alcohol industries.

Some 20 years ago, I saw an announcement of a conference in Yugoslavia, entitled **„Economics as if people mattered"**. I propose a conference on technology policy under the same title.

**My interim conjecture is:**

Besides environmental destruction, the major calamities of the last few decades seem to have been

- unemployment
- bottom-up redistribution of wealth and
- growth of the North/South and the East/West gap in income and opportunities.

To all of these developments, technology policy and its waves of technology push have made their contributions.

A correlated drama, particularly in Central Europe, is the dismantling of a unique societal achievement: her comprehensive social network. It took 150 years to build it up. It may take only a few more decades to ruin it.

The basic idea of Marx, Schumpeter and other forefathers of an economics where people mattered, is to establish and maintain an admittedly delicate balance between capital and productivity accumulation by a small minority, on the one hand, and overall social sustainability, on the other hand. Present trends point into the opposite direction, a consequence of Robert Merton's Saint Matthew effect.

Let me take a further step. If you analyse these and previous examples, you find that, from the point of view of an actor in the economy, in politics, in technology or of an individual voter at the ballots, the available options are almost always highly controversial. As already indicated, the reason is: fundamental societal **dilemmata and risks**.

- A NO to investments in harmful products, cigarette manufacturing or genetic engineering in agriculture for example, may be beneficial to health and the environment, but harmful to employment and international competitiveness, not to mention tax revenues.
- Microelectronic-driven increases in labor productivity are beneficial to the capital owner, but dangerous to many present jobs, in the wealthy and the poor countries alike.
- Investment-driven economic growth is harmful to the environment, but may save jobs.

All of this is of course a function of the time scale chosen.

Now, to take the preceding considerations to the level of the **social sciences**, let me ask: *Is there a theory capable of integrating these examples?* In my view, economic models would not suffice. We need a more holistic approach which asks: *What is the structure of world dynamics that is enabling and inducing the present catastrophic development?* The classical answers of Karl Marx must be readjusted. The single most important achievement in this theoretical field in the past 25 years has been the development of the **sociological theory of systems**, initiated by Talcott Parsons and others, but basicly modified and greatly refined by Niklas Luhmann in Bielefeld. It can be interpreted as a major step toward the fulfillment of Schumpeter's dreams: In his earlier years, Schumpeter dreamt of a merger between economics and sociology in his and Max Weber's Sozioökonomik – Social Economics; in his later life, he wrestled with a formal theory of evolutionary economics.

Let me briefly summarize a framework developed from this background which I call **Schumpeter dynamics**. In my view, it allows us to „explain" or interpret the phenomena cited – see attached diagram.

Its starting point is this: From the great variety of decisions of billions of people on Earth, *communication systems* have evolved. They rationalize, that is they greatly reduce the complexity of global communication, both locally and globally. The mechanism is to adopt strict encodings of the pertinent operations:

- In the economy, the bottom-line of all its operations – so the theory says – is *payments*.
- Similarly, politics is about the distribution of *power*. Political tasks are tackled as a means to stabilize or increase political power.

- Technology is about new *technical know-how* and apparatus.
- For consumers, besides their physical reproduction, consumption is about their subjective *well-being*.

Thus, the theory stresses **the fundamental selfishness of the societal systems**. These systems are autonomous in that they decide by themselves on what to do with external stimuli. Implementation theory shows that the economy, for example, finds *its own ways* to respond to a regulation or tax law.

The systems do of course *couple with their respective environments*. The most important feature of what I call the synergism of Schumpeter dynamics is the resonance between the four systems economy, politics, technology and consumption. Their mutual reinforcement leads to exponential growth, rationalization and global networking. Unemployment and ecological devastation are only **external effects** vis-à-vis Schumpeter dynamics.

The media contribute in their way to stabilize Schumpeter dynamics.

**In the last one or two centuries, it has been predominantly this societal institution which drives the evolution of humankind.**

Let me enumerate a few heuristics of this theory:

(1) Any attempt at a coherent view of global society, as a Gemeinschaft – as a community, is thwarted by its fragmentation into the different, mutually exclusive rationales of systems, organizations and people involved.

(2) There is no longer any center of control of the evolving stratified society, neither within society nor outside the Earth.

(3) In principle, societies may run astray, may get stranded, similarly in biology.

(4) As the course of evolution emerges from the action of billions of people, at least in principle a catastrophic path may be redirected. History seems to show, that this capacity is very much a function of human suffering. People and systems do react, but usually only when under severe pressure, from within the systems or from their respective environments.

To me it appears that several decades will be needed to accumulate enough suffering and societal pressure to transform the present Schumpeter dynamics.

*One* systemic response might be the formation of problem-focussing negotiation networks on all levels, including the presently developing regional organizations such as the European Union, NAFTA, and the East Asian blocs – although their *present* function is liable to rather accelerate the rate of damage. On the other hand, without compromises among major global regions, the problems both of **unem-**

**ployment** and the **ecological environment** cannot be attacked – except at devastating social costs and too late, for instance by total liberalization or deregulation.

Finally, as to the heuristics of the model of Schumpeter dynamics, it explains why technology policy is only concerned about itself so that people do not really matter, except as buyers and as a source of externalities. That is because technology policy is an instrument of the introvert political system.

**My conclusion is:**

In the present world, there is no **sustainability**, neither ecological nor societal, including **work** for all. In the evolutionary world of Schumpeter dynamics, such a state is even quite **improbable**, because of the chaotic nature of self-organizing evolutionary processes, the subsequent disbalances and the fundamental openness of the future. In such a world of dilemmata and risks, there is no stationary state, no homeostasis, no equilibrium. **Thus, sustainability is only a mobilising political slogan.**

From a **normative point of view**, one might want Schumpeter dynamics to be self-transformed by a self-coordinating global network of fundamental re-regulations against social dumping and environmental devastation, for example. This would be a principal task of the large regional blocs, to be fuelled by trade unions, churches, the United Nations and by new social movements, both within and outside the national and transnational parties. This might be a chance for reflexive self-control as an alternative to evolutionary transformation through accumulated suffering. Reflexive self-control would be a chance for humankind to transcend the blind mutations of natural evolution by self-regulation – a project proposed repeatedly from Hegel onwards. The next centuries will operate on this and other options, including countermovements to globalization.

Joseph Schumpeter has warned us that systems perish if left to their endogenous rationale. Therefore, **Schumpeter dynamics must transform itself, if it wants to survive**.

Let me end with a few concrete, however only *normative ideas* related to unemployment, ecological concerns and technology policy.

As to *unemployment*, a first step *in Germany* might be to

- continue the decades-old trend and reduce the number of annual working hours, as demanded by the union of metal workers
- put *taxes on natural and ecological resources* and use the revenue to strengthen the German social network.

A *structural change of the priorities of German technology policy* may be based on the following three postulates:

(1) Priority should be given to infrastructural projects, such as
   - increase in energy efficiency and solar energy
   - extended public transport and facilities for non-motor driven individual transport
   - protection of the environment, including the diversity of species and the quality of drinking water which does not meet the norms of the European Union
   - improved quality of German clinical medicine and its open evaluation
   - a new attempt at participatory technology assessment and more public debate on technology policy
   - continued support of competitive fundamental science, also in re-regulated German universities.

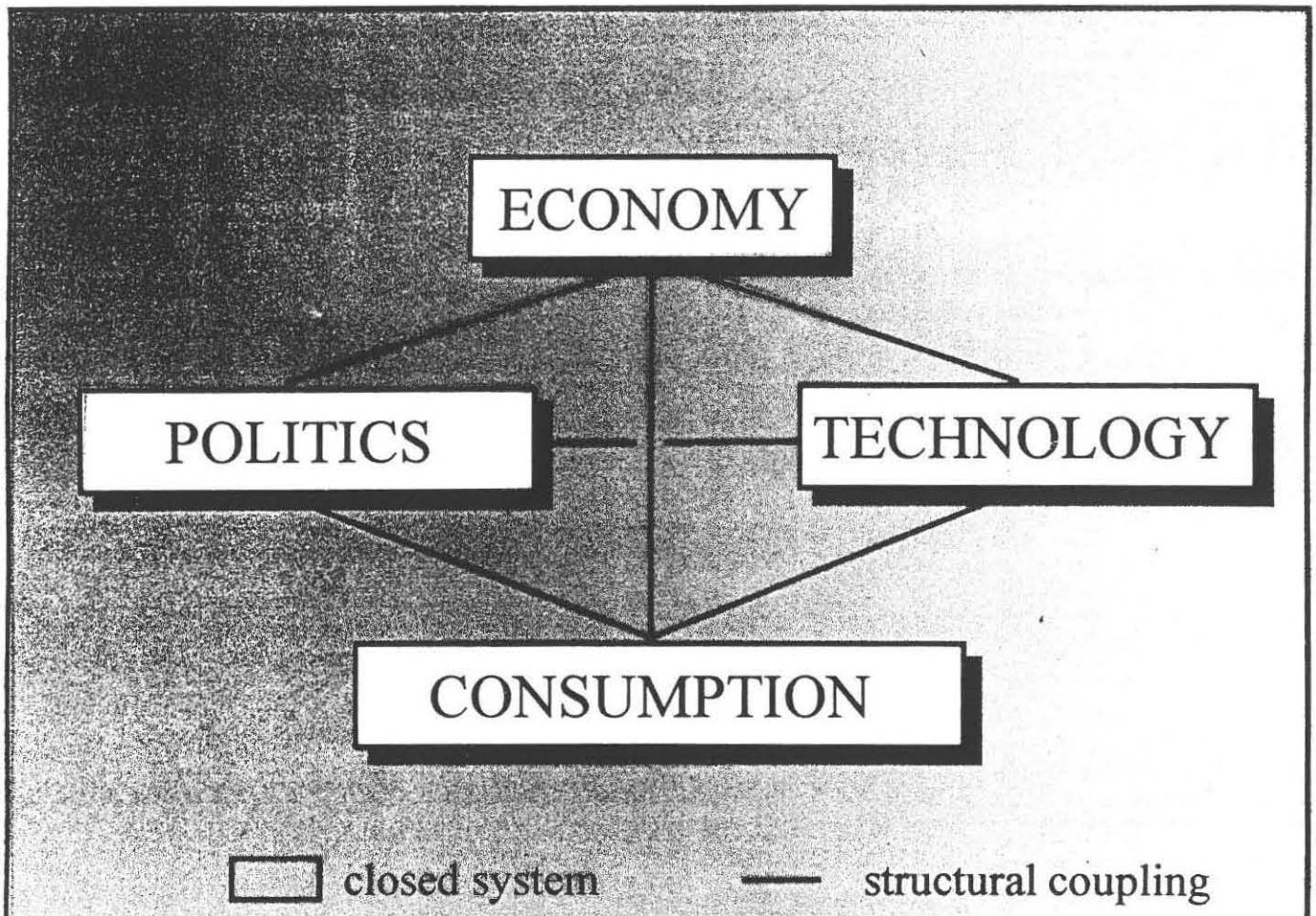
(2) In contrast, major projects of the economy may not need public finances. Examples are
   - automation
   - mass multimedia
   - non-medical genetic engineering
   - magnetic trains and supersonic planes.

(3) The supply of capital and new technology to small and medium-sized enterprises may also be delegated to the economic system, in particular its financial institutes and the large cooperations.

Such changes have little chance of implementation without at least European, if not OECD-wide solidarity – that is the crux of Germany's embedment in the large globalizing systems. Therefore, any major change of present trends hinges on a co-evolutionary self-transformation of the present global Schumpeter dynamics. For that matter, already a great number and variety of economic, political and ecological regulatory instruments have been proposed and will be discussed in the coming decades.

They will show how the global society will fare precariously between the two poles of a blind systemic evolution, on the one hand, and human design, on the other.

Technology policy will be a not at all unimportant wheel in this global drive and drama.




SYNERGY
INNOVATION
EVOLUTION
GLOBALIZATION

| KRUPP 1996 | SYSTEM MODEL: SCHUMPTER DYNAMICS |
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# The Delphic Oracle and the Progress of Mankind Then and Now

**25th Anniversary of Fraunhofer ISI**
**June 3-4, 1997**

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The Delphic Oracle and the progress of mankind then and now - what kind of contribution to an international symposium on technology, economy and policy might this be? If you permit, I will answer this question in some detail.

The last five years or so in this country and elsewhere have witnessed an upsurge of interest in technology foresight. Prior to 1990, there was comparatively little technology foresight in the United States, Germany or other European countries. Together with Germany's unification the situation began to change. The first foresight initiatives were taken in collaboration with Japan, which was then in the process of carrying out its fifth thirty-year survey. Among several possible scientific methods in technology foresight, the so-called Delphi Survey is only one. But in the eyes of many observers, the Delphi technique seems to be more prominent than other, comparable approaches. This might be due to the magic word 'Delphi' and the association with the ancient Greek oracle. I have come over numerous press releases that guide the reader to serious results of Delphi foresight results by introducing the Delphic oracle first. So do I today.

I first want to start with hindsight and consider briefly what the function of the priestess in the old Delphi temple was, whether historical research found any impacts on politics or society in those days and whether there was a lasting impact on the progress of mankind in prehistory. I will then pose the same queries to our present society, '*what is*' or better '*what could be* the function of technology

foresight on our economy, policy and technology development'? I will conclude by discussing possible benefits of technology foresight for our societies, that march soon into the next millenium.

## Benefits of the Delphic oracle

The foundation of Delphi and its oracle took place before recorded history. Thanks to archaeologists and historians we have extensive knowledge on the functions and benefits of the oracle. As I am not an expert in history, in the next few minutes I will - among other things - present some deliberations of Herbert William Parke, professor of ancient history at the Trinity College in Dublin, which he published in the fifties. I will then return to my own field of expertise, innovation economics.

For a thousand years of recorded history the Greeks and others, sometimes as private individuals, sometimes as official ambassadors, came to Delphi to consult the prophetess, who was called Pythia. Her words were taken to reveal the wills of the Gods. These prophecies were not usually intended simply to be a foresight of the future as such. The Pythia's function was to tell the divine purpose in a normative way in order to shape coming events. To put it briefly and coarsely: Professor Parke is convinced that the mystery of the oracle can only be accounted for on two extreme spheres or a blend of them. According to the first, the priesthood and the Pythia were deliberate charlatans who worked a traditional 'hocus pocus', because it paid them well. According to this view the Pythia's role was simply play-acting on her part, traditional and effective in impressing the credulous. The opposite view would be to suppose that the priesthood and the Pythia were perfectly sincere. Instead of being the deceivers they were the deceived.

Are the extremes really different? Is it a blend of them that is most likely? One should consider that the Delphic monastery was one of very few spots on the earth where knowledge was accumulated, ordered and preserved. The information came in from the ambassadors through their queries and the answers were written down on metal plates, several of them found by archeologists. The temple was the locus of

knowledge, or, if we put it more mundanely, the Delphic oracle was probably the largest data base of the ancient world. The priests could read and write; who else could do so in Greece? If due allowance is made for these circumstances, modern psychology will find no special difficulty in accounting for the operations of the Pythia and of the priests interpreting her utterances. Knowledge was used and disseminated to make the world better.

Certainly, the consultations were religious in form and not mere inquisitive speculations on the future or attempts to obtain practical shortcuts to success, but at least in earlier periods religion entered into every aspect of Greek life and there were few subjects on which the advice of Apollo was not sought, to quote Parke's book 'The Delphic Oracle' again. There ist no doubt, the oracle acted as an international arbitrator. It shared the rise of hellenic civilisation to which it contributed no small part. It is no wonder that a witness of that time, Socrates in his 'Phaidros', around 400 years before the year zero, judged: 'The prophetess at Delphi (...) turned many good things towards the private and public affairs of our country'.

Thanks to the oracle the Greek people learned over many generations to abstain from bloody vendetta, to apply to courts when quarreling in private life occured and to solve disputes in a fair way. It can be traced back to the oracle that one should not poison the well of one's enemy and should take care of the olive trees in war. Thus the idea of the long-term oriented development of landscaping achievements we owe the Delphic oracle.

Based on this impressive historic material the first part of my answer is clear: Mankind benefited from the oracle in the old days. Let us turn now to the roots of modern foresight.

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## On the history of modern foresight

The main initial work was performed at the RAND corporation, Santa Monica, in the years following 1948, the pioneers being A. Kaplan, O. Helmer, N. Dalkey et al. 'Forecasting', as it was known then, was motivated by Vanevar Bush's book 'Science the endless frontier', advocating the transformation of the US military economy research during World War II (e.g. the Manhattan project) into long-term civilian research and commercial exploitation. The early attempts were also spurred by the amazing scientific successes of the Soviet 'planned economy' (e.g., the hydrogen bomb or the launch of the Sputnik). In the context of forecasting work at RAND, also a new innovation economics developed (including work by Arrow, Winter, Nelson et al.; compare Hounshell, 1996).

Methodological starting points were systems analysis, operations research and comparable procedures. After early successes, many serious misconceptions of what 'forecasting' ought to be arose. In the sixties and early seventies, the mechanical 'prognosis' or 'trend prediction' type of work based on 'linear', i. e. sequential, models ceased to look interesting and the related forecasting activities fell into oblivion. This coincided with the end of the long growth euphoria following the War heralded by the first oil price adjustment; or the 'Limits to Growth' report of the Club of Rome. Although the 'linear' models of thought were discarded (e.g. by the project 'Hindsight'), some science policy communities further supported them for their legitimating power on research spending with no priorities (e.g. the project TRACES by the NSF 1968).

With the new evolutionary economics coming up with selection procedures and the notion of variety generation by new products, and the sociology of science working on the functions of social systems in science as opposed to technology or the economy emphasising the 'bounds of rationality' and 'negotiating systems', it became clear that there may be a new, different use of forecasting methods. Martin and Irvine (1984) coined the term 'foresight' and pointed to the communication or procedural power of it. The modern perception is that the actions of social systems, in particular science communities, cannot be predicted in terms of 'natural' laws, and

that future events in science and technology cannot be determined by extrapolation, but are shaped by these communities and a negotiating system.

However, this present understanding of foresight was available in the literature from the very beginning and, though less-well pronounced than nowadays, may have been found already in one of the earliest papers in the field: 'Policy making rests in part on anticipation of the future (...) and of the consequences of and responses to alternative lines of action. Many policy decisions require *foreknowledge* of events which cannot be forecast either by strict causal chains (...) or by stable statistical regularities (...).' A. Kaplan et al., 1950, p. 93 (emphasis added by H.G.). Even the forerunner of the term 'foresight' was coined in 1950! 'Verification' or 'falsification' of foresight results are, thus, meaningless ends.

## Functions of modern technology foresight ...

There is constant temptation for foresight to restrict itself to describing the potential supply of scientific and technical solutions and the study of their impact. However, it must do far more than depict the supply factors. The potentials and the risks of technology in the future depend just as much on the pressure of the social, ecological and economic problems expected to arise and make important demands on science and technology. For this reason, any discussion of problems must focus increasingly on factors relating to demand. How one might determine which basic values for innovation activities might be adopted world-wide in the medium and long-term perspectives, and forecast the resulting problems, of course, has no satisfactory empirical answer.

Because of many supply-demand mismatches, initially euphoric expectations of a new technology (mostly on the part of the scientific community) tend to be followed by increasingly cautious developmental phases before the market is finally satisfied. The use or rejection of innovative products often leads to new demands on research and technology, which is why it generally makes sense to speak of 'feedback processes'. Foresight has to incorporate aspects of industrial research and pure

research, and consideration must also be given to institutional support. These deliberations also call into question the possible expectation that a technology needs no more than a single action to regulate its impacts. Any hopes of being able to drop the accompanying pure research once the applied objectives have been achieved, will meet with disappointment; tomorrow's science-based technology is shaped continuously through targeted basic research.

## ... and the modern Delphi method

In foresight studies, the Delphi method is considered especially useful for long-range aspects (20 - 30 years) as expert opinions are the only source of information available, as in the ancient times. The Delphi method is one of those methods developed during the fifties at the RAND Corporation to make better use of the knowledge potential through group interaction. A questionnaire sent to experts more than one time is the medium for group interaction (Martino, 1983). The panel members will usually have widely varying estimates on each question in the beginning of the process and do not always shift their opinion under the influence of the assessments given to them by the other panellists. The main advantage of Delphi is that panel members can shift position without losing face if they see convincing reasons for doing so. The main problem remains, that the issues asked must be generated elsewhere; they do not originate from the panellists, they must come in by some ambassadors, as in the Delphic temple.

Most recent foresight surveys were undertaken by government agencies. Yet enterprises may also make effective these approaches. One pharmaceutical company in Germany has just concluded its own Delphi investigation on the future of general practitioneers (i.e.physicians in residential areas) and their ability to follow modern trends both in medical technology and in pharmaceuticals assuming an increasing use of information technology in the health care system.

An important function of modern foresight, in particular the Delphi technique, is moderation between different sectors of the economy, different disciplines in

science and different departments in politics and the public. How can one communicate in the best way on the future across these boundaries? We have very well established peer review systems to judge on priorities and on quality within scientific disciplines. Strategic business managers normally know enough in their core business. But we are now in the decade of transdisciplinary matters, the hyphenated technology areas herald the future such as bio-sensors, micro-systems, opto-computers, neuro-informatics, bionics.

How should we proceed with the long-term application-oriented basic research of the hyphenated type? I used this term deliberately, I did not make a mistake, I mean *long-term application-oriented basic research.* This is the research where one does not know what will be found out in the laboratory in the next month or year, but it is a research which does not only satisfy scientific curiosity and the enhancement of knowledge. It is a research with a definite long-term economic or social perspective. Let me mention climate research, health research, environmental research and so forth. In days of low budgets many business and policy makers think it is impossible to support each piece of interesting research only for the sake of good quality. One has to discuss the long-term orientation in which we invest our dear money. The public is convinced that science and technology are partly responsible for modern bottlenecks and problems and hence has a right to learn about priorities in technology and also the opposite, the non-priorities, what is down at the end of the list of priorities.

Consider the situation in which a company or a ministry has to decide which of two research programmes to support, A or B. Programme A is proposed from faculty A and industry A and the peers from discipline A have given their reviews. Programme B in conjunction with industry B originates from faculty B and the peers of discipline B made up their minds. Everybody did her or his best. But how to decide between them? Know the peers each other? Our science and technology system of tomorrow needs, alongside with disciplinary peers, new instruments to mediate between A and B, and here is another function of foresight, across the board.

Most sociologists of science assume that there is a positive relationship between involvement in a research area and assessments of it and that this relationship

derives from the tendency of scientists to select problems in areas where there is high pay-off for successful solutions and career. The tendency to overrate fields in which a person works may be termed 'bias'. Not only a tendency toward positive bias for fields in which researchers have beeen active was found, but also this bias to be stronger in less innovative sub-fields. As market signals fail to be useful for business strategy in the long run and expert assessment is not always objective, Delphi surveys may play a part in science and innovation management.

Let me give you only two examples from the first German Delphi: Specialist experts and thus future knowledge may not be available in some countries. The availability of experts in the case of biotechnology in Germany is mixed. Among the N=73 respondents who are all experts in biotechnology, many did not answer in particular sub-areas (most expressed for tissue and organs). The largest number of specialist experts (i.e. those working in the sub-area) among all experts in Germany is found in molecular biology but not in the sub-area of tissue and organs. An almost perfect correlation was found between the number of experts and their rating of German research performance. In sub-areas where we know more, we are good. In sub-areas where we are not advanced, we know little of the opportunities.

A test for Delphi expert bias in the energy area tends to support this view. Top experts rate the importance of their own research speciality significantly higher than the other experts - both in Japan and in Germany. At the same time the top experts downplay technical constraints in Germany (less so in Japan) in their own working area.

## Challenges of tomorrow

Contemporary technology policy has moved away from the inappropriate idea that the state can direct technological developments right down to individual national innovations. Equally outmoded is the idea that the state should be satisfied with the role of a subsidiary supporter of research leaving the future control of technology to anonymous market processes. Technology policy for the start of the 21st century

requires a middle course, i. e. one in which the state plays an active role as an intermediary between social systems negotiating (companies, associations, interest groups, science, consumers, media, employers' and employees' representatives, etc.). This intermediary role also must take account of the fact that national technology policy is increasingly restricted in its scope, both from above and below. This is because of the activities of the European Union and the efforts of regional bodies such as the Federal Länder in Germany to promote research on a regional basis.

The state's new role as active moderator necessitates a policy process which is co-ordinated with industry, science and society. However, co-operation does not occur by itself, since too many divergent interests predominate. If there is to be agreement over the possibly selective eligibility for support of technology, dialogues with other social players must be initiated and pursued on a permanent basis. Otherwise, it cannot be expected that lasting co-operation can be achieved or that the platforms to be created for a subject-specific understanding will become more than simply forums for the exchange of information. Don't we need integrated technology foresight to provide the knowledge base for these platforms?

Care has to be taken so that these social negotiations on technological wants should not stray too far from what is reliably known, and wander into the realms of speculation. In view of the typical recursive phases of science-related technological innovations, it can be generally assumed that everything that will dominate technology impacts in 10 years' time is already recognisable today. However, strategic planning in enterprises is necessary, aiming towards horizons even further in the future, because new technologies - especially those which will contribute to long sought solutions to problems - must be identified at an early stage.

As far as enterprises are concerned, a considerable improvement of the intramural knowledge base through participation in foresight surveys is reported. There is sporadic evidence that in some companies, during participation in the Delphi, it was felt that too little effort is dedicated towards strategic innovation management and some remedies have been taken. Some companies engaged in own investigations in the direction of an intramural breakdown of the overall national studies towards the special interest of their business areas or establishments, both in the manufacturing and the service sectors. One large chemical company in Germany, especially,

started with topics of the Delphi survey, made their own evaluation of the topics and built up a strategy until 2010. In working groups, the information was discussed and distributed. Some smaller-scale comparisons of the business portfolios to the future-oriented areas are also being done in other companies, sometimes assisted by external consultants. These activities are largely confidential.

## Opportunities of technology foresight - Scoping future applications for policy, business and society

Several lessons can be learned from the application of foresight methods. Firstly, it is important to note that a foresight activity should not be a single event but should rather become part of a broader strategy which deals with strategic orientation. Secondly, the individual results of a survey should trigger various follow-up activities within the organisation, for example, workshops on selected items. Thirdly, going through the process of a foresight survey itself is a very valuable undertaking, since great numbers of experts are motivated to think critically about future scenarios favoured or rejected by their peer colleagues. Fourthly, for the company, the benefits of a foresight survey should not only be seen as gains in information and reputation among its clients, but also extended to the internal situation: the strategies for dealing with challenges of the future must become broad company issues which are to be discussed and supported by many employees, thereby contributing to an increase of in-house motivation and identification.

From the social point of view, the direction to be taken in the future may be derived from the increasing demands made on technological development in terms of minimal use of resources, elimination of emissions, recycling economy and sustainable development. These demands require the creation of the new framework conditions, especially those of a non-technical nature, such as legal regulations. Equally important as such ecological problems is the sociopolitical dimension - in particular the unemployment problem. From the point of view of technology policy, we need a form of technological development which encourages wide-ranging

participation by employees in various sectors, and firms of varying size, which leads to an open market with no specific centralised structure.

It is in the nature of long-term foresight that it is burdened with a high degree of uncertainty how the decision-making groups will behave; it is not unusual for wishful thinking, arising from the most diverse motives, to be presented as a probable future event. Taking the long term view, the motivating power of guiding visions is helpful in that it releases social energies and the willingness to undertake concerted action. Long-term lead projects in technology can produce lasting motivation and unite powers which can work towards problem-solving requirements recognisable in the long term, and also produce successes along the way (through desirable multiplier effects).

Lead projects in technology which represent outline solutions to large, global, economic, social and ecological problems, and especially the visionary view of technological development and the challenges now facing us, throw up other, more radical questions of technology policy than those set out here for the time being. It was not the aim of this brief essay to give the questions more concrete form. However, it has been possible to indicate that technology assessment through foresight can itself provide the key to far-reaching changes in future policy. The technology policy of tomorrow must be in place to shape technology policy in the long run.

In Germany, generally, there is a public tendency to be critical about new technology, often without going into any detail. After some foresight studies were published - rich in presenting visions of detailed trends in science and technology - several 'second thought' articles concerning the public understanding of technology by science journalists were published. The message in these articles is basically that dogmatic scepticism against new technology as such should be replaced by public reservations against *certain* technologies. A *technology-specific* public debate on the future of the so-called 'science and technology nation' need to be triggered off. From these observations one is tempted to conclude that the assessment and foresight processes have a lasting and direct impact on society as it affects our notions of future technology. By reflecting future opportunities and impacts of technology, we reflect our procedures to get there.

## The second answer

To answer the second part of my basic question: I am not fully convinced that our present society has already made optimal use of forsesight for its own progress. There is great potential if we look forward. I know that some people are very sceptical and see no progress in technology and society. For these, foresight is both costly and irrelevant. Let me list some examples of what has changed in the *past* 25 years since this institute operates. I do not think that in the *next* 25 years we are really not getting anywhere. I conclude by quoting from our anniversary report a list of novelties since then:

'Germany was in the grip of economic recession; in almost all OECD countries the unemployed were standing on the streets. Social Democrat Chancellor Willy Brandt has resigned over the affair of a GDR spy, and the Federal Minister of Economics, Karl Schiller, a professor of economics, felt he could no longer vouch for his Keynesian policy of demand. On some Sundays at that time you could go for a walk along the motorway. Chancellor Schmidt had decreed 'car-free Sundays'. Germany, at that time, did not have: a Federal Ministry for the Environment, a Green Party, relatively well-developed local public transport, separate refuse collection, private TV channels, cable TV, Internet, text programmes, 16 German states, chlorine-free or environmentally friendly paper, industrial robots, genetically engineered tomatoes, CDs, milk bottles, a solidarity tax (to help reunified East Germany). There was no State of Bosnia, no German age-care levy; there were no energy-saving lamps!'

We would probably be irritated by a return to the year 1972; the changes that have occurred since then, albeit imperceptibly, have been too intensive. However, many problems have remained with us and new problems occurred, so that we are sure that the work of ISI, which consists in uttering answers - and reformulating - complicated questions thrown up at the interface of technology, industry and society, will continue with unabated impetus.

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# The Economics of Hope

*Essays on Technical Change, Economic Growth and the Environment*

***Christopher Freeman***

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# 11 Technology, progress and the quality of life*

## I. Introduction

In a time of cholera, AIDS, earthquakes and volcanic eruptions, renewed famine in Africa, assassinations, nationalistic, sectarian hatred and killings, wholesale corruption in numerous governments and business enterprises, it is difficult to find grounds for optimism about the quality of life or the possibility of progress.

After the terrible Lisbon earthquake of 1759 and in the midst of the Seven Years' War, when, as Voltaire put it, men were ready to slaughter each other enthusiastically for sixpence a day, people were driven to reflect in a similar way on natural and social disasters. Frederick II, who provoked the war if not the earthquake, remarked that wars, devastations and plagues would always be with us. Others maintained that in spite of these disasters this was still the best of all possible worlds. Whatever is, is good. This facile, complacent optimism drove Voltaire to write his classic masterpiece, *Candide*, although even before that he asked rhetorically, 'If this is the best of all possible worlds, what are the others like?'

If this chapter nevertheless indicates some grounds for optimism, this is not so much because of what the quality of life actually is for most people, but because of what it might become. Policies for science and technology must always be a mixture of realism and idealism.

The chapter will first of all briefly discuss the development of science and technology policies since the Second World War. During the lifetime of SPRU, the emphasis has shifted from an essentially science-push framework in the 1950s, through a phase of preoccupation with economic growth and management of innovation in the 1960s, and on to a wider concern with the environment and quality of life since the 1970s. Within this context, the second part of the chapter will discuss some quality of life issues which are only indirectly related to economic growth: civil liberty, quality, variety and choice in new products and services, and social equity.

On an occasion such as the twenty-fifth anniversary of SPRU and

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dealing with such a topic as 'quality of life', where subjective values are ever-present, much of what I say will be in the nature of personal comments, rather than the results of any organised research.

I first heard of 'research and development' when I was a student at the London School of Economics. However, it was not from economists. The first lecture I ever heard which dealt specifically with the links between organised research and development, technological competition and the associated growth and decline of firms and industries was by an Irish physicist, J.D. Bernal. In 1939 he wrote his classic book entitled *The Social Function of Science* which attracted the attention of Keynes and included the first systematic attempt to measure the total research activity in British industry, government and universities.

More than Schumpeter, Bernal perceived that the allocation of resources to the various branches of organised and professionalised R&D and related scientific and technical services and their efficient management had become crucial for the development and performance of enterprises and nations in war and peace alike. Around this central idea he was able to build up a critical analysis of the use and misuse of science and technology in Britain and other countries, and thereby to establish 'science policy' and 'technology policy' as important issues of public debate and government policy. To this day, his book represents an agenda for research in social studies of science.

Half a century later groups like SPRU in various parts of the world have done much to fill in the picture which Bernal sketched out in the first part of his book: 'What science does'. The tenfold increase in resources for R&D which he advocated in 1939 seemed at that time absurdly Utopian to many people. Nevertheless, it has in fact been realised and exceeded in most industrial countries on approximately the time-scale which he envisaged. We have learned to define and measure the R&D system a little more accurately than he and his colleagues so that the 'map' of the world science–technology system is both more comprehensive and more detailed, even though there are still many gaps and inaccuracies.

We have also learned much more about other areas which were neglected by Bernal and his contemporaries, for example, the diffusion of innovations and the uses and limitations of a variety of output measures for the science–technology system. In all of this work SPRU has made original contributions which go well beyond what Bernal achieved. However, when it comes to the second part of Bernal's agenda ('What science could do'), the position is different.

## II

In the twenty-five years after the Second World War GNP grew at a high rate in Europe, Japan and North America and also in some Third World

countries. Increased investment in science and technology (S&T) certainly played an important part in this accelerated growth, which was probably more rapid than in any previous period of world history. To this extent Bernal's hopes and expectations were vindicated.

However, the improvements in human welfare which he had hoped would be associated with increased prosperity have only been partly realised and in many parts of the world not at all. Moreover, the high expectations which he had of the communist countries have manifestly not been fulfilled, as he himself recognised in the 1950s despite the very big investments in R&D which most of them made, especially the Soviet Union. In part of course this was for the very reasons that he analysed: the vast increase in the world's military R&D. From the recent work of Soviet colleagues it seems that this bias was even greater in the Soviet Union than previously estimated. To keep up in the arms race, the Soviet Union seems to have devoted about three-quarters of its R&D budget to military–space objectives, leaving less than 1 per cent of GNP for civil objectives. The high growth rates achieved in Eastern Europe in the 1950s and 1960s gave way to stagnation and decline in the 1970s and 1980s and many environmental and social problems became more acute. In the OECD countries too, growth slowed down, unemployment once more became a serious problem and environmental issues came to the fore. In the Third World the structural crisis was far more severe. However, technology policy and science policy have still not fully responded to the new issues and still make more connections with military and economic problems than they do with wider social problems and quality of life issues.

In the first phase of post-war science policy, (Table 11.1) the experiences of the war still dominated public policies. Not only did the Cold War mean that military expenditures predominated in the superpowers, as well as in Britain and France (although not in Japan and Germany), but civil science and technology were also profoundly influenced by the military model and especially the Manhattan Project. The devastating weapon systems achieved by this and other projects, such as rocket and radar projects, led people quite naturally to think that big science and technology and big government laboratories could achieve similar results elsewhere. Physics enjoyed enormous prestige and most science advisers to governments were physicists in this period. Nuclear physics and nuclear energy occupied far more government attention and accounted for far greater expenditures than agriculture or other civil technology. Stefan Dedijer, who established the first academic Science Policy Unit in a European university in Lund in Sweden, and helped to inspire the establishment of SPRU, left his own country, Yugoslavia, in the 1950s in protest against the extreme distortion of R&D by huge nuclear projects. The Studiengruppe für Systems Forschung in Heidelberg (which also preceded SPRU) made a number of studies, which, like Dedijer's work showed the extreme imbalance in science and technology towards military objectives.

**Table 11.1** Three phases of science policy

| 1 | 2 | 3 |
|---|---|---|
| Manhattan Project, military aircraft, V1, V2, missiles, radar, guidance systems | Nuclear reactors, CERN, ESRO, NASA, ELDO, etc. Civil aircraft | ERAs (Japan), ESPRIT, 'Human Frontiers' Programme |
| Science Advisory Councils | Science and Technology Councils and Ministries | Science, Technology and Industry Departments. Technology Assessment bodies |
| Physicists<br>Chemists | Physicists<br>Economists<br>Engineers<br>Chemists | 'Hard sciences'<br>Biology, ecology<br>Economics<br>Social sciences |
| Military R&D<br>Basic research<br>Government labs<br>Universities | Applied research<br>Industrial R&D<br>Big science & technology<br>Universities | 'Generic technologies'<br>Networks<br>Systems<br>University–industry links |
| J. Bernal, *Social Function of Science* (1939)<br>V. Bush, *Science the Endless Frontier* (1948) | I. Svennilson, *Science, Economic Growth and Government Policy* (1963)<br>Brooks Report (OECD, 1971), *Science, Growth and Society* | R. Nelson and J. Salomon, *Science and Technology in the New Economic Context* (1979)<br>Sundqvist Report (1989), *New Technologies in the 1990s: A Socio-Economic strategy* |
| Weapon systems | Economic growth<br>Weapon systems | Environment<br>Weapon systems<br>Economic growth<br>Quality of life |

Of course the Science Advisory Councils, dominated by physicists as they were, were not altogether unmindful of economic and social issues. However, as in the case of nuclear weapons and nuclear power, they tended implicitly to assume a science-push model, in which the benefits of scientific discovery would almost automatically flow through into technology (often revealingly called 'Applied Science', as at that time in our own School of Engineering here in Sussex), and thence into the economic system. It was also commonly assumed that there would be major 'spin-off' or 'spill-over' benefits from military R&D to the civil economy.

However, already in the 1950s, economists such as Dick Nelson and Nathan Rosenberg in the United States, Charles Carter and Bruce Williams in this country, Perroux in France, Dahmen and Svennilson in Sweden began to transform this situation. Moreover, the large civil aircraft projects, such as Concorde, and the various nuclear reactor projects which imitated the military model began to run into serious problems of cost overrun. Derek Price (1963) in his book *Little Science, Big Science* pointed out that the exponential growth of scientific activities, so successfully advocated by Bernal, could not continue indefinitely into the future. Both industry and government began to recognise the need for far more careful project evaluation than had been the case in the days of headlong expansion which followed the Second World War.

During the second phase of post-war science policy, at both the national and international level, in the UN, the OECD and the EEC economists began to be seriously involved in the debates on science and technology policy, the writing of reports and the advisory bodies. Svennilson played the leading part in writing the OECD report on *Science, Economic Growth and Government Policy* in the early 1960s, to which both Keith Pavitt and I also contributed; Bruce Williams became an adviser to the British Ministry of Technology, and most countries began to appoint economists to similar positions. Growth and economic performance became the main concern of science and technology policy, even though in many countries military influences remained extremely strong.

Economists, although sometimes more cautious than physicists, certainly did not advocate wholesale curtailment of R&D and other S&T expenditures. On the contrary they often provided hard evidence of the beneficial effects of these activities. However, they probably did succeed in injecting greater discrimination into the allocation of resources, through a more careful consideration of potential costs and benefits. They also largely succeeded in their critique of the hitherto prevalent 'science-push' model and in putting technology policy more firmly on the agenda as well as science policy more narrowly conceived. Indeed some of them went too far in their emphasis on 'demand-pull' until corrected by Mowery and Rosenberg (1979) in their classic piece in *Research Policy*.

In retrospect, the 1960s were a golden age of growth although by the end

of the decade many social and environmental problems began to cast a shadow over the triumphs of economic growth and growth-oriented R&D. The oil-based energy and materials-intensive mass production system, which had been so successful in the post-war period and indeed during the war itself, began to bump against limits of various kinds. Dissatisfaction became widespread with working conditions in large mass production factories (as so evident in France in 1968), with the quality of many consumer durables, and the philosophy of 'consumerism' itself, with the destruction of urban and rural amenities and quality of life brought about by mass use of automobiles, the threats to wildlife from mass tourism and unrestrained commercialism, and the poor quality of the mass media and mass education. All these and other unpleasant consequences of growth led to widespread questioning and criticism. The MIT study on *Limits to Growth* (1972) became the best-known general critique of growth policies, although there were many other manifestations of this dissatisfaction, including of course the rise of the 'Greens' and Scitovsky's (1976) critique of *The Joyless Economy*.

All of these developments contributed to a third phase in science and technology policy, which was also associated with a radical shift towards information and communication technology, gathering force in the 1970s and 1980s. Environmental and ecological issues became more prominent in policy-making. Quality of working life and worker-participation in technical change began to be taken more seriously. Biologists and even sociologists began to be invited to join top-level government advisory bodies. OECD reports such as the Brooks Report (OECD, 1971) and even more the Sundqvist Report (OECD, 1989) both reflected and stimulated these developments.

## III

From 1 July 1991 SPRU began work on one of the most difficult and challenging projects: 'Global Perspective 2010: Tasks for Science and Technology'. This project, led by Tom Whiston and sponsored by the European Community through its programme on 'Future Applications of Science and Technology' (FAST) enabled us to take up again some of the main quality of life issues which we began to research in the 1970s in our own programme for the Research Councils on Social and Technological Forecasting. In that programme we were involved in a critique of the MIT work on *Limits to Growth* (Cole *et al.*, 1973) and a wider comparative analysis of many different computer models of the future development of the world economy (Freeman and Jahoda, 1978). Now, nearly twenty years later, in embarking on our new EC project, it may be useful to look back as well as forwards and try to see what can be learnt from our earlier work.

In the 1960s it was commonly assumed that high economic growth rates

could be extrapolated into the future and that unemployment was a thing of the past. It was also often assumed that high rates of energy production and consumption could be extrapolated with fixed energy coefficients related to gross national product (GNP).

Simple extrapolation is of course a dangerous technique in forecasting.

A trend is a trend, is a trend, is a trend,
But when and how does it bend?
Does it rise to the sky?
Or lie down and die?
Or asymptote on to the end?

The validity of extrapolation of the trends of the 1950s and 1960s was one of the main points of the controversy with Denis and Donella Meadows (1972) and their colleagues at MIT in the early 1970s. In our books and papers we criticised some of the basic assumptions used in the MIT models and their main conclusion that zero growth was the only way to avert collapse. We argued that there was too much extrapolation of earlier trends and that both technical change and social change were underrepresented in the MIT models. Since in any computer modelling the assumptions determine the outcome ('Malthus in, Malthus out') the extrapolation of exponential trends in population growth, materials and energy consumption and pollution would necessarily lead to the collapse of the system. We maintained that a combination of technical and social changes could lead to a different pattern of growth and that the MIT models had confused a particular mode of materials and energy-intensive growth with the problem of economic growth in general.

We also argued that the pattern of growth which was especially characteristic of the US economy in the nineteenth and twentieth centuries would not necessarily be the standard for other countries in the next century. If materials became scarce and expensive, or if their use created unacceptable pollution hazards, we argued that technical changes could (and very likely would) facilitate reduction in materials intensity, substitution between materials, innovation in processes, recycling and other changes which would lead to a different pattern of growth. There has in fact been a change in materials intensity and energy intensity of production in the 1970s and 1980s (Table 11.2), which suggests that our ideas about a new pattern of growth were not too far removed from reality, even though we still have a long way to go. Information and communication technology can greatly facilitate reduction of energy and materials intensity.

We did not use the expressions 'sustainable growth' or 'sustainable development' in our books in the 1970s. These expressions entered the debate somewhat later, but they convey the sense of what we were suggesting in our comments on the 'composition' of growth and the distribution of the fruits of growth (Cole *et al.* 1973: p. 10).

**Table 11.2** Energy intensity of GDP (tonnes per 1000 ECU)

| | *1973* | *1988* |
|---|---|---|
| Denmark | 0.46 | 0.31 |
| France | 0.44 | 0.36 |
| Germany (FR) | 0.51 | 0.40 |
| Italy | 0.46 | 0.36 |
| Netherlands | 0.59 | 0.47 |
| Spain | NA | 0.42 |
| UK | 0.62 | 0.45 |
| EC | 0.52 | 0.41 |

*Source:* CEC, *Panorama of European Industry*, 1990.

## IV

Economists have always maintained that growth of GNP is quite distinct from happiness or improvement in the quality of life. Nevertheless the objective of increasing per capita GNP has often been equated with improvement in the standard of living or even quality of life. Nor is this transposition entirely misplaced. For people suffering from malnutrition, homelessness, disease and poverty on a vast scale, it is difficult to conceive of a substantial improvement in the quality of life without the kind of growth in per capita production and consumption which is measured, however crudely, in GNP indices. To continue world-wide economic growth, especially in the Third World, is a necessary condition for the achievement of many other quality of life objectives. Therefore in our work we should continue to pay attention to long-term sustainable forms of economic growth.

However, in the SPRU contributions to the debate on *Limits to Growth*, in the 1970s we insisted on two important qualifications to simplistic growth policies. These qualifications concerned both the distribution and the composition of GNP. Clearly it is possible to have quite high levels of per capita GNP growth, as in Brazil in the 1960s and 1970s, whilst leaving a large proportion of the population in the direst poverty and even becoming worse off. In Britain between 1979 and 1989 the income of the richest households increased 40 per cent whereas that of the poorest fell by 5 per cent. Again, some increases in measured GNP, as in military production, may bear no relationship to improvements in the standard of living. In polluting forms of growth, damage to the environment and loss of amenity may be so great as to create a general deterioration in quality of life, even though GNP growth rates are high.

Finally, people do not live by bread alone. Many other factors affect perceptions of the quality of life as well as the production and consumption of food and other necessities. Among these are civil liberty, social equity, opportunities for satisfying employment, conditions at work, standards of design, leisure amenities, the urban and rural environment, personal and group relationships, women's rights, the state of the arts, levels of crime, international relationships, and personal and public health standards. For many people some combination of these factors may often be more important than increases in per capita income and expenditure. Some forms of economic growth may of course promote the improvement of many aspects of the quality of life. For example, there is generally a connection between higher standards of living, health and life expectancy. But the correspondence is not automatic and cannot be taken for granted, either in this or other areas. It is therefore essential to pursue quality of life objectives for their own sake and not to pursue the reductionist path of trying to fit everything into the growth and measurement of GNP.

The lack of one-to-one correspondence between GNP and quality of life and in particular concern with environmental damage and other negative externalities of economic growth led to many attempts in the 1970s to improve GNP measures with quality of life indicators (see for example, Miles, 1985). Other attempts were made to develop composite indices of social welfare or new types of revised GNP indicator which took greater account of environmental and social issues. It must be said that these attempts did not prove very successful and perhaps they were misconceived from the outset. Almost by definition some of the most important indicators of quality do not lend themselves to quantitative measurement. Even when quantitative measures of quality or life can be used, they are not easily combined. The separate consideration and assessment of various quality factors is therefore essential in developing both policies for economic growth and for science and technology, as well as their interrelationship. The arts and humanities necessarily play a much bigger role in quality of life issues.

It might appear at first sight that quality of life objectives bear little or no relationship to science and technology policies, but by taking a number of examples I hope to show that there are very important connections in almost all instances. Clearly, the direction and scale of some types of R&D may have a great influence on health, conservation, pollution prevention and the efforts of Third World countries to overcome poverty. Twenty years ago a group of us in SPRU and IDS advocated a major reorientation of global R&D in this direction and away from a predominantly military emphasis. This became known as The Sussex Manifesto and a version of it was published in *Science Studies* (Cooper *et al.*, 1971). However, the most important connections are not simply in R&D expenditures but also in the organisation of scientific and technical activities and the methods of evaluation, assessment and regulation of discoveries, inventions and

innovations. These were the main concern of Part 2 of Bernal's book. The examples which I shall take are: civil liberty, choice, quality and variety in the design of new products and systems and social equity.

One of the few generalisations in political science which has stood the test of time is Lord Acton's dictum: 'Power corrupts and absolute power corrupts absolutely'. It has been demonstrated time and again that the concentration of economic and political power can be extremely dangerous. Since the time of Aristotle or earlier human beings have been concerned to devise checks and balances in social institutions to guard against the abuse of power. History shows only too well that this is not easy since the restraints are constantly in danger of being circumvented or destroyed. This is just as true in the area of science and technology policy as any other. Even in the small world of SPRU we have learnt in the last twenty-five years that government departments and industrial organisations sometimes do attempt to suppress evidence and critical comments and to manipulate reports. It does not come easily to any powerful organisation to welcome informed public criticism of its policies. Nevertheless, this spirit of toleration and encouragement of alternative points of view is fundamental for a civilised way of life.

Among the most important constraints on the abuse of power are freedom of speech, freedom of publication and freedom of information. These freedoms are also fundamental to the science system and over the years scientists have by and large succeeded in establishing sophisticated self-regulating institutions to maintain these freedoms and the quality of scientific research. Harold Laski and other political scientists have shown that the rise of these norms in the scientific enterprise was very closely associated with the rise of civil liberty in general in the seventeenth, eighteenth and nineteenth centuries. The accepted norms in the science system recognise, just as John Stuart Mill argued in his essay on Liberty, that no one has or ever can have a monopoly of truth, that all theories and hypotheses benefit from a continual process of critical debate, re-examination and testing, including whenever possible experimental validation. The world-wide diffusion of these norms in the science system represents a recent and an extremely important reinforcement for those wider institutions which promote civil liberty in society at large, thus giving new grounds for hope for the future of democratic institutions.

C.P. Snow (1961) in his essay on 'Science and government' expressed the more cynical view that science could flourish just as well in the totalitarian political systems of Nazi Germany or Stalinist Russia as in liberal democracies. He was wrong. Whereas some results can of course be achieved by the application of established technologies, especially in the military area, in the long run both science and technology depend on iconoclastic challenges to established theories and methods, on freedom of criticism and open debate.

Anyone who imagines that nothing has changed in the Soviet Union, has

forgotten or never knew what life was like under Stalin. They should read or reread the *First Circle*, or the Reports of the Genetics Conference, or the trials of Trotskyists and Bukharin in the 1930s, or see the film of *A Day in the Life of Ivan Denisovich*, or read *Darkness at Noon*. All of us would of course like to see higher living standards in the Soviet Union and less queueing, no one more than the Russians, but so far as civil liberty is concerned the shadows which still remain are small compared with the horrors of the first half of this century. Sakharov and his colleagues made a very important contribution to this change.

The change from the first half of this century is even more remarkable in Germany and the countries which were occupied during the Second World War. Moreover, this also applies more recently to many countries of the Third World. The rejection of military regimes in many countries of Latin America as well as in Southern Europe is especially notable. Even in South Africa and Haiti there are now real grounds for optimism.

Of course there are still repressive regimes in various parts of the world and there are still countries like my own, with a long tradition of civil liberty where ugly abuses of police power have recently occurred. Nowhere can the very real gains in civil liberty be taken for granted. Nevertheless there are legitimate grounds for optimism. Social innovations such as Amnesty International reinforce world-wide public opinion, which now finds constant expression in the international institutions of the world community of nations. This is something new and hopeful in the world, even though the last report of Amnesty International in 1991 points to many countries where torture of prisoners and the work of 'death squads' are still everyday occurrences.

This conclusion has been challenged in relation to the recent industrialisation of the Asian NICs and China. Much of this took place under authoritarian regimes. But one of the authors and advocates of rather authoritarian policies in that period, Lee Kuan Yiew, the former Prime Minister of Singapore, has recently acknowledged that further progress of these countries too depends increasingly on democratisation, because the complexity of modern technology requires a highly educated and more participative work-force, who will not easily accept authoritarian norms (*Economist* magazine interview, 9 June 1991, pp. 18–19). An essentially similar argument was put with even greater conviction by Slater and Bennis (1990) in their article 'Democracy is inevitable' in the *Harvard Business Review*. This was originally published in 1964, and was recently republished with the legitimate claim that events over the last quarter century have vindicated the views they put forward.

It is true, however, that when it comes to technology, even though many of the same principles apply, as in science, there are also some big differences. It is not only a matter of open discussion and free criticism but also a matter of choice based on a variety of physical artefacts and systems, which can be seen, tested and used. Organised markets provide the

opportunities to select, accept or reject new and old products and processes, for both individuals and organisations. Markets also provide incentives to develop and improve such products and processes. As both Marx and Schumpeter insisted, the capacity to generate a continual flow of innovations has proved one of the greatest evolutionary advantages of capitalism. Hegel described history as the 'world court of judgement' but it is the world market which performs this function in many ways.

However, the freedom to choose between alternatives in the market, rightly extolled by Milton Friedmann (1980) as an important extension of human freedom, has to be qualified in several important respects. The first and most obvious is the case of safety and environmental standards. The problems which have arisen in almost every industry, but especially in food, chemicals, energy, construction and transport, have shown that it is quite impossible to promote quality of life objectives without some form of public regulation of quality and safety standards and of the hazards and externalities which are inevitably associated with diffusion of innovation. This means that choice in technology will always have a political and social as well as an economic dimension.

The scale and intensity of these problems has led in many countries to the development of some form of 'technology assessment' (TA). Sometimes it has a different name but this function is likely to become increasingly important with the growing complexity of new technologies. This complexity means that parliamentary institutions may lack the expertise to assess what are often conflicting claims about the merits and dangers of new technologies. Sometimes this function can be devolved to those primarily and directly concerned. Often this is not possible, however, because of conflicts of interest, the scale of the problems or the dangers of 'expertocracy' and monopoly.

This means that technology policy research must be increasingly concerned with the problems of TA and international comparative studies can be especially valuable. The idea of 'constructive' TA first introduced by Arie Rip, Wiebe Bijker and their colleagues (Bijker *et al.*, 1987) and by the Netherlands OTA seems to be especially interesting. TA has too often been viewed as a negative way of safeguarding society against dangers or even as a form of 'technology harassment'. It must of course have the role of reducing hazards; however, it also has a very important positive function—to help in the face of great uncertainties, difficulties and conflicts to find constructive solutions so that society benefits from potential innovations. The research of Van de Wen (1991) and his colleagues in the University of Minneapolis has shown how important this role of institutional innovation can be in the case of Cochlea implants and many other innovations, especially in the medical field. The systematic representation of potential users and other affected groups is especially important.

It is here too that sociologists have made an important contribution to

technology policy studies with their concept of social construction of technology (Mackenzie, 1990) and their critique of the idea of 'natural' trajectories. Economists often make use of the expression 'natural' to describe phenomena which are far from natural, such as the 'natural rate of unemployment', 'natural rate of interest', 'natural monopoly' and 'natural trajectories in technology'. All of these are social and not natural phenomena; all of them are the result of human actions, human decisions, human expectations, human institutions.

It is of course possible to discuss this as a purely semantic issue. Shakespeare in *King Lear* used the word 'natural' in two completely different senses. On the one hand he used it to describe the traditional norms of behaviour in a feudal hierarchical society: it was 'unnatural' for daughters to behave towards fathers in the way that Goneril and Regan behaved. This is the way that economists use the expression 'natural'—to describe stable norms of social behaviour. However, Shakespeare also used the word 'natural' to describe a totally different phenomenon—the rebellion, like that of Edgar, against archaic and outdated institutions. Both continuity and discontinuity can be described as 'natural'.

The sociologists of science have compelled us to face this semantic problem and to decide which (if any) kind of 'naturalness' we are talking about. In doing so, they have pointed to the extremely important role of institutional development which surrounds the emergence of any major new technology and enables us to shape and influence it before it hardens into a standardised system, which we then (too late) regard as a 'natural' system.

This leads to a second general problem of the market as a form of selection and improvement of new products and systems: this is the locking-in effects and concentrations of power which may result and may for a long time inhibit the development and introduction of alternative and possibly superior technologies. The example of QWERTY, thanks to the work of Paul David (1985) will forever be quoted in this context, although he and Brian Arthur have shown that standardisation and lock-in effects go far beyond this beautiful example. Because of scale economies, complementarities and institutional inertia (Perez, 1983), lock-in effects are pervasive throughout the economy as any major technological system matures.

Scitovsky (1976) in his book *The Joyless Economy* tried to account for the existence of widespread consumer dissatisfaction side by side with the huge growth of per capita incomes. One part of his explanation related to the loss of choice represented by such lock-in effects of mass production. He describes the mass production lifestyle as one where millionaires are satisfied because they can afford to indulge all kinds of eccentric tastes. Conformists who share their tastes with millions of others can also be satisfied by a mass production lifestyle. However, that still leaves many people deeply dissatisfied with the design and quality of mass-produced

articles and services and the conditions under which they are produced. He concluded: 'Modern technology creates great possibilities but it also pushes us towards standardisation and uniformity, both of which inhibit our ability to exploit the possibility it creates.'

That was written in 1976. Since then we have seen considerable progress in the flexibility of production systems, including more flexible mass production systems able to provide a wider product mix, a better quality of product and a more rapid response to changes in consumer tastes. This is another break in trend. Nevertheless, it still does not mean that all the problems to which Scitovsky drew attention have been resolved. Small variations in the existing product mix and lifestyle may be less important than substantial variations which are still inhibited by lock-in effects and lifestyle pressures of conformism. The preservation of the capacity for more radical innovations remains extremely important. In part this can be achieved by the kind of small firm policies adopted in many countries as awareness grew of the importance of promoting alternative sources of technical change. Innovative small firms must be complemented by the preservation and enhancement of the university tradition of path-breaking innovative R&D.

Piore and Sabel (1982) may be right in thinking that networks of small firms provide greater work satisfaction to those who work in them as well as to consumers. However, it cannot be assumed that the change of techno-economic paradigm towards information and communication technology automatically ensures that the days of giant oligopolistic firms are over and that a new era of small networking firms has begun. On the contrary, much evidence points to a new wave of concentration precisely within the IT heartland industries, especially computers and telecommunications. In the 1970s there was a burst of small firm start-ups associated with the microprocessor and the new generations of computers. Firms like Nokia, Nixdorf and Norsk Data flourished in Europe, Wang and Apple in the United States and many small cloning firms in Asia. Now a reverse process of reconcentration is taking place. It is true of course that the biggest firm of all, IBM, is experiencing severe problems in adjusting to the decline of its mainframe business and in making a flexible response to the new types of competition. However this competition comes increasingly from large Japanese firms. Jim Utterback (1991) has shown that the number of firms associated with the emergence of such diverse products as automobiles, typewriters and television in the United States fell very rapidly as each industry matured. ICT is unlikely to be exempt from the concentrating and scale economy effects which have affected other new waves of technology in the past (see Table 4 in Chapter 5).

In the preparation of our recent book *Technology and the Future of Europe* (Freeman, Sharp and Walker, 1991), we found that there were strong tendencies towards oligopolistic concentration in many of the new industries and concluded that some major international social innovations

will be needed to cope with these world-wide oligopolies in the Triad of Japan, the United States and the European Community. This was also a major concern of Luc Soete (1991) and his colleagues in the recent TEP Project for OECD.

## V

As in the case of political power, the dangers of abuse of concentrations of economic power are ever-present and the need for appropriate checks and balances is also a continuing one (Whiston, 1990). Nor are the two unconnected. The past evidence is very strong that those wielding large concentrations of economic power frequently abused their position to reinforce political movements which sought to destroy civil liberties. Consequently the integrity and independence of those making technology assessment and competition policy will be a key issue in the development of new institutions, both nationally and internationally.

Not only is civil liberty essential to a satisfactory quality of life; so too is the element of social equity. Extreme disparities of wealth and income not only jeopardise civil liberty and inhibit technological choice, they also endanger industrial and national security and are offensive to common decency. In particular, the disparity between rich and poor countries is so great that almost everyone accepts the need to reduce this gap and many international institutions have this as one of their main goals.

In most parts of the world absolute as well as relative poverty constrains choice to a bare minimum and talk of freedom of choice is often empty air. As Anatole France ironically remarked: the rich and the poor are equally free to sleep under the bridges of the Seine. (Today, you do not have to go to Paris to find people sleeping under bridges. There are even more in London.)

The satisfaction of very elementary human needs for shelter, nutrition, health and clothing is still the most urgent priority for huge numbers of people in the Third World as well as for substantial minorities in the richer countries. This does not mean, however, that they all have to accept the same pattern of consumption or way of life.

Two apparently contradictory principles have to be reconciled: the biblical principle 'Do unto others as you would be done by' and the Bernard Shaw principle: 'Do not do unto others as you would be done by because their tastes may be different'. They are not so irreconcilable as they might appear at first sight. The biblical principle recalls our common humanity and shows us a way to develop a sympathetic insight into the needs of others by prohibiting discrimination against people because of race, nationality, gender or other attributes. The Shaw principle recalls the fact that people have a great variety of tastes and needs and just as we should not want someone else to force their tastes upon us, so we ought not

to try to enforce our pattern of consumption or way of life on others.

In our work on *World Futures* we calculated that it would be possible for many Third World countries to catch up in living standards with the OECD countries by growing more rapidly for half a century or so. What in fact occurred in the 1980s was that only a few of the NICs in Asia succeeded in achieving these high growth rates whereas most of the Latin American and African countries suffered severe setbacks, and so too did the Soviet Union and many East European countries. Whereas in the 1960s and 1970s Brazil, Venezuela and Mexico had vied with South Korea and Taiwan in their rate of growth, a stark contrast between Latin America and East Asia emerged in the 1980s (Table 11.3). In many Latin American countries both education and R&D expenditures have been cut in response to the international financial pressures to reduce budget deficits, thus further undermining the prospects for future growth. The scenario of the Third World catching up with the richer countries seems in many ways more remote than in the 1970s.

**Table 11.3** Divergence in national systems 1980s

| *East Asia* | *Latin America* |
|---|---|
| Return to high levels of economic growth | Stagnation or negative growth |
| Moderate inflation | Galloping inflation |
| Debt burden reduced or eliminated | Persistent heavy burden of debt |
| Major wave of Japanese investment | Low level of US and other investment |
| High rate of technical change and productivity growth | Low rate of technical change and productivity growth |
| Rapid growth in total R&D (1–2% GNP) | Stagnation or decline in R&D (<0.5% GNP) |
| Industrial R&D growing most rapidly and proportion of total reaching 40–65% | Industrial R&D low and stagnant (<30% of total) |
| Strong and fast-growing electronic industries with strong exports | Weak electronic industries with very little export |
| Expanding higher education with output of engineering graduates per 100,000 population >Japanese | Deteriorating higher education with output of engineering graduates per 100,000 population much <Japanese |
| Relatively low income disparities | Very high disparities of income distribution |
| Universal access to education | Big disparities in access to education |

However, the East Asian countries do demonstrate that given the right combination of economic, science, technology and education policies, considerable catching up is possible even in rather unfavourable global economic circumstances. Andrew Tylecote (1990) has shown that greater equity in income distribution and education in East Asia has been an important factor in their growth, and there is a remarkable unanimity about the beneficial effects of radical land reform after the Second World War (e.g. Wade, 1990; Lee Kuan Yiew, 1991). Nevertheless, the later stages of catching up will probably require further major political and social reforms, as already foreshadowed in South Korea.

Since its inception, SPRU has maintained an active research programme in Third World technology. From early on this programme, led by Geoff Oldham, Charles Cooper and Martin Bell, pointed to the need for Third World countries to develop an autonomous capability in science and technology, which, although not eliminating the need for technology imports, would enable the importers to make better choices and to make some independent contribution to the development and modification of the technology to meet local needs in a more satisfactory way. This research was always conducted jointly with colleagues in Latin America, Asia and Africa, and it has made a small contribution to new institutional developments in various parts of the world.

Side by side with these new and hopeful developments, even though they are still at an early stage, there are some parallel changes in international agencies and institutions. Within the World Bank, as Francisco Sagasti indicated, there is an increasing recognition that the development of autonomous scientific and technological capability is a fundamental necessity for development and a growing readiness to provide support for projects aiming to strengthen scientific and technological infrastructure. Within the UN system there is also a renewed interest in an idea put forward in one of the first papers ever produced in SPRU by Geoff Oldham, Ergun Türkcan (a Visiting Fellow from Turkey) and myself (1967). We proposed a new International Technology Agency which would provide an independent assessment of alternative technologies and licensing proposals for Third World clients. This would be achieved through an international network of consultant experts, whose consultancy fees together with any royalty and know-how payments, would be paid by the international agency, although financed by the country of origin of the technology with a small contribution from the client. This would thus be a positive sum game.

The need for a greatly enhanced role for independent consultants has been very widely recognised during the change of techno-economic paradigm towards information and communication technology. This is one of the fastest growing service industries in the world. Both technical and organisational changes are of such novelty and complexity that few organisations either in rich or poor countries have been able to dispense

with the services of outside consultants. It is a crucial issue for reconstruction in Eastern Europe. While developing their own capability Third World countries urgently need access to independent advice and help. Such an agency as we proposed would specialise in the assessment of alternative technologies especially suitable for Third World countries and would also be a vehicle for the selection of environmentally superior technologies, whose application should be subsidised for investment projects financed through the World Bank and other international agencies.

Other social innovations will be needed in the world's international economic institutions, including reform of the World Bank and IMF themselves. Keynes already thought them to be inadequately resourced forty-five years ago and today they clearly need a greater role for other countries in their management, especially Japan, Germany, Russia and China, and also Third World countries.

All these are truly complex problems, although I have tried to give in this chapter a number of examples of changes in trend, influenced by and sometimes closely related to changes in science and technology which give some grounds for hope. The book by Gabriel Garcia Marquez, *Love in the Time of Cholera*, can be read at many different levels; however, I take the message to be: 'Never give way to cynicism or despair. Remain true to the ideals of youth.' If we do this, and like Voltaire, we cultivate our gardens, improve industrial technology, use science intelligently and uphold civil liberty, we can realise some of his hopes and those of the Encyclopaedists and Bernal for a better world, if not the best of all possible worlds.

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25th Anniversary of Fraunhofer ISI:
International Symposium on Technology, Economy and Policy

# Perspectives on the Future Role of National Technology Policy in the Age of Globalization: The Next 25 Years to Come

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Modern industry, like economics, is an increasingly global affair. The technology policies that influence both fields, however, have been drafted and enforced by national governments. In the next twenty-five years to come, there will be serious conflicts between "globalized" economic activities and "national" technology policies. Many experts fear that technological decisions made at the national level cannot function effectively on a global economic scale. Is this true?

While we are in the age of globalization, we are also in the age of high technologies at the same time. By paying a careful attention to the process of high-tech innovation, therefore, can we be innovative in formulating technology policies so that there exist less serious conflicts or hopefully complimentary relations between globalization and national technology policy-making. In this talk, I am going to give some thoughts on this issue.

We must first understand why industries go global; in other words, why would an industry relocate its technology, production, and sales function offshore? I will examine the history and globalization of the three industries that have sustained Japan's economic growth since the end of World War II: steel, automobiles, and electronics. We will find the manner in which a given industry goes global is closely related to how it attempts to compete on the international market.

Based on the process of industrial globalization as exemplified by the steel industry, we can formulate the policy problem in terms of how to transfer the tacit knowledge of production technologies across national borders. The analysis of the globalization process of the auto industry will bring us to a policy of globalization through localization. Thus, the policy problem is to be formulated as how to reconcile globalization with localization. The globalization which is occurring in the electronics industry will set the policy agenda of how to integrate different national competences into a global network for innovation.

Finally, I will give some thoughts on those large science and engineering projects, that cannot be managed neither by scientists nor corporations alone without direct government involvement. In these projects, even a single national government's involvement is no longer sufficient, thus, an international cooperation will be necessary, because none of us can easily afford the total cost. However, our study of Japanese nuclear program will reveal the following: path dependencies, which are often involved in large national science and engineering projects, indicate the possibility that the system will *lock into*

paths that are not globally optimal.

Technology policy discussions, therefore, should be centered around how to unlock the path we have been taking, and to explore all the possible alternatives. Only through international cooperation, is it feasible to purse all potential options. In a world in which "techno-nationalism" is the prevailing mood, international cooperation through option sharing may offer the breakthrough that can make the ideal of "techno-globalism" the new reality.

**1. Transferring Tacit Knowledge across National Borders**

In the past three centuries, the world's steel production was dominated first by Northern Europe, then by Western Europe, and most recently by the United States. Japan is now the world's leading producer of steel, at least from a technological standpoint.

Steel-producing countries once use their abundant natural resources to dominate the world market, but Japan -- with scant resources of its own -- has had to rely almost entirely on its technology. Japanese steel makers built their mills on sea coasts to make transportation more efficient. They developed large-scale furnaces, LD converters, and other advanced technologies to compensate for their lack of mineral resources. By pioneering the use of computers in heavy industry, they have developed the world's most efficient system of mass production and strengthened their ability to compete internationally.

Two major factors can make the globalization of the Japanese

steel industry possible. First, by designing and building their own facilities, Japanese steel makers have accumulated a considerable amount of technological know-how which can be applied under various disparate conditions. Second, they have quantified and systematized their workers' empirical and tacit knowledge of operating technology.

Since production technology is specific to the company that owns it and not easily codifiable, it is difficult to transfer and put into effect outside the company. Therefore, it is said that we can not easily separate technology from direct investment so that only the technology is transferred.

However, Japanese steel manufacturers are going global via "technological cooperation". The need for harbors and other major infrastructure prevents them from relocating all their production facilities abroad. Moreover, there is a general tendency to assume that the steel-making should be the national industry. Therefore, Japanese steel manufacturers are sharing their technology with offshore steel companies instead. In these contexts, technology policy problem in globalization as illustrated by the steel industry can be formulated as how to transfer the tacit knowledge without foreign direct investment.

A careful analysis of the productivity increase of the Japanese steel manufacturing reveals the following phenomenon: before 1975 the productivity of making steel had been highly correlated with the average inner volume of blast furnace, but the correlation between them dropped drastically and suddenly after 1986. This implies that while the past increase in productivity had been brought about by the scaling up of the manufacturing equipment,

the recent increase in productivity is being brought about by the sophistication of computer control of the manufacturing process. It is made possible by developing computer software which theorizes the tacit knowledge based on the modern control theory and on the artificial intelligence. In other words, the productivity increase is attained by transforming the tacit manufacturing experiences into the explicit computer software.

The high-tech innovation results in transforming tacit knowledge into explicit knowledge, and thus production technology is becoming transferable without foreign direct investment. Indeed, with these high-tech innovations, can we decentralize production activities throughout the world without losing the high efficiency which had been only available by concentration.

**2. Reconciling Globalization with Localization**

The globalization of the Japanese auto industry began when cars produced for the domestic market became marketable overseas. In the 1970s, when rapid economic growth led to increased production, Japanese automakers came up with their own highly efficient "just-in-time" production systems that allowed for parts and materials to be produced and delivered on demand.

Air pollution brought on by the economic boom led the Japanese government to enact the world's toughest auto emissions standards, and the oil crises of the 1970s prompted consumers to demand more fuel-efficient cars. Japan's automakers competed fiercely with one another to develop new technologies in response to these demands, and the resulting advances in micro-electronics

and other fields sharpened their competitive edge on the world market.

The globalization of Japan's auto industry has also been characterized by a constant effort to develop, produce, and sell cars at the local level. The trade friction of the 1980s persuaded automakers to localize their operations in the U.S. and Europe, and the soaring value of the yen in the middle of that decade had them moving overseas in earnest. By 1994, the number of Japanese cars produced overseas had exceeded the number exported from Japan.

Unlike their counterparts in the steel industry, Japan's automakers moved every aspect of production offshore. Their local subsidiaries now work independently to develop cars that are right for local markets. We might say that Japan's automakers have pursued a policy of globalization through localization.

In the high-tech era, the key issue of technology policy is not how to make possible unprecedented technological capabilities, but how to put technology to the best possible use. In the past, technology policy has emphasized the supply side of development, but it now must work on the demand side. Indeed, a policy of globalization through localization can be only attained by shifting the emphasis of technology policy from the supply side to the demand side. Converting demand from a vague set of wants into a well-defined products requires a sophisticated translation skill, which I call "demand articulation."

In the coming materials revolution, the main actors might not be the materials industry, but instead could be manufacturers who use the materials' technology to solve specific customer prob-

lems. In this way, international businesses, including chemical companies, can capitalize on these demand articulation capabilities built in Japanese fabrication industries such as automobiles. In other words, we can demonstrate how a high-tech firm can find the best way to capitalize on the demand articulation capabilities of its customer companies when these companies are located in other countries.

Minnesota Mining & Mfg. Co. (3M), for example, had developed a core technology in acrylic adhesive foam tapes, which auto industry uses to attach body side moldings. The base technology was developed in 3M's U.S. labs, but when it was transferred to Germany, costs and customer value concerns led to the need for further development. The 3M labs in Germany did this, and because of the excellent communication and technology transfer in the 3M technical family, the company's customer in Japan -- Toyota Motor Corp. in particular -- had some specific performance requirements for the use of the product in their Lexus models. To meet these requirements, 3M's Japanese laboratory advanced the technology to the next level. Now, the technology is widely available to all the U.S. auto manufacturers.

This example demonstrates how the technology which was developed in response to specific local demands can become a global technology. Thus, the pattern of innovations that is emerging in such areas as in the new material development does work positively for reconciling globalization with localization.

### 3. Networking National Competences into a Global Capacity

Since the end of World War II, all of Japan's electronics industries have passed through the same stages on their way toward globalization. In stage one, their business activities were confined to the domestic market alone. In stage two, they began exporting their products through trading companies. In stage three, they set up their own overseas sales networks. In stage four, they sought to alleviate trade friction and currency-exchange risks by relocating their production and R&D facilities abroad. By stage five, their sales and production activities have become altogether borderless. A number of Japanese industries are now entering stage five, but the electronics industry in particular is encountering "mega-competition" on the global market.

The biggest challenge for electronics makers today is the skyrocketing cost of research and development. Cutting R&D expenditures is thus a high priority for electronics makers. It has prompted some companies to try a new form of technological cooperation: joint research programs with both domestic and overseas firms. But the real advantage of joint research projects is the opportunities they provide for participating experts to pool their accumulated knowledge. Discussions between researchers from different cultural backgrounds often yield highly creative results. A fine example of this is the 256 Mbit DRAM development project that IBM, Siemens, and Toshiba have been working since 1992.

In order for the world to benefit from these joint research collaborations among global companies, national technology policy in each nation should be formulated as how to transform these cross countries' joint efforts into a global capacity for innova-

tion. Only by a global networking of national competences owned by different firms in different countries, can we build a global capability to produce breakthroughs from which every nation can benefit more less equally.

A dynamic networking of national competences into a global innovation capacity is best illustrated by reviewing the development of the greatest invention in the postwar history, the integrated circuit, which was begun in the U.S. defense sector and carried further then in Japanese government-sponsored research consortia.

A vaguely defined demand for national security did not propel the development of IC technology; it came about because of the U.S. security policy was successfully translated into a technological concept. With the intensification of the cold war, U.S. defense strategy became deterrence, rather than retaliation. The Kennedy administration created a new strategy that was dependent upon precision in the delivery of nuclear weapons. Defense R&D then focused on the development of small, reliable electronic circuitry to control the missiles. In this way, the defense strategy of deterrence was translated into the technological problems of miniaturization and higher reliability of electronic circuitry.

It soon became clear that these requirements could not be fulfilled by conventional vacuum tube technology or by transistors. In 1958, the U.S. Air Force suggested the use of molecular

electronics.[1] Responding to the concept articulated by the military, various laboratories across the country began R&D experiments, and IC technology was born.

In the transition from the defense to the civilian market, more specifically, from the prototype market through the military and industrial market to the consumer market, leadership in technology development shifted from the United States to Japan. When it became obvious that integrated circuit technology could be applied to home computers and consumer electronics, the Japanese MITI decided to orchestrate the establishment of a research consortium, the Engineering Research Association (ERA) for Very Large Scale Integration (VLSI) development. Although the association included all five of Japan's major IC manufacturers at the time, it did not directly help these chip-makers in developing manufacturing technologies.

Instead, by gathering all the major chip manufacturers together in one place, the association was able to articulate the demand for manufacturing equipment and materials. The specific activities of the association included the development of the stepper, a piece of equipment used to reduce the electronic circuit onto the silicon base optically. Therefore, one of the association's lithography laboratories contracted the research necessary for the development of the stepper to the camera manufacturers that owned the lens technology. Thus, companies such as Nikon and

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1. In brief, components using this technology would have various electronic functions without specifically fabricating such individual electronic parts as transistors, diodes, capacitors and resistors. The material used would simulate the electronic function of oscillators and amplifiers.

Canon succeeded in developing the stepper. In this way, an engineering infrastructure was established for civilian use of IC technology.

It should not be assumed that a country can cover the full spectrum of needed technological competences. As exemplified by the development history of IC technology, therefore, only by dynamic networking of national competences, can we build a global capacity for innovations which the world can benefit from.

**4. Unlocking Path Dependency in National Programs**

Japan's total R&D budget for nuclear development is now far larger than any other country's, and comparing how this sum is being spent in Japan with how money is spent for nuclear development in other countries makes it clear that Japan has made a strong commitment to a specific technical option, the fast *breeder* reactor (FBR). It is not surprising that a resource-poor country like Japan adopted FBR as its major goal, as in theory FBRs can produce more fuel that they consume.

Japan's FBR budget has become the largest in the world. Having reached that level, the market condition has become volatile, as have the domestic and international politics. Various countries, including the United States, the United Kingdom, Germany, and even France, have decided to curtail FBR programs. However, all of these countries obviously have the vested interests in keeping the FBR option open in case it proves necessary. Therefore, to break the prevailing stalemate in launching large science and engineering projects, as well as to realize an ideal of techno-

globalism in the midst of the growing sentiments of techno-nationalism, we need to consider a new scheme of international cooperation.

The cumulative nature of technological advance has been described by Nelson and Winter as following a *natural trajectory*: today's research produces successful new technology and the natural beginning place for tomorrow's searches. They discuss a "neighborhood" concept of a quite natural variety: once a system proved to be a success, it is possible only to make minor changes. However, a set of technological possibilities sometimes consists of a number of different classes of technology. Within any of these classes, however, technological advance may follow a particular trajectory. At any given time, all R&D may be focused on one class of technologies with no attention paid to other classes of technologies. These path dependencies, which are often involved in technology development, indicate the possibility that the system will *lock* into paths that are not globally optimal.

Public policy discussions, therefore, should be centered around how to unlock the path we have been taking, and to explore all the possible trajectories. In order to *unlock* a less-globally-optimal trajectory which have been taken, we might need a *diversity* in technological approach and a *redundancy* in organizational setting. The Manhattan project, however, is still the conventional model for government involvement in the creation of new technology. This model involves a willingness to make large early bets on particular technological *options* and force these through at very high cost.

In order to break off the intrinsic dilemma observed in the

dynamics of national programs, we are proposing international cooperation based on *option sharing*. Option sharing entails dividing up the burdens and responsibilities for pursuing each possible scientific and technological options in a given area. A thorough search of all possible options, therefore, should be the main objective of future international cooperation.

International cooperation has been dominated by notions of cost sharing and task sharing. However, dividing up costs and tasks suggests that an option has already been selected. Moreover, the soaring costs involved in large engineering projects is due, at least in part, to the increasing number of options and to the pressure imposed on a single government to cover all the costs involved in exploring all the options simultaneously. Only through international cooperation, is it feasible to pursue all potential options.

Covering all possible options through international cooperation would have a profound effect on the development of technology. While science aims at an absolute truth, technology aims at relative superiority. Determining the most meritorious technical option, therefore, is not possible unless all the options are demonstrated and compared. Option sharing should not be looked upon that a country relies on advances made by competing projects of other countries. Instead, the other countries will provide a *calibration* of the state of art of technical advance, with transparency provided through international cooperation.

Through option sharing, it is possible to resolve the inherent tension that exists between international cooperation and nation-

al autonomy. Through the principle of cooperate-and-compete, nations in the industrial world may capitalize on parallel interests. There are growing fears that the shift toward technological protectionism will turn into a minus-sum game for the world as a whole. It can be said that only through option sharing can a plus-sum game be assured. In a world in which "techno-nationalism" is the prevailing mood, international cooperation through option sharing may offer the breakthrough that can make the ideal of "techno-globalism" the new reality.

# TECHNOLOGY POLICY OVER THE NEXT 25 YEARS - EMERGING RESEARCH NEEDS

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**Presentation at the International Symposium on Technology, Economy and Policy, celebrating the 25th Anniversary of Fraunhofer ISI, held at the City Festival Hall, Karlsruhe, 3-4 June 1997**

## STRUCTURE OF TALK

- Introduction
- Views of 3 former SPRU Directors
- Challenges identified in UK Technology Foresight Programme
  - Sector panel priorities
  - Generic priorities
- Analysis of 4 global driving forces
- Concluding remarks





## 1. INTRODUCTION

- Speculative, subjective, partial - aim = to stimulate/provoke
- Focus on emerging research agenda for S&T policy researchers
- Focus on public policies for technology
  but many parallels with technology management at level of firm
- Three approaches

# 2. VIEWS OF FORMER SPRU DIRECTORS

## 2.1 Chris Freeman

Basic principles of S&T policy research

- *interdisciplinary* collaboration of soc. scientists + natural scientists/engineers
- active interaction with *users* - decision-makers in government/industry etc.
- approach S&T as *global* phenomena
- new knowledge/skills best transferred through *people moving*

Importance of incremental Vs radical innovation

- Thomas Hughes - history of technology consists of incremental changes
- Freeman - society made up of interacting subsystems - science, technology, economy, politics, culture, natural environment

  Where there are differential rates of change in subsystems, may get revolutionary changes





# 2.1 VIEWS OF CHRIS FREEMAN

## Possible discontinuities over next 25-30 years

- Increasing importance of technology in *services*
  ==> changing nature/role of services
- Information *overload* but knowledge shortage
- Income distribution and *inequality* - relationship to technological change?
- Industrialisation of *Asia* etc. - threat or blessing?

## 2.2 VIEWS OF GEOFF OLDHAM

- Is long-term forecasting possible?
- Changing significance of international S&T policy issues
  ==> old issues never die, we just keep adding new ones
- Scenario analysis of impact of IT in Canada
  ==> widening or narrowing the inequality gap?
- Danger of technology policy research tending to support status quo?





### Changing Significance of International S&T Policy Issues - Geoff Oldham

| | 1966 | 1996 | 2026 |
|---|---|---|---|
| Brain drain | + | + | + |
| Technology - make or buy | +++ | +++ | +++ |
| Role of MNCs in tech'y transfer | +++ | ++ | ++ |
| Local S&T capabilities | ++ | +++ | +++ |
| Role of international org'ns | + | ++ | +++ |
| Environmentally clean tech's | + | ++ | +++ |
| Tech innovation in China/Asia | + | ++ | +++ |
| IT & development | + | ++ | +++ |
| Globalisation of technology | 0 | ++ | +++ |
| Countries in transition | 0 | +++ | + |
| Technology & social sectors | + | + | ++ |
| S&T policy instruments | + | ++ | +++ |

## 2.3 VIEWS OF MICHAEL GIBBONS

Focus on relationship of S&T and production of knowledge to higher education (HE)

HE - trend of *massification* - increased numbers + extended over lifetime

Science moving from *discipline-based* knowledge production system (Mode 1) to a *socially distributed* knowledge production system (Mode 2)

==> Increasing number of interactions + complexity

Science being asked to operate beyond the limits of what it can deliver effectively

==> Need analysis of changing structure etc. and appropriate policies





# 3. UK TECHNOLOGY FORESIGHT PROGRAMME (TFP)

## 3.1 Introduction and background

1983 - SPRU study ==> learn from overseas and try foresight as experiment
- not right time - 10 years too early!

1992 - Phone call - review foresight? Report + options for UK

1993 - Briefed Minister - chose Foresight as big new idea for White Paper

1994 - Pre-foresight stage - what? why? how? ==> change in approach + buy-in

1994/5 - Main foresight stage - 15 panels - expert groups, brainstorming, scenarios, Delphi etc.

==> 15 panel reports - analysed sector, driving forces, strengths & weaknesses ==> identified priorities

1995 - Steering Group - identified generic S&T priorities & infrastructural priorities

## 3.2 PANEL REPORTS - SOME TECHNOLOGY POLICY CHALLENGES

### i Agriculture, Natural Resources and Environment

- Environmental analysis
- Integrated ecosystem management
- Life-cycle evaluation and management
- Public and political understanding of S&T

### ii Chemicals

- Image of chemical industry
- Networking

### iii Communications

- Regulatory regime
- Standardisation





## 3.2 PANEL REPORTS - SOME TECHNOLOGY POLICY CHALLENGES

### iv Construction

- Application of modern business processes
- Benefiting the environment and society
- Establishing a favourable fiscal regime
- Promoting learning and learning networks

### v Defence and Aerospace

- Systems integration

### vi Energy

- Process design

## 3.2 PANEL REPORTS - SOME TECHNOLOGY POLICY CHALLENGES

### vii Financial Services

- Financial innovations
- Management of financial risk

### viii Food and Drink

- Consumer science

### ix Health and Life Sciences

- Infrastructure for development/exploitation of life sciences
- Ageing
- Genetics in risk evaluation and management





## 3.2 PANEL REPORTS - SOME TECHNOLOGY POLICY CHALLENGES

### x IT and Electronics

- Creating the environment for investment and growth
- Encouraging new IT/info businesses

### xi Leisure and Learning

- Regulation and copyright
- Demand for information and learning
- Skills
- Social impact of new technologies

### xii Manufacturing, Production and Business Processes

- Business process optimisation
- Education and training
- Extended vision for manufacturing and production businesses
- National infrastructure for improved competitiveness

## 3.2 PANEL REPORTS - SOME TECHNOLOGY POLICY CHALLENGES

### xiii Materials

- New materials to enhance the quality of life

### xiv Retail and Distribution

- Social and cultural factors
- Security of information
- Legal aspects of electronic commerce

### xv Transport

- Enhancing access with reduced need for mobility
- The informed traveller
- Transport and the environment
- Impact of telecommunications





## 3.3 TFP GENERIC PRIORITIES

### 27 generic science and technology priorities

Classified into 6 categories

1. Harnessing future communications and computing
2. From genes to new organisms, processes and products
3. New materials, synthesis and processing
4. Getting it right: precision and control in management
5. A cleaner world
6. Social trends and impact of new technology

Ranked 27 S&T priorities in terms of - 'attractiveness'

- 'feasibility'

## 3.3 TFP GENERIC PRIORITIES (continued)

**Identified main bottlenecks**

- Getting potential of technology understood by managers, workforce, consumers
- Complementing new technology with right skills
- Freeing up markets & ensuring market transactions conducted on orderly basis

**==> 18 generic infrastructure priorities**

1. Education and training infrastructure
2. Research infrastructure
3. Communications infrastructure
4. Financial infrastructure
5. Policy and regulatory infrastructure





## 3.3.1 GENERIC SCIENCE AND TECHNOLOGY PRIORITIES

**1. Harnessing future communications and computing**

- Communicating with machines
- Design and systems integration
- Information management
- Modelling, simulation and prediction of complex systems
- Optical technology
- Software engineering
- Telepresence

**2. From genes to new organisms, processes and products**

- Bio-informatics
- Biomaterials
- Genetic and biomolecular engineering
- Health and lifestyle

## 3.3.1 GENERIC SCIENCE AND TECHNOLOGY PRIORITIES (cont.)

**3. New materials, synthesis and processing**

- Catalysis
- Chemical and biological synthesis
- Materials
- Materials processing technology

**4. Getting it right: precision and control in management**

- Management and business process engineering
- Automation
- Process engineering and control
- Sensors and sensory information processing
- Security and privacy technology





## 3.3.1 GENERIC SCIENCE AND TECHNOLOGY PRIORITIES (cont.)

**5. A cleaner world**

- Clean processing technology
- Energy technology
- Environmentally sustainable technology
- Product and manufacturing life cycle analysis

**6. Social trends and impact of new technology**

- Demographic change
- Risk assessment and management
- Social impact in workplace and home

## 3.3.2 GENERIC INFRASTRUCTURE PRIORITIES

### 1. The skills base

- Training better SET teachers
- Communication skills
- IT competence
- Public understanding of science
- Business awareness

### 2. Research in the science base

- Support for excellent basic research
- Incentives for multidisciplinary research
- Incentives for industrial involvement

### 3. Communications

- Promote the information superhighway
- Gather overseas science and technology intelligence





## 3.3.2 GENERIC INFRASTRUCTURE PRIORITIES (cont.)

### 4. Finance

- Long-term funding for innovative R&D
- Special incentives for SMEs
- Enterprise architectures

### 5. Policy and regulation

- Intellectual property rights
- Procurement by Government
- Supportive environmental, financial and communications regulations
- Scientifically based standards
- Demonstrator projects

# 4. GLOBAL DRIVING FORCES AND THE TECHNOLOGY POLICY CHALLENGES

Focus on 4 key drivers of global change over next 25 years

- *the 4 Cs*

- increasing **C**ompetition
- increasing **C**onstraints on public expenditure
- increasing **C**omplexity
- increasing importance of technological **C**ompetencies
  - knowledge, information, skills





## 4.1 INCREASING COMPETITION

More 'players' in market economies

Huge variations in labour costs (> 2 orders of magnitude) + globalisation

Emerging challenge from large second-generation Asian tigers (Malaysia, Vietnam, China etc.) + more successful transition economies

==> Emphasis on innovation and knowledge-based industry

==> Technology and science becoming more important competitive resources

Also increasing concern about interaction between competitiveness and

- unemployment and working conditions
- inequality and social cohesion
- environment and sustainability
- new risks and their distribution cf. the benefits

Different dynamics/growth rates may result in C Freeman's discontinuities?

## 4.1 INCREASING COMPETITION (cont.)

==> Need for new national technology policies that ***balance*** competitiveness against unemployment, inequality, sustainability, risk etc.

i.e. that link new technology to social as well as economic needs

Requires new technology policy analyses (e.g. of costs Vs benefits and their distribution, of national/regional strengths and weaknesses), indicators and policy tools

### Specific problem of short-termism

In age of global deregulated finance, what incentive to invest in >5-7 years?

Particular problem for R&D?

- R&D as % of GDP fallen in most OECD countries since ~1990

How to encourage long-term investment?





## 4.2 INCREASING CONSTRAINTS ON PUBLIC EXPENDITURE

Growing problem in most of OECD ∵ Maastricht criteria/desire to balance budget

Constraints likely to grow ∵

- demography and ageing population
- increasing costs of healthcare, education, social welfare
- reached political limits to tax-raising? + greater opportunities for avoidance

Will result in increasing demand for

- Accountability, effectiveness etc. ==> need new technology policy tools (e.g. for evaluation)
- Policies to develop technologies to deliver healthcare, education etc. more cheaply/effectively
- Better justification for government funding of research and technology

## 4.2 INCREASING CONSTRAINTS ON PUBLIC EXPENDITURE (cont.)

Argument that research and technology should be a high political priority

- in past, based on linear model - very convenient & successful but now dead!
- current models more complex ==> difficult to convince public/government

==> Need for a new ***social contract*** between researchers, funders and users/beneficiaries

Challenge to technology policy researchers to establish new/more effective mechanisms for linking researchers, funders and users

- to identify research/technology areas that will yield greatest benefits
- to work together to develop and exploit those new technologies

Spread of technology foresight post-1990 = a response to this
but still considerable scope for improvement





## 4.3 INCREASING COMPLEXITY

Driven by greater coupling and closer interactions of systems

Involves interactions between

- national, regional and global systems
- S&T and economy, politics, culture, environment (i.e. Freeman subsystems)
- public and private sectors (e.g. healthcare)
- different technologies - technology 'fusion'
- different producers of knowledge (Mode 2)

==> Need for

- better understanding of complex systems
- *flexible* policies/responses/systems
- policy tools linking different partners and their needs, values etc.
- increased and more effective networks, partnerships, collaboration
- clear division of responsibility between national and regional/EU policies

## 4.4 INCREASING IMPORTANCE OF TECHNOLOGICAL COMPETENCIES

S&T *knowledge* becoming a strategic resource for companies and countries as well as vital to quality of life

*Tacit* knowledge especially crucial - best transferred through people moving
==> Need policies to encourage mobility

Growth in importance of S&T *information* driven partly by new ICTs
Need policies to ensure ICTs help in

- early identification of S&T opportunities
- combining information from several sources
- rapid (but targetted) dissemination to all who might benefit
- effective exploitation of new technologies





## 4.4 INCREASING IMPORTANCE OF TECHNOLOGICAL COMPETENCIES

S&T *skills* ever more important in relation to wealth creation and quality of life

New technologies

- demand new skills
- make old skills obsolete (more quickly?)

==> Need for continuous ***learning***

- individual - lifetime learning + technologies to support/encourage
- organisational - creation of 'learning organisation' - but how?

∵ Growing complexity and interaction of systems, need new/more generic and system-wide skills

- interdisciplinary/transdisciplinary/multi-technology
- team-working
- networking

## 5. CONCLUDING REMARKS - TOWARDS EVIDENCE-BASED TECHNOLOGY POLICIES?

Argued that S&T will

- become more important
- find it harder to attract resources
- involve more complex interactions

Highlighted some opportunities/challenges for technology policy makers and researchers

Analogy with healthcare + desire for evidence-based medicine/treatment?

Technology policy (and management) - very little evidence-based?

If to convince public, governments and companies to invest more in S&T, likely to need ***evidence-based technology policies***





## 5. CONCLUDING REMARKS (cont.)

Evidence-based technology policies will require new/improved

- indicators
- concepts, models etc.
- rationale for investing in R&D
- processes for long-term analysis and decision-making
- mechanisms for working together
- approaches for comparing 'apples and oranges' ?

A rich agenda for technology policy researchers over next 25 years!

## Conclusions of the conference

*Frieder Meyer-Krahmer*

We wanted to offer you a panorama - an entrepreneurial view of the world of innovation, serious research and emotional discussions. Our idea was to offer you information, inspiration and to a certain extent entertainment. I hope that you enjoyed this 25th anniversary celebration.

To finalise, I would like to draw three types of conclusions in a selective and very short manner: policy conclusions, conclusions for a future research agenda and conclusions on principles to run a research institute such as ISI.

1. Policy conclusions:
   - there is a strong need for a systemic approach to research, technology and innovation policies
   - new instruments beyond the usual support of R & D projects, private products and institutions have been developed and will become more prominent in the future:
     - new ways of self-control of science and industry
     - change of the price system, increased competition
     - technology transfer through networks of firms
     - mobilisation of demand, public as well as private
   - corresponding to the globalisation of economic activities an internationalisation of technology policy is also developing
     - becoming more involved in innovation in other countries (e. g. energy sector reforms, R & D corporations)
     - option sharing (in the sense of Kodama)
     - new ways of international bargaining processes

2. Conclusions for a future research agenda:
   Besides the list of topics mentioned by SPRU colleagues, presented by Ben Martin, I hold the following topics for especially important
   - Conditions and consequences of a stronger role of users.
   - Renewal of technology assessment, esp.
     - careful assessement of economic, social and ecological consequences in a very early phase of technology generation
     - participatory technology assessment
   - Political and societal decision processes and conditions of implementation of new solutions and normative concepts
     - Implementation of new concepts: major context conditions
     - Which political structure supports innovation?

- Institutional arrangements fostering intergenerational equity.
- Influence of the power game between losers and winners.

– Requirements of social acceptability of new working conditions.

3. Conclusions on principles to run a research institute such as ISI:

   Although neither an explicit presentation and discussion of this topic was requested nor took place, between the lines I understood the message: be realistic, observe scientific integrity, think on systemic and global lines, behave proactively, collaborate with pioneers, follow fashions only if it is unavoidable, be independent, keep your identity.

Finally, I like to thank sincerely the "invisible hand" of the 25th anniversary: the organizers and the supporting team. They worked hard and did an excellent job. So many members of the ISI team were involved that I cannot name them all, but I would like to thank those who were especially active and responsible: Monika Silbereis, Uwe Kuntze and Hariolf Grupp. Also I have to thank very much the speakers and the audience. With the help and critical accompaniment of clients, colleagues and friends with whom we are happy to be here and to hold this event of commemoration. Closing this symposium, I want to express that I hope to have you with us for many more years and I hope you enjoyed our anniversary celebration.

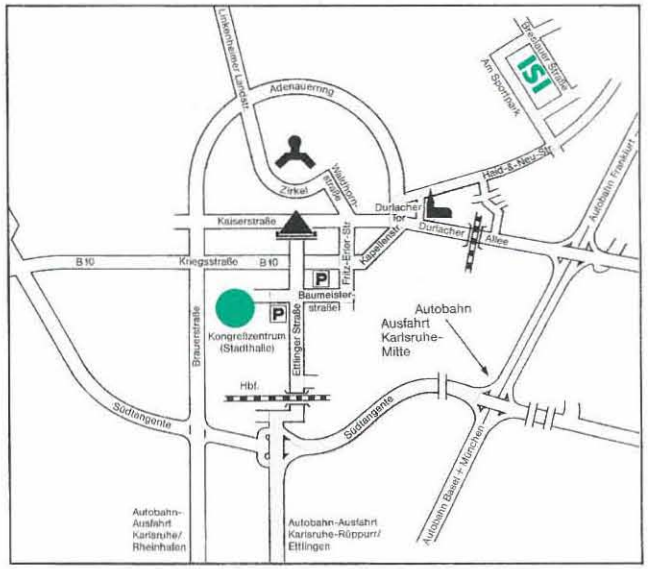
## 25-Jahr-Feier des ISI
## 25th Anniversary of Fraunhofer ISI

Um Anmeldung wird gebeten mit beiliegendem Antwortschreiben.
Please register with the attached form.

**Veranstaltungsort**: Karlsruhe, Stadthalle (Kongreßzentrum KKA)
**Venue**: Karlsruhe, City Festival Hall (Convention and Exhibition Centre KKA)

**Anfahrtswege**: Das KKA liegt im Zentrum der Stadt und ist nur 10 Gehminuten vom Hauptbahnhof entfernt. *Mit dem Auto:* Karlsruhe liegt am Kreuzungspunkt von 3 Autobahnen: A5, A8, A65. Über die Ausfahrt Karlsruhe Mitte, Richtung 'Kongress/Messe', ist das Karlsruher Kongress- und Ausstellungszentrum KKA schnell erreicht. Parkhäuser gibt es vor Ort. *Mit der Bundesbahn* bis Hauptbahnhof und dann mit den Straßenbahnen Linie 3 (Richtung Rintheim), Linie S4 (Richtung Bretten) oder S1/S11 (Richtung Neureut/Hochstetten) bis Haltestelle 'Kongresszentrum' (Dauer: ca. 5 Minuten). *Mit dem Flugzeug* über die Flughäfen Frankfurt/Main, Stuttgart oder Straßburg (Bundesbahn- oder Autobahnentfernung ca. 1,5 Stunden).

**Directions**: The KKA is located right in the city centre, just a 10 minutes' walk away from the main railway station. *By Car:* Karlsruhe is situated at the intersection of 3 motor-ways: A5, A8 and A65. The Karlsruhe Convention and Exhibition Centre KKA is easily accessible by the exit Karlsruhe Mitte following 'Kongress/Messe'. Parking facilities are located. *By train* to Karlsruhe main station; trams no.3 (direction Rintheim), no. S4 (direction Bretten) or no. S1/S11 (direction Neureut/Hochstetten), to 'Kongresszentrum' (5 minutes). *By air* via Frankfurt/Main, Stuttgart or Strasbourg Airport (all approximately 90 minutes by car or train).




**Unterkunft/Accommodation**
Wir weisen Sie auf die beigefügte Hotel-Reservierung hin.
Ermäßigte Kontingent-Reservierung ist möglich bis spätestens 11. April 1997.
Please see the attached form 'Hotel Reservation'.
Reservation for reduced prices is possible till April 11th, 1997, at the latest.

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**Fraunhofer** Institut
Systemtechnik und
Innovationsforschung

Einladung
## 25-Jahr-Feier des ISI

Invitation
## 25th Anniversary of Fraunhofer ISI

25

3. Juni 1997
Festakt zum 25jährigen Bestehen des ISI

June 4th, 1997
International Symposium on Technology, Economy and Policy

Karlsruhe, Stadthalle, Johann-Peter-Hebel-Saal
Karlsruhe, City Festival Hall, Johann-Peter-Hebel-Hall

## 3. Juni 1997
## Festakt zum 25jährigen Bestehen des ISI
(in deutscher Sprache - with simultaneous translation into English)

13.00 *Anmeldung, Kaffee, Tee*

13.15 **Eröffnung**
Professor Hans-Jürgen Warnecke, Präsident der Fraunhofer-Gesellschaft
**Grußworte**
Elke Wülfing, Parlamentarische Staatssekretärin im Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF)
Dr. Horst Mehrländer, Staatssekretär im Wirtschaftsministerium Baden-Württemberg
Professor Gerhard Seiler, Oberbürgermeister der Stadt Karlsruhe
Professor Ewald Konecny, Medizinische Universität zu Lübeck, Vorsitzender des Kuratoriums des ISI
**Einführung**
Professor Frieder Meyer-Krahmer, Leiter des ISI

14.15 Professor Hansjörg Sinn, Universität Hamburg, Senator für Wissenschaft und Forschung a.D.
**Wechselbeziehungen von Wissenschaft, Wirtschaft und Politik**

15.00 Professor Hasso Plattner, Stellvertretender Vorstandsvorsitzender der SAP AG , Walldorf
**Zukünftige Rolle der Information im Wandel der Strukturen**

15.45 *Pause, Kaffee, Tee*

16.15 Professor Klaus M. Meyer-Abich, Wissenschaftszentrum Nordrhein-Westfalen, Essen, Senator für Wissenschaft und Forschung a.D.
**Ist biologisches Produzieren natürlich? - Kulturelle Grenzen der Biotechnik**

17.00 Professor Hans Sieber, Schweizerisches Bundesamt für Konjunkturfragen, Bern
**Wissenschaftliche Evaluierung der Politik - Schiedsrichter oder Spieler? Das Beispiel der Schweizer Technologiepolitik**

17.45 **Podiumsdiskussion**
**Sieben Jahre nach der deutschen Einigung: Innovationssystem - wohin?**
Edelgard Bulmahn, MdB, Vorsitzende des Forschungsausschusses des Deutschen Bundestages
Professor Hans-Jürgen Ewers, Präsident der Technischen Universität Berlin
Hans Dietmar Sauer, Vorsitzender des Vorstands der Landeskreditbank Baden-Württemberg
Professor Dagmar Schipanski, Vorsitzende des Wissenschaftsrats
Leitung: Rainer Korbmann, Chefredakteur von "Bild der Wissenschaft"

19.30 **Empfang**

## June 4th, 1997
## International Symposium on Technology, Economy and Policy
(in English)

9.00 **Introduction**
Professor Frieder Meyer-Krahmer, ISI and Université Louis Pasteur Strasbourg

9.15 Professor Robert H. Williams, Princeton University
**21st Century Energy Strategies Based on Environment-Driven Innovation**

10.00 Dr. Eberhard Jochem, ISI
**Shrinking Natural Resources and Stressed Environments - Pressures for Systemic Innovations**

10.45 *Break, Coffee, Tea*

11.15 Professor Richard K. Lester, Massachusetts Institute of Technology, Cambridge, MA
**Coming Changes in the Industrial System: Implications for Academic Institutions**

12.00 Professor Helmar Krupp, Founding Director of ISI
**The Lasting Challenge of Unemployment and "Sustainable Development"**

12.45 *Lunch*

14.00 Dr. Hariolf Grupp, ISI
**The Delphic Oracle and the Progress of Mankind Then and Now**

14.45 Professor Christopher Freeman, Founding Director of the Science Policy Research Unit (SPRU), University of Sussex
**The Economics of Hope**

15.30 *Break, Coffee, Tea*

Two perspectives on
**The Future Role of National Technology Policy in the Age of Globalisation: The Next 25 Years to Come:**
16.00 Professor Fumio Kodama, The University of Tokyo
16.45 Professor Ben Martin, Director of the Science Policy Research Unit (SPRU), University of Sussex

17.30 **Conclusions of the Conference**
Professor Frieder Meyer-Krahmer

## Teilnehmerliste / List of participants

***25-Jahr-Feier des ISI am 3./4. Juni 1997***
***25th anniversary of Fraunhofer ISI, June 3-4, 1997***

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