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New Energy Horizons
Opportunities and Challenges

Design of appropriate ICT Infrastructures for Smart Distribution Grids

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Session: Future ICT Infrastructures for Smart Distribution Grids

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Development of Installed Renewable Energy Capacity 1990-2011

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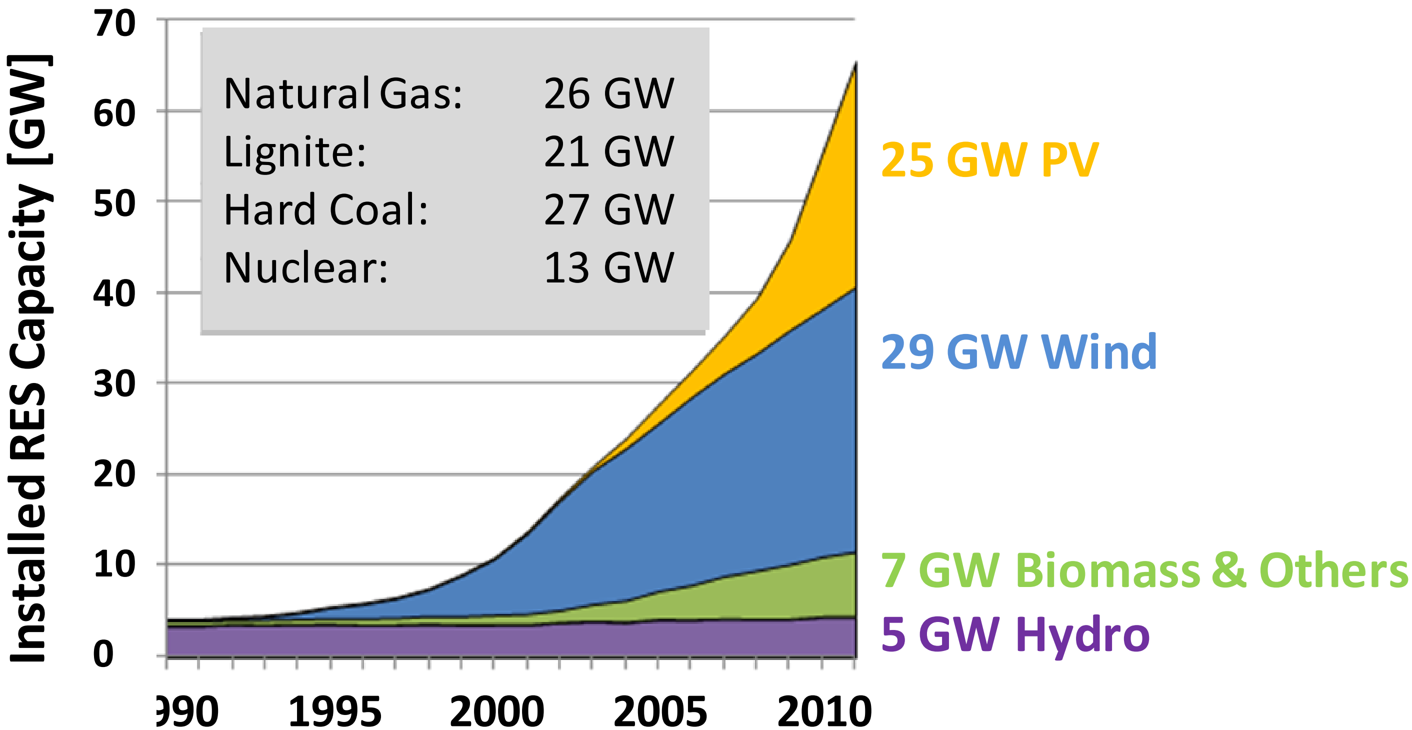
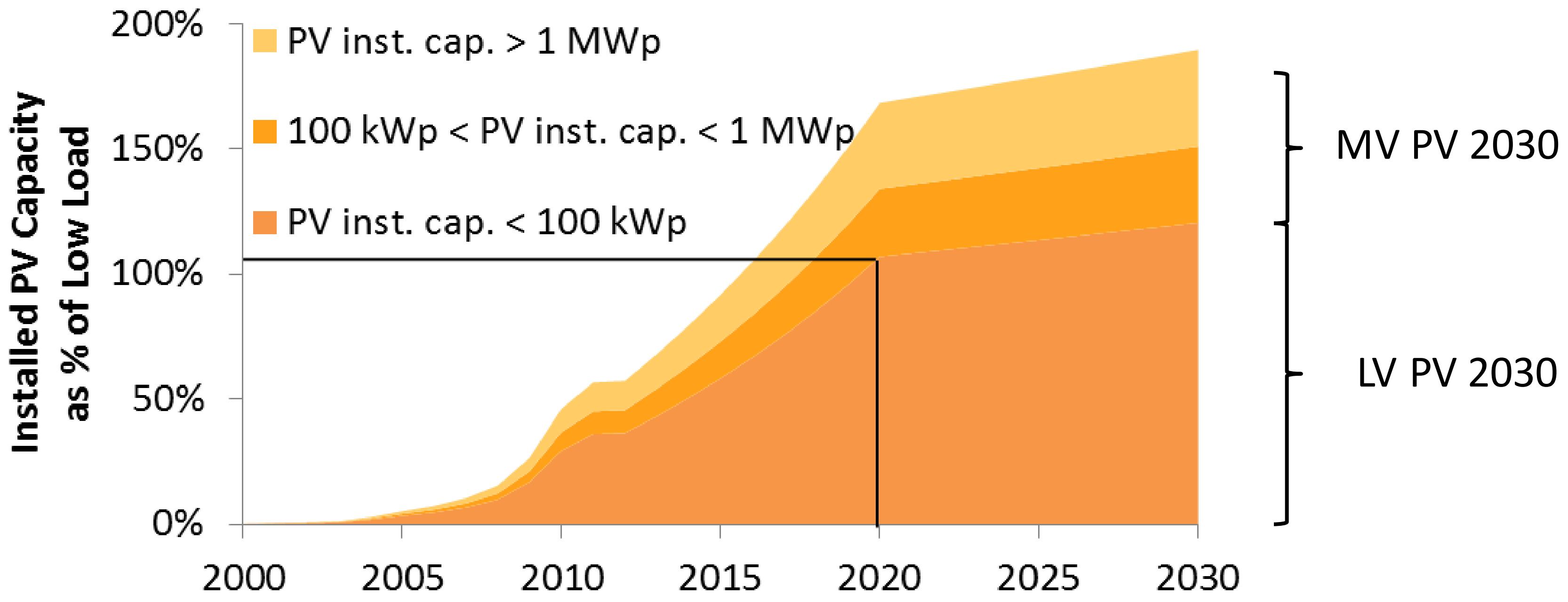


- ➔ PV and Wind are pillars of the German electricity supply
- ➔ PV and Wind mainly in distribution systems
- ➔ > 1.000.000 plants

Development of Distribution System PV in Germany



- → Challenging in terms of system stability and network reinforcement
- → Focus on potential ICT Solutions
- → Constant need for regulatory updates shaping the smart grid vision

Germany‘s view on ICT Infrastructure for Distribution System

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Smart Grid Freaks
High-speed bidirectional link to every DER

TSO
Improve PV forecasts
Make PV controllable

Virtual Power Plant
High-speed bi.-d. link at least for DER > 100 kWp

DSO
Contain data volumes
Enable PV feed-in cut

Regulatory Authorities
Can ICT save grid reinforcement costs?

Energy Consumers
Data Privacy
Cost of ICT Infrastr.

Research Institutions
What about ICT contingencies?

The more ICT, the smarter the grid?

How to determine, which kind and how much ICT is needed?

„Appropriate“ ICT Infrastructures

Appropriate:

→ Neither over-, nor underperformance

-Too high cost
-Complexity management

Safety / Reliability issues

→ Tailored to surroundings and requirements

Outline

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1) ICT Infrastructure Design Process
   - Consideration of Boundary Conditions
   - Outline of Design Steps
2) Case Study

Tailored to surroundings → Considering boundary conditions

Life Time of 20 years → Boundary Conditions will change

Tailored to surroundings ➔ Considering boundary conditions

Which are the key, unmovable boundary conditions?

➔ „Hard “

Which boundary conditions are subject to change?

➔ „Soft“

Boundary conditions of ICT Infrastructure Design

HARD

- ✓ Primary energy availability, incl. geographical and weather influences
- ✓ Load density and distribution
- ✓ Legacy power system infrastructure
- ✓ Legacy communication infrastructure
- ✓ ICT technology available on the market
- ✓ Cultural standards, e.g. high need for personal information security
- ✓ Technical standards
- ✓ Regulatory boundary conditions
- ✓ DSO workflow and in-/outsourcing decision
- ✓ Design from a certain stakeholder’s viewpoint, e.g. DSO

SOFT

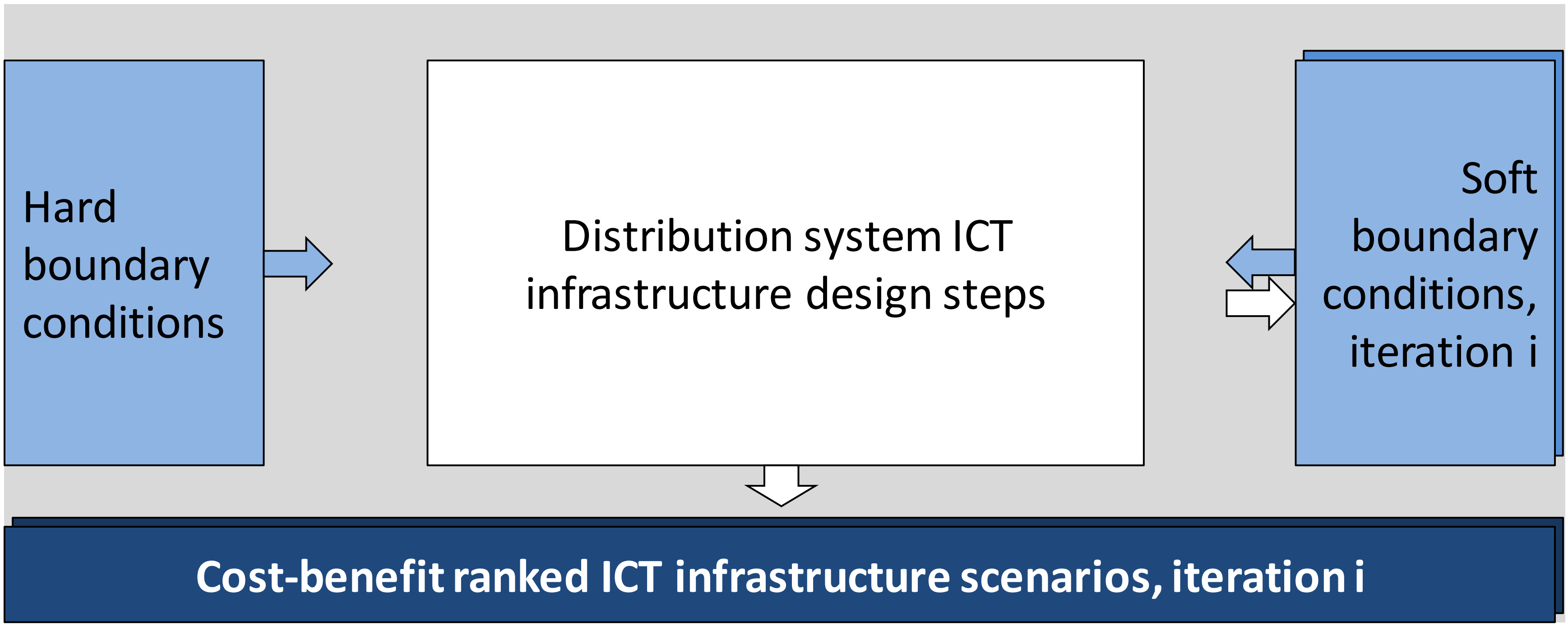
Tailored to surroundings → Considering boundary conditions

Goal:

Design a process that on the one hand considers the boundary conditions and on the other hand is flexible enough to evaluate alternative scenarios.

It should support developing regulatory recommendations.

How to incorporate Boundary Conditions in the Design Process



„What if“ scenarios and cost-benefit ranked infrastructure scenarios
➔ Ideal for developing regulatory recommendations

Examples of what may happen, when a soft condition is taken to be a hard one (1)

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Soft condition ‚Design from DSO viewpoint' taken as hard:

Multiple installation of the same infrastructure without having checked, whether synergies with other parties could be used

Regulatory authorities develop recommendations that neglect the existence of certain parties in the market

Example: ‚BSI-Schutzprofil' neglecting interface for remote parameterization of inverter manufacturers

Examples of what may happen, when a soft condition is taken to be a hard one (2)

Soft regulatory condition
‚Prequalification conditions for providing secondary regulation'
taken as hard:

Installed ICT infrastructure does not support provision of secondary regulation although, most likely, both prequalification and remuneration conditions are going to change

Outline

1) ICT Infrastructure Design Process
   - Consideration of Boundary Conditions
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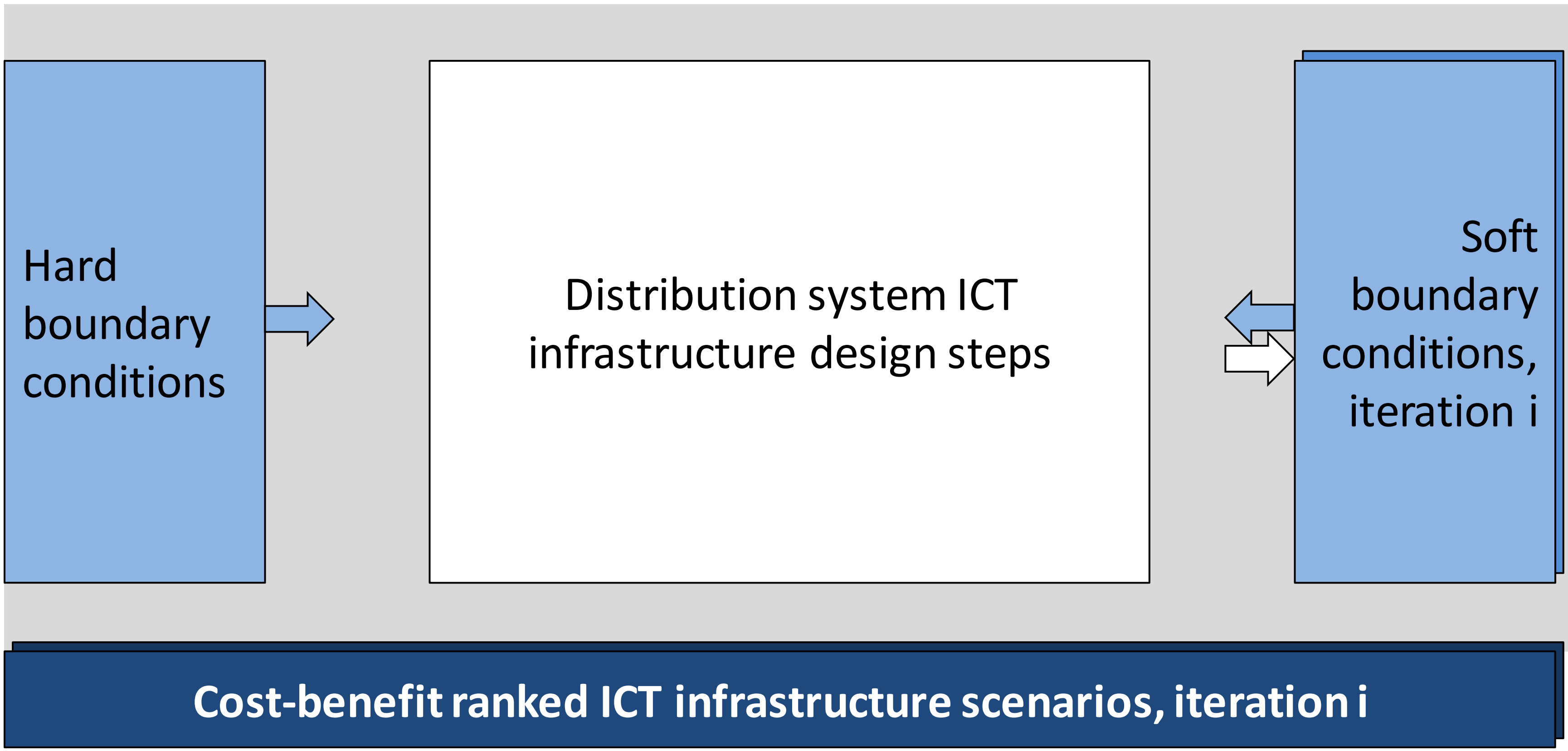
2) Case Study

Outline of Design Steps
- Recall Design Process Framework -



Outline of Design Steps

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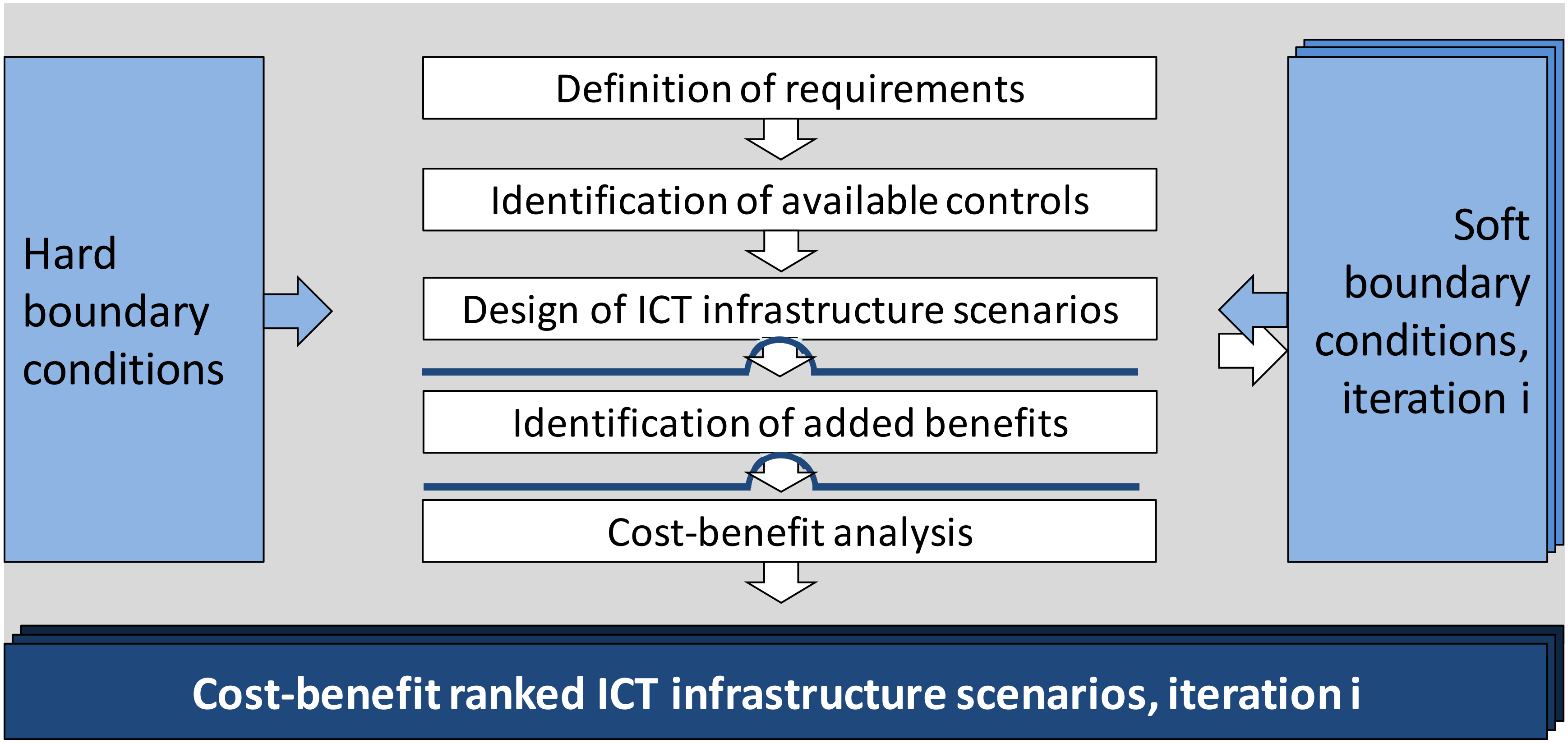

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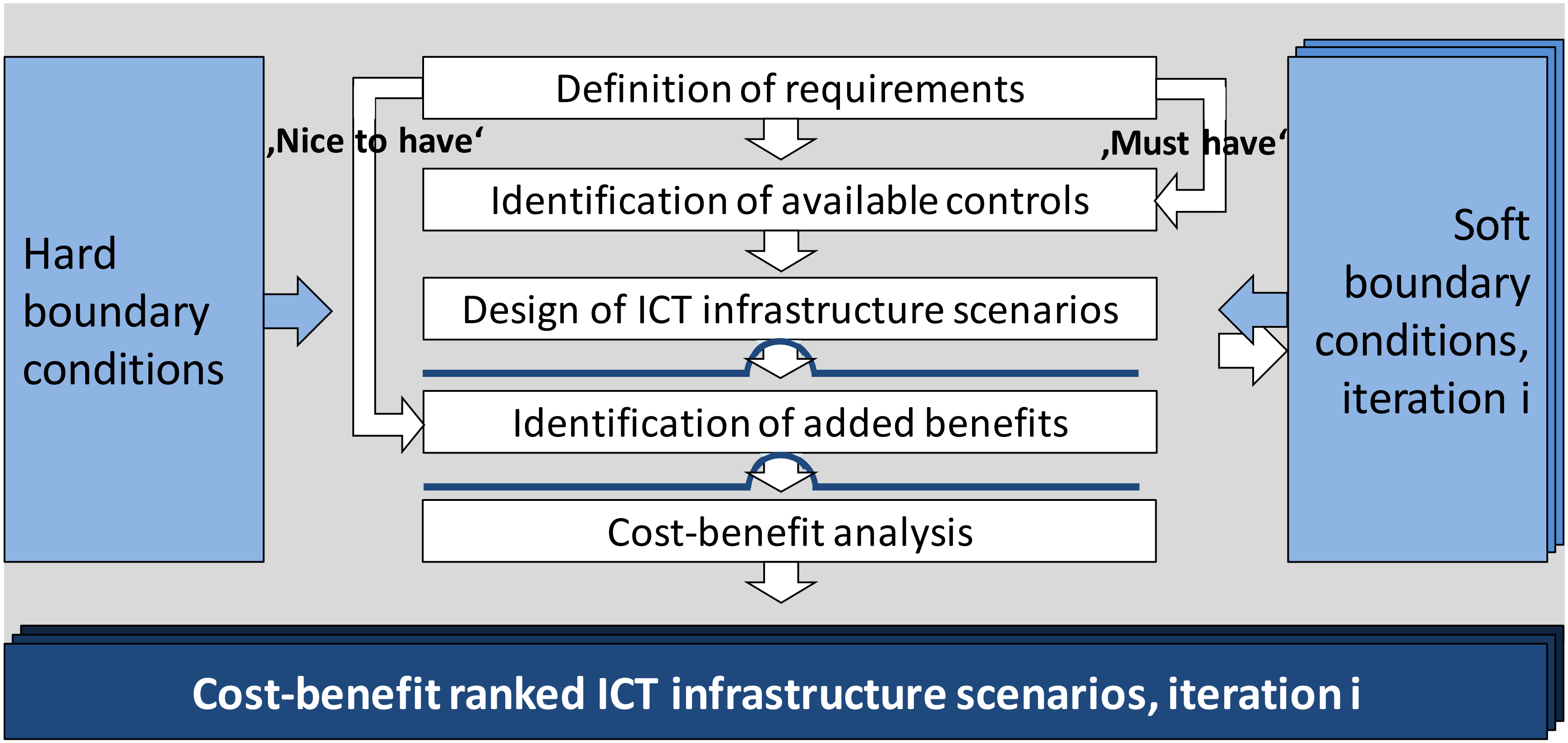
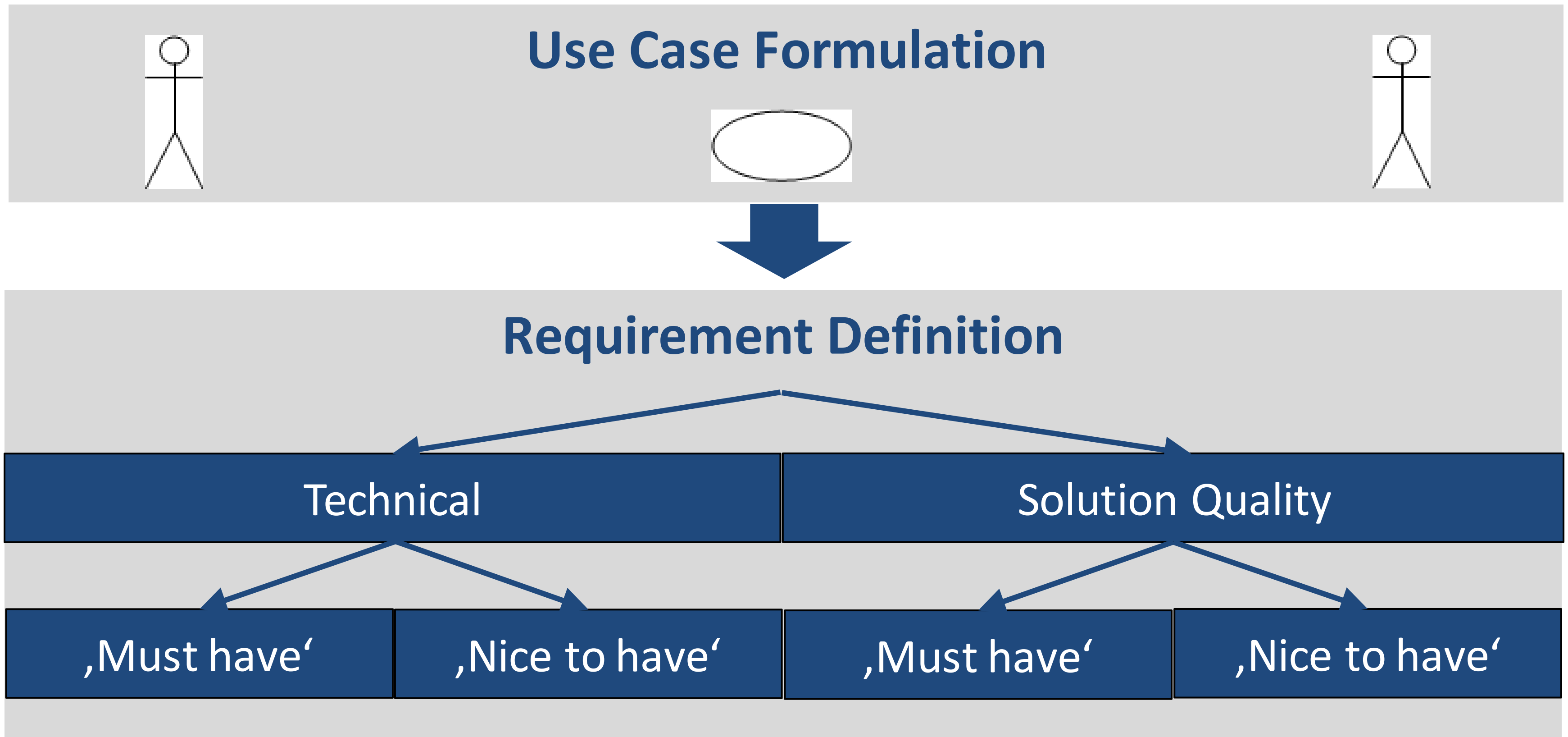
Outline Design Step 1: Processing of resulting ‚must have' and ‚nice to have'



Outline Design Step 1: Definition of Requirements



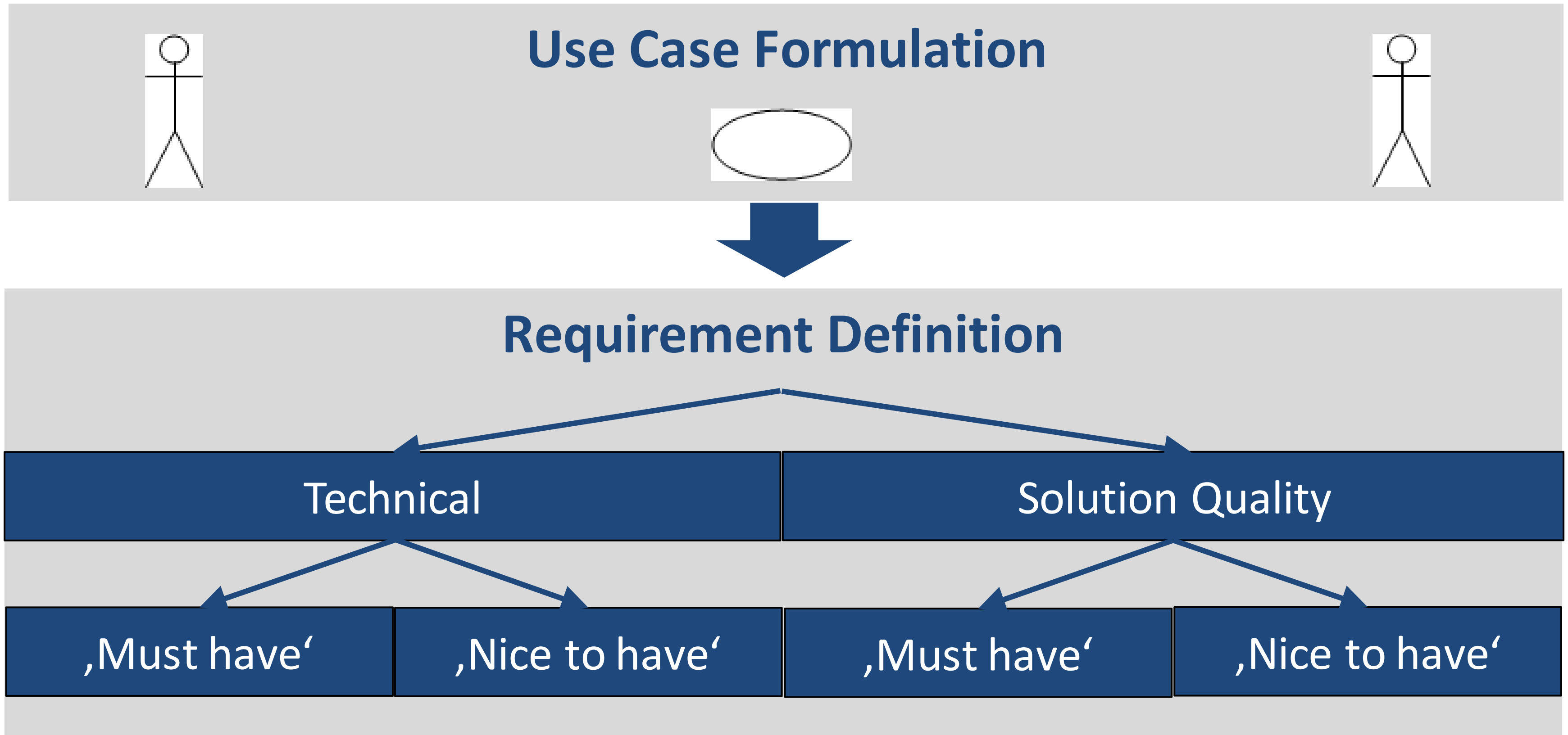
Outline Design Step 1: Definition of Requirements - Technical

Example of ‚Must Have' Technical Requirements

The Distribution System ICT Infrastructure must

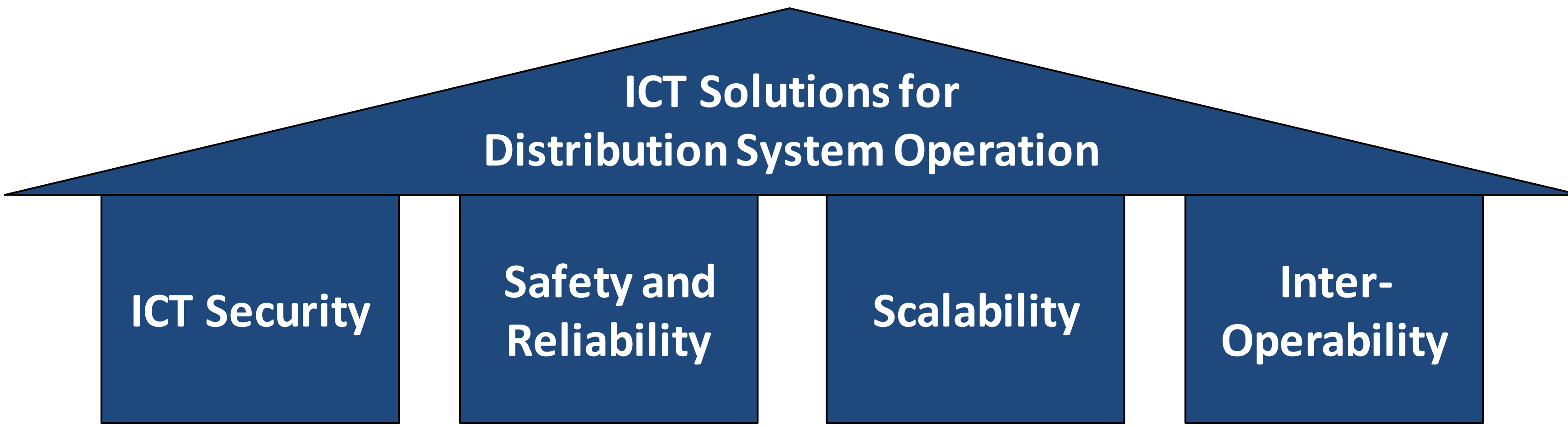
- Maintain voltage and overload limits under all system conditions
- Supply required ancillary services
  - On the relevant own voltage level
  - To the higher voltage levels

Outline Design Step 1: Definition of Requirements



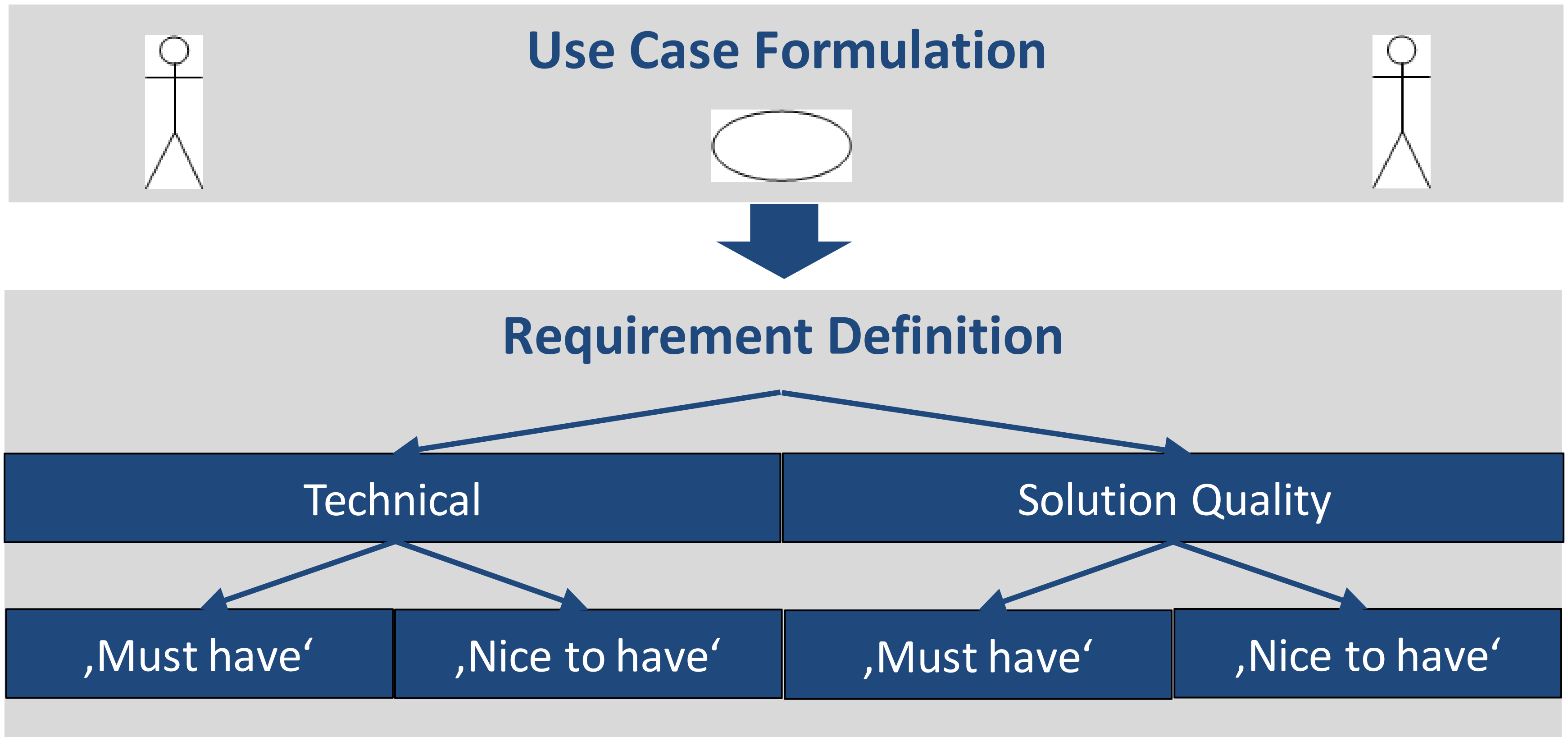
Outline Design Step 1: Definition of Requirements - Quality

‚Must Have‘ Solution Quality Requirements



➔ Minimum Standards must be fulfilled

Outline Design Step 1: Definition of Requirements



Outline Design Step 1: Definition of Requirements - Quality

‚Nice to have' Solution Quality Requirements

- Multifunctionality
- Energy Efficiency
- ...

➔ May be translated into a montary component

➔ Integration in cost-benefit analysis

Outline of Design Steps: Step 2

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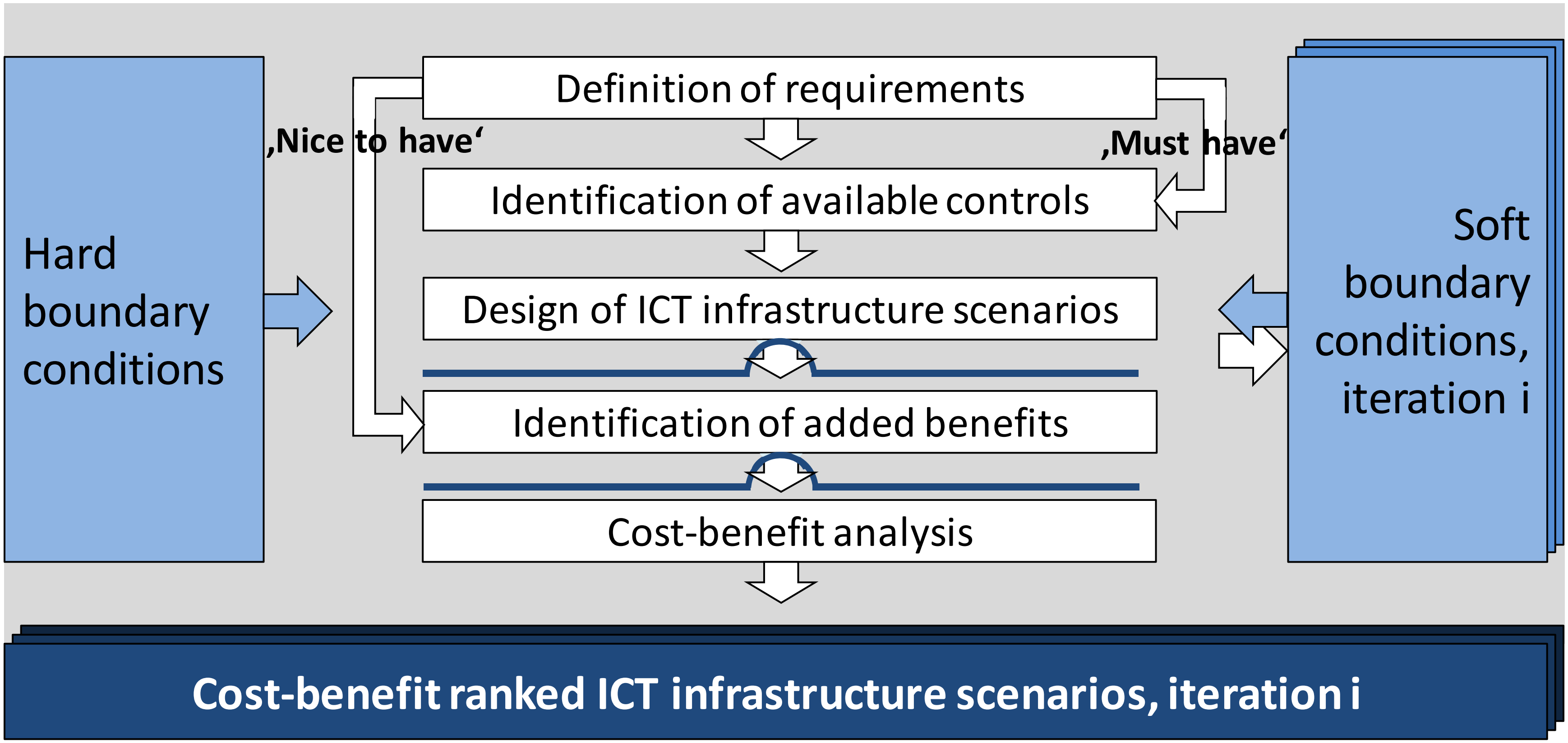

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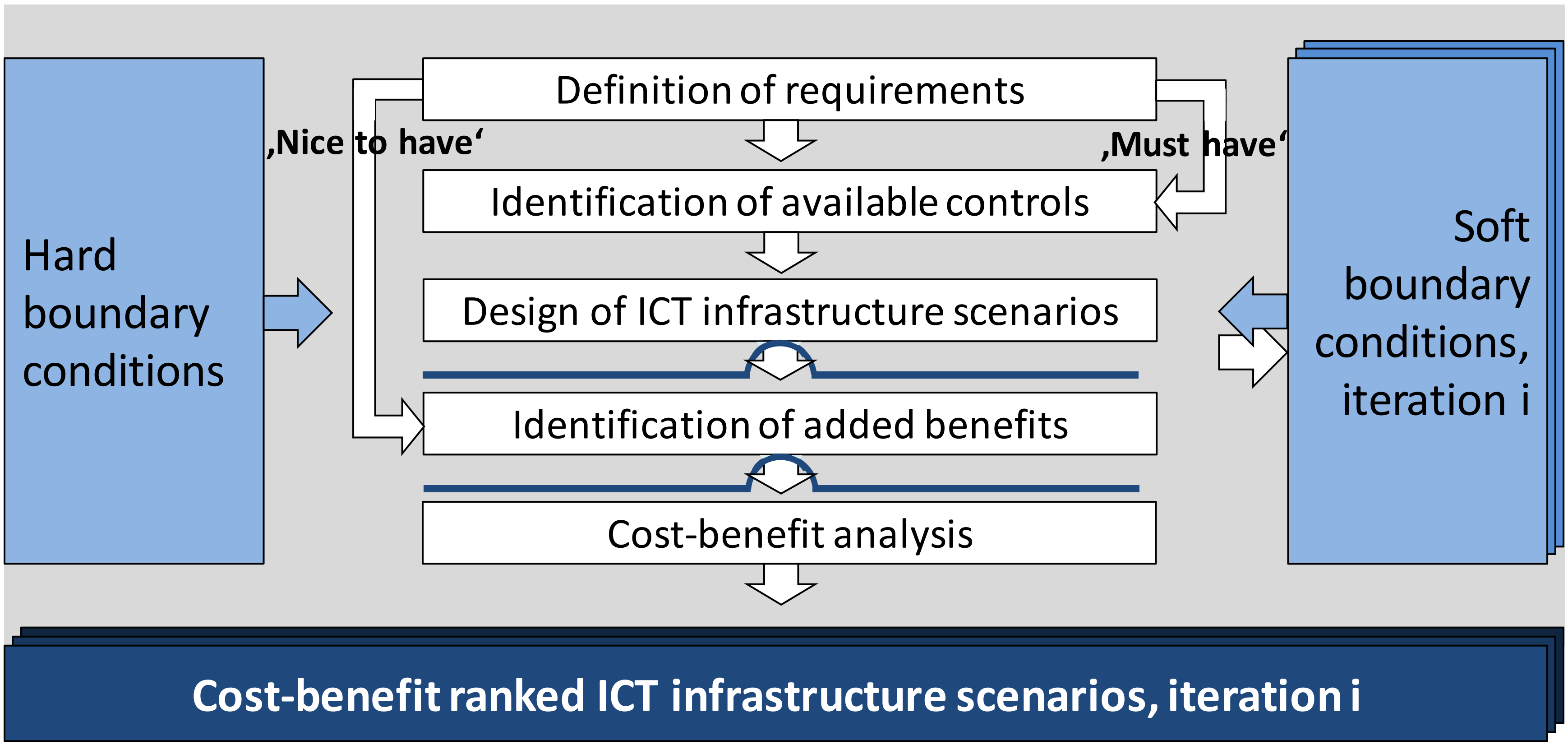
Outline Design Step 2: Identification of Available Controls

Typical Selection:

- On-Load Tap Changing Transformers (OLTC)
- Controllable Distributed Generators
- Controllable Distributed Storages
- Demand Side Management

Outline of Design Steps: Step 3



Outline Design Step 3: Design of ICT Infrastructure Scenarios

Goal:

Propose sets of possible ICT infrastructures that all fulfill the primary requirements from stage 1.

Process:

Don’t forget to analyse possibilities of neighboring systems, e.g. the higher voltage levels, to satisfy the requirements.

Result:

Designs of fully operational distribution system infrastructures, including a definition of control protocols and control signals,

as well as a definition of who has access to which infrastructure

Outline Design Step 3: Design of ICT Infrastructure Scenarios

Exemplary assumptions concerning soft boundary conditions:

- DSO and Metering Responsible Party access may, but must not have common access to one same infrastructure

Outline Design Step 3: Example Scenarios
Design of ICT Infrastructure Scenarios

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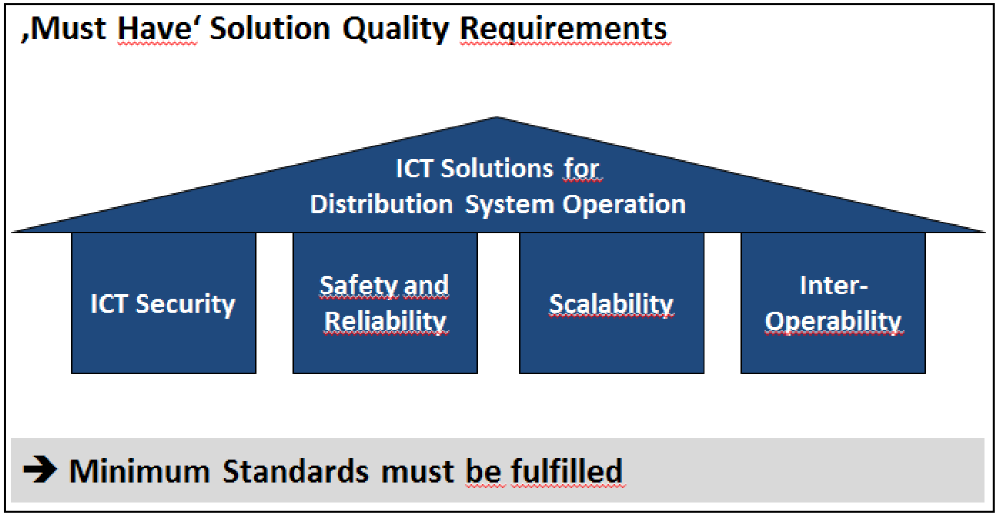
ICT Scenario n°	ICT Infrastructure Description	DSO Access	Metering Responsible Party Access
10	Smart Meter (metering only)	No	Yes
11	Smart Meter (metering & control)	Yes	Yes
…			
20	Smart Meter (metering only) DSL (control)	No Yes	Yes No
21	DSL (metering & control)	Yes	Yes
…			

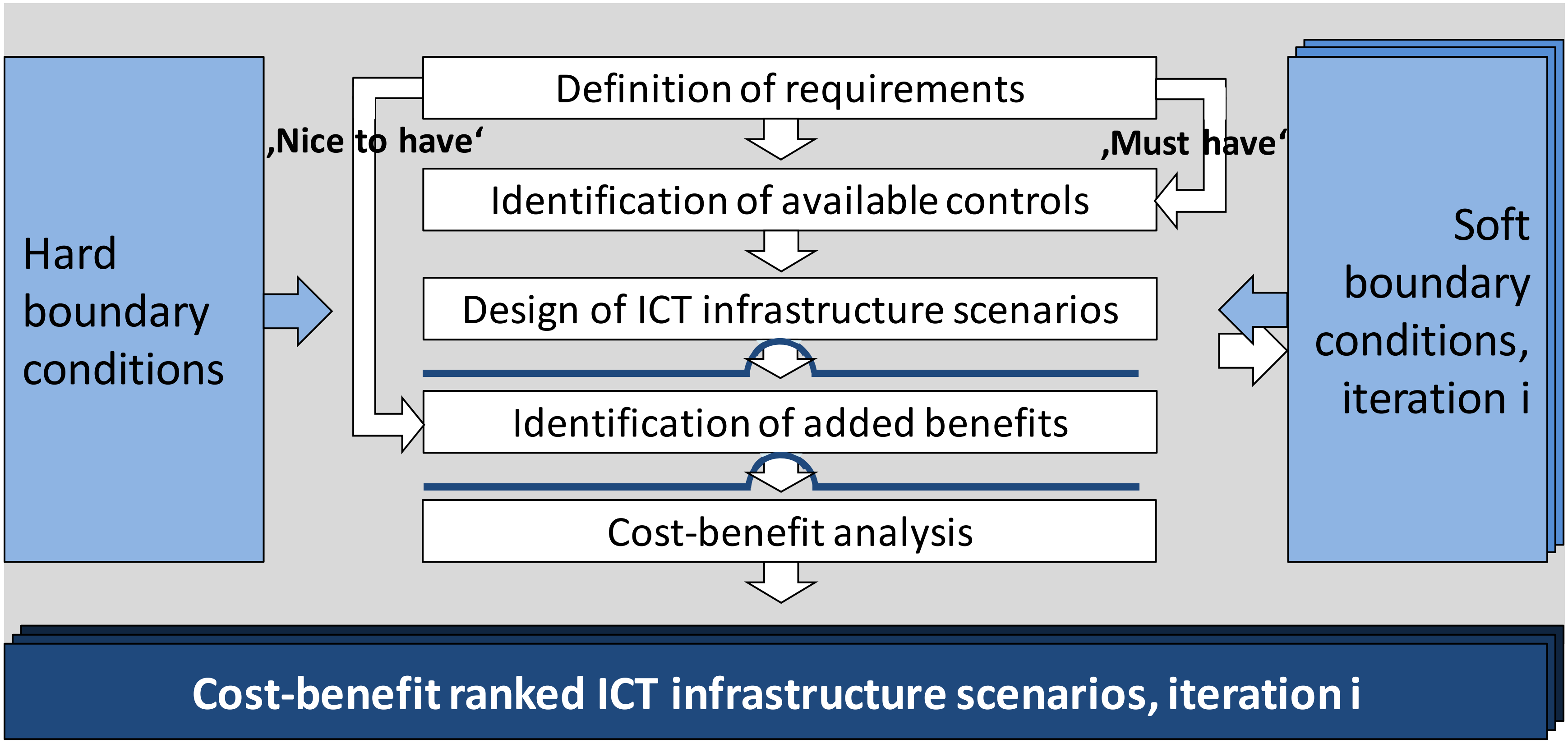
→ **Numerous scenarios possible**

Outline Design Step 3: Quality Gate Design of ICT Infrastructure Scenarios

Before proceeding with further analyses it should be checked if the requirements defined in stage 1) are met by the developed solutions: To reach stage 4, all identified ICT infrastructure alternatives must go through the quality gate. Only those options will pass that meet the minimal requirements.



Outline of Design Steps: Step 4



Outline Design Step 4: Identification of Added Benefits

Identified ICT infrastructure scenarios from step 3

Sc N°	ICT Infrastructure Description	DSO Access	VPP Access	Metering Serv. Provider Access	Manufacturer / Plant Operat. Access
10	CI I: no control CI II: radio ripple control	No Yes	No No	No No	No No
20	CI I: local U control CI II: radio ripple control	No Yes	No No	No No	Yes No
30	CI I: local U control CI II: DSL connection	Yes (via Op.) Yes	No Yes	No No	Yes No
40	CI I: DSL connection CI II: Broad Band PowerL	Yes Yes	No Yes	No Yes	Yes Yes

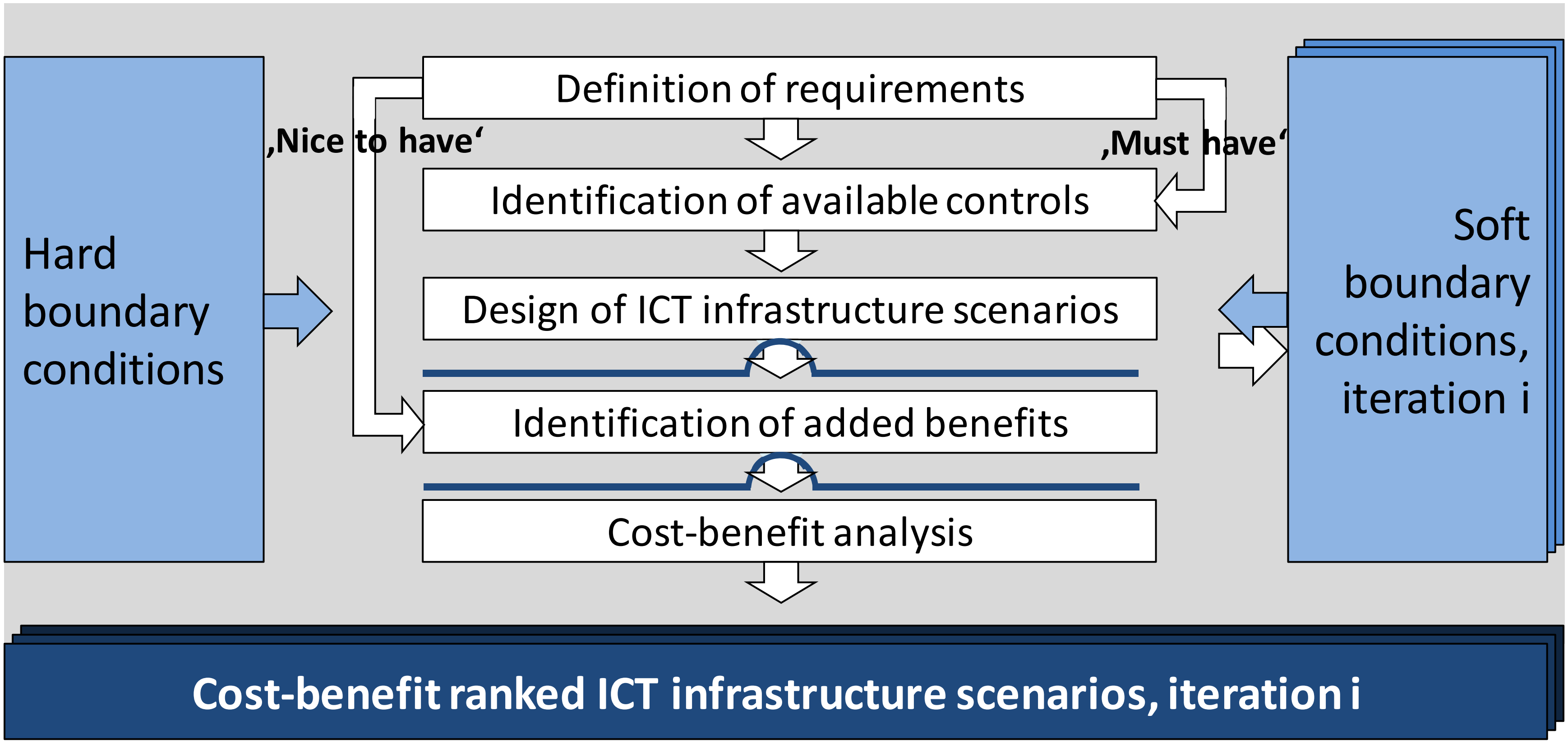
‚Nice to have' requirements

Identify potential Added Benefits, e.g.

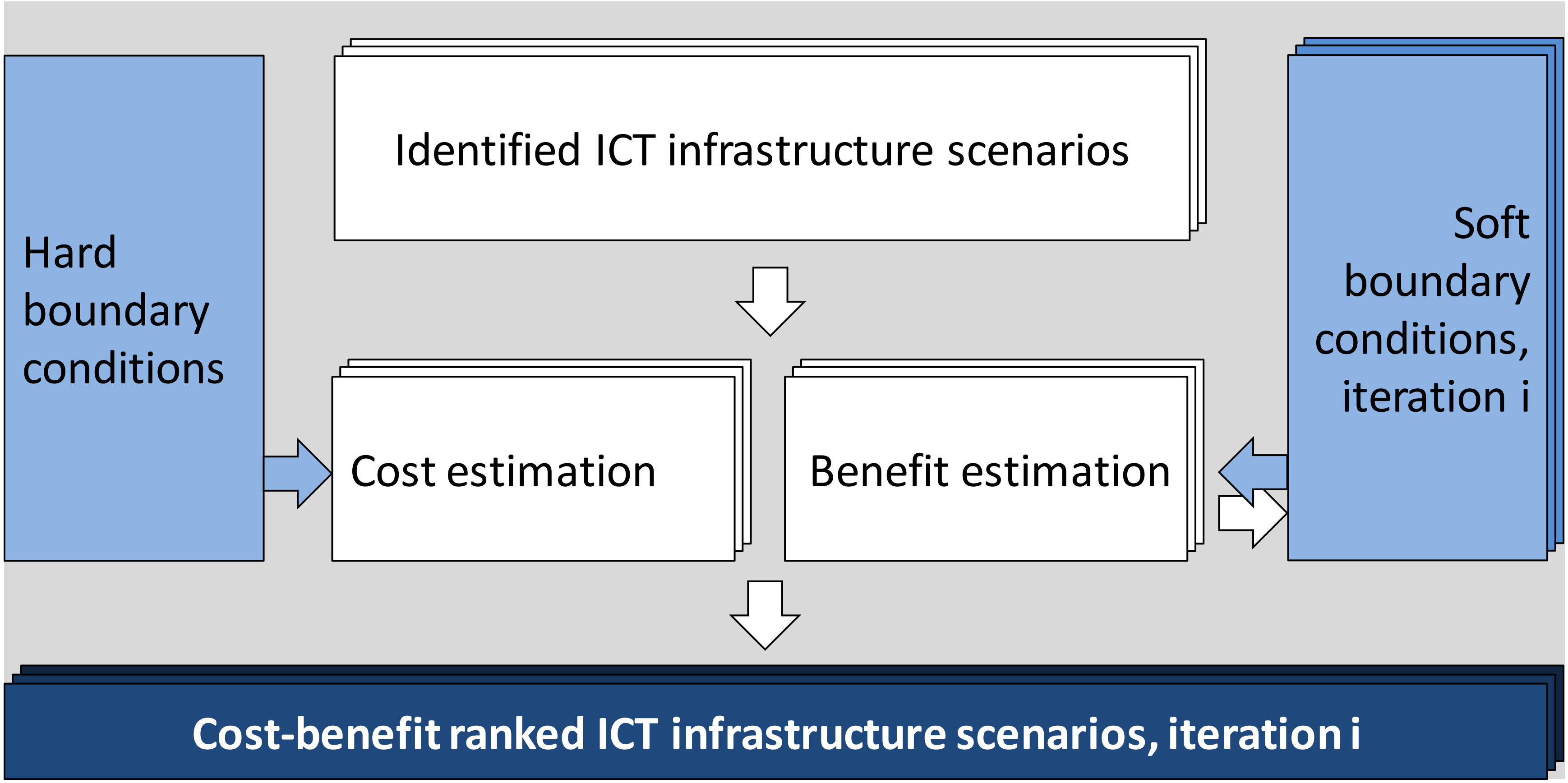
Power System:
- Support of secondary regulation by distrib. PV plants
- Support of online condition monitoring
- Support of demand side management functions
- ICT of use to further stakeholders

Non-Power System:
- Possibly safer home banking or internet access

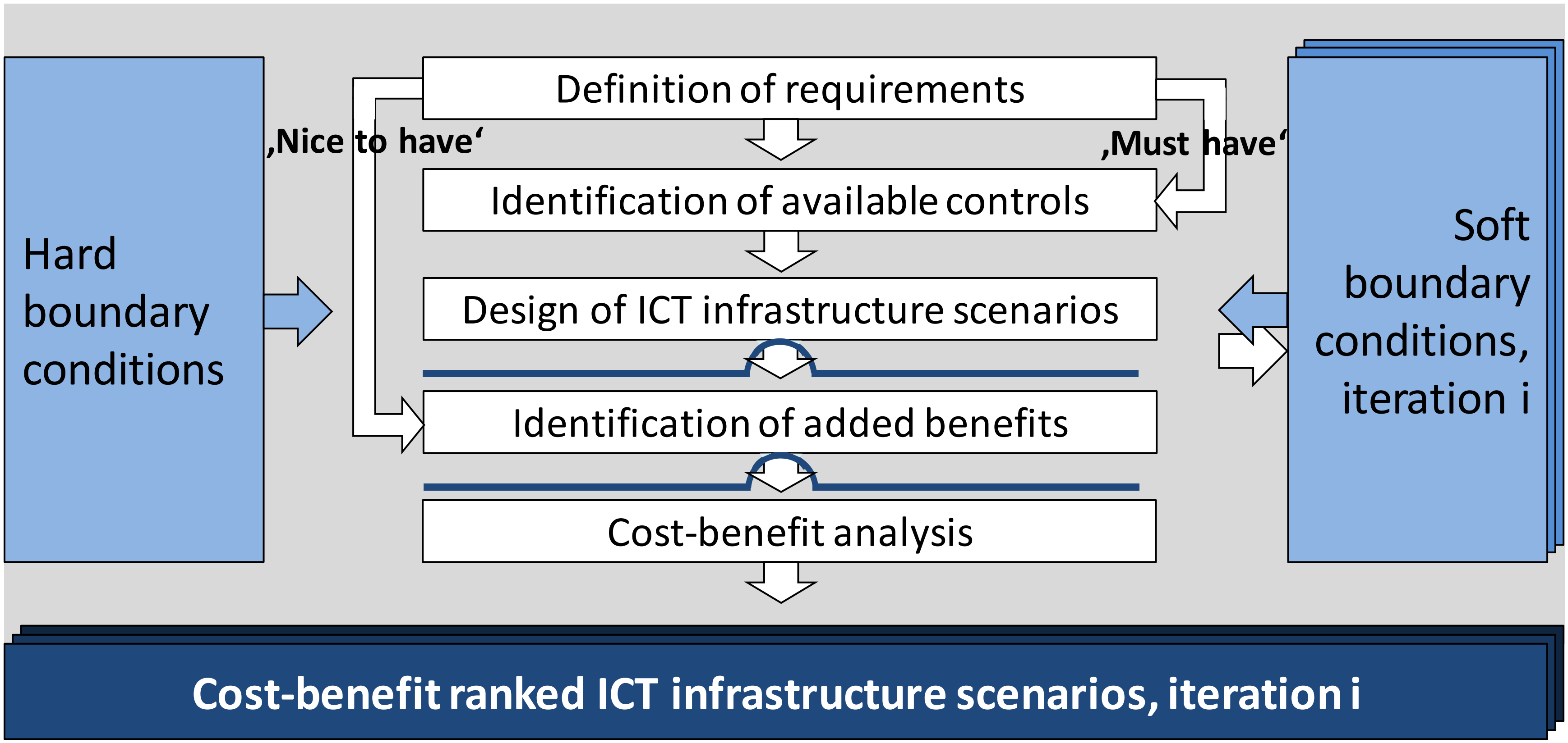
Outline of Design Steps: Step 5



Outline Design Step 5: Cost-Benefit Analysis



Outline of Design Steps: Iterative Process - Repeat with new soft boundary conditions



Outline

1) ICT Infrastructure Design Process
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   - Outline of Design Steps

2) Case Study

Case Study for Germany: (How) Should LV-DER be integrated to the ICT infrastructure?

Decide today about an investment in 2013

Take projections for 2020 / 2030 RE share in electricity as hard boundary conditions

Case Study for Germany: (How) Should LV-DER be integrated to the ICT infrastructure?

Hard Boundary Conditions

- primary energy mix for electricity generation
- Load magnitude & distribution

→ **LV DER share in low-load**

Projected installed capacity of PV plants <=100 kWp
2020: 107 % of Low Load
2050: 135 % to 200 % of Low Load

Focus on PV in LV

Case Study: Should LV-DER in Germany be integrated to the ICT infrastructure?

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Hard Boundary Conditions

- Geographical distribution of primary energy
- Existing ICT infrastructure

→ Radio ripple control available

→ GPRS / UMTS available

- Long wave radio communication is usually also available, but for the sake of brevity it is not further considered in the following.
- DSL is frequently not available in rural areas

Case Study for Germany: (How) Should LV-DER be integrated to the ICT infrastructure?

Regulatory Boundary Conditions I

Provision of interfaces for remote control obligatory for:

- PV >= 100 kWp
- 30 kWp < PV < 100 kWp *)

Given the projections for 2020 / 2030 → Considered as hard requirement

Case Study for Germany: (How) Should LV-DER be integrated to the ICT infrastructure?

Regulatory Boundary Conditions II

DSO must be able to cut PV feed-in in case of emergencies, e.g. on request of the TSO.

Required ICT infrastructure should be in place till end of 2013.

Given the projections for 2020 / 2030 → Considered as hard requirement

Case Study for Germany: (How) Should LV-DER be integrated to the ICT infrastructure?

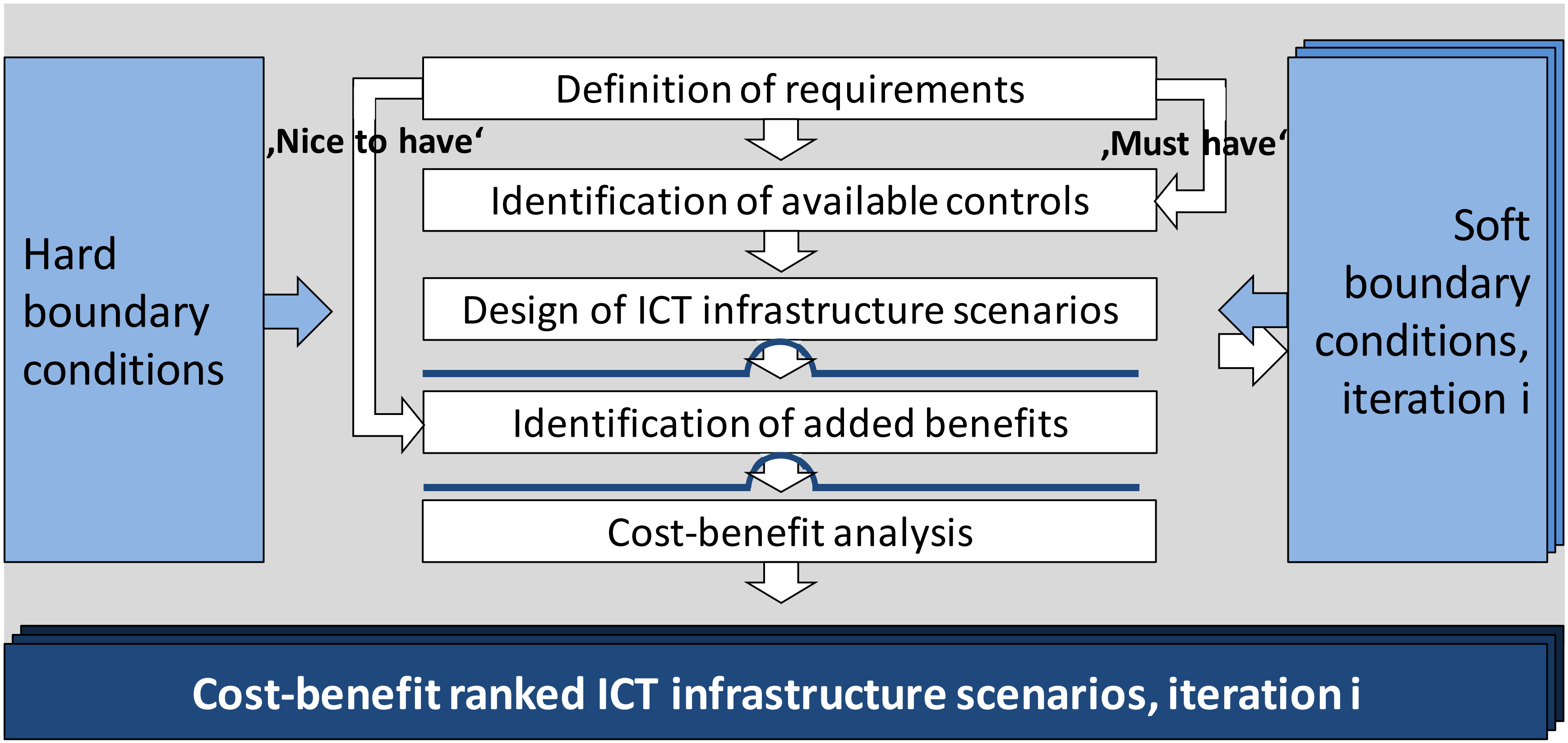
Soft Boundary Condition

Which customer(s) do we have in mind when designing the infrastructure?

- DSO, VPP, Metering Resp. Party, Regulatory Authority, Consumers …?

➔ Boundary condition to be relaxed during the different iterations
➔ Task is to provide support in identifying regulatory optimization potential

Case Study for Germany - Design Step 1: Definition of Requirements



Case Study for Germany: - Design Step 1: Definition of Requirements

Step 1: Definition of requirements (from use cases)

– DSO cuts PV in-feed in emergency situations

‚Must have immediately'

Step 2: Identification of available controls

Case Study for Germany: - Design Step 1: Definition of Requirements

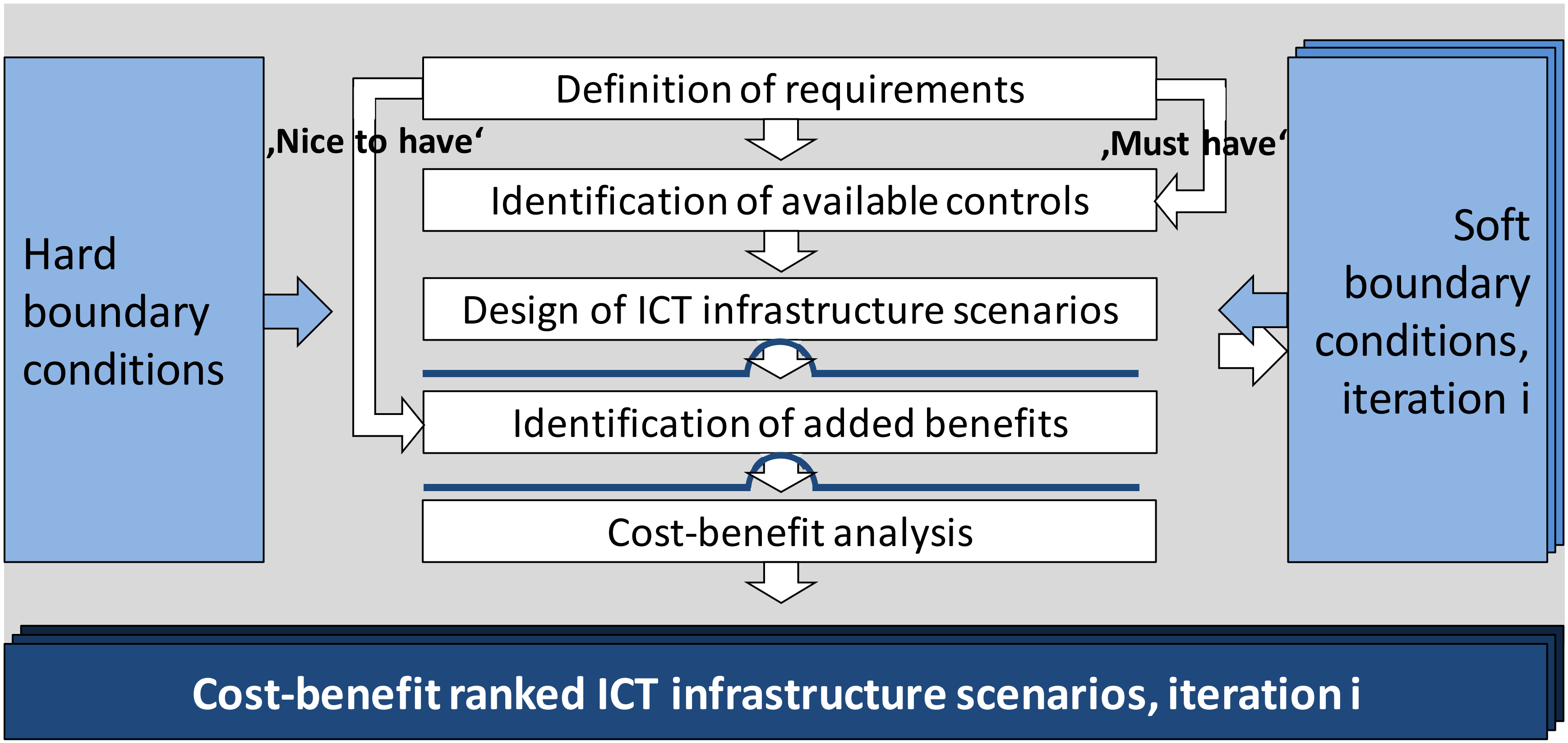
Must have later
➔ ‚Nice to have'

Step 1: Definition of requirements (from use cases) ctd.

– Virtual Power Plant monitors & controls LV DER
– Metering resp. party transmits metering-relevant data
– DSO evaluates LV-DER feed-in online, e.g. every 2-15 min.
– LV DER deliver centrally controlled reactive power to DSO

Step 4: Identification of added benefits

Case Study for Germany - Design Step 3: Design of ICT infrastructure scenarios



Case Study for Germany: - Design Step 3: Design of ICT infrastructure scenarios

Assumptions Concerning Hard Boundary Conditions (Extract):

- Mass-market ready and regionally available technologies:
  - Radio ripple control
  - GPRS / UMTS
  - Local voltage control of DER, e.g. cosphi (U)
- Distribution system DER may, but must not contribute to secondary / tertiary regulation
  → Sufficient regulation capacity is available in the higher voltage levels
  → Decision between the two a matter of cost-benefit (Step 5)

Case Study for Germany: - Design Step 3: Design of ICT infrastructure scenarios

Assumptions Concerning Soft Boundary Conditions (Extract):

- Design study is carried out on behalf of the government seeking regulatory advice → among others, the number of parties accessing the same infrastructure shall be subject to sensitivity analyses

Extract soft structural parameters, iteration 1

Extract soft structural parameters, iteration 2

Extract soft structural parameters, iteration 3

Parties with access to ICT infrastructure

- DSO
- VPP
- Manufacturer / Plant Operator

Case Study for Germany: - Design Step 3: Design of ICT infrastructure scenarios

Iteration n°	ICT Scenario n°	ICT Infrastructure Description	DSO Access	VPP Access	Manufacturer / Plant Operator Access
3	10	Cl I: local U control Cl II: radio ripple control	No Yes	No No	No No
3	20	Cl I: local U control Cl II: GPRS / UMTS	Yes (via Op.) Yes	No No	Yes No
3	30	Cl I: GPRS / UMTS Cl II: GPRS / UMTS	Yes Yes	No Yes	Yes Yes
3	…				

Cl I: PV < 30 kWp
Cl II: PV 30 to 100 kWp

- → **Numerous further scenarios possible**
- → **Scenarios N° 10 and 20 rely on provision of entire secondary / tertiary regulation from plants connected to higher voltage levels**

Case Study for Germany - Design Step 3: Design of ICT infrastructure scenarios

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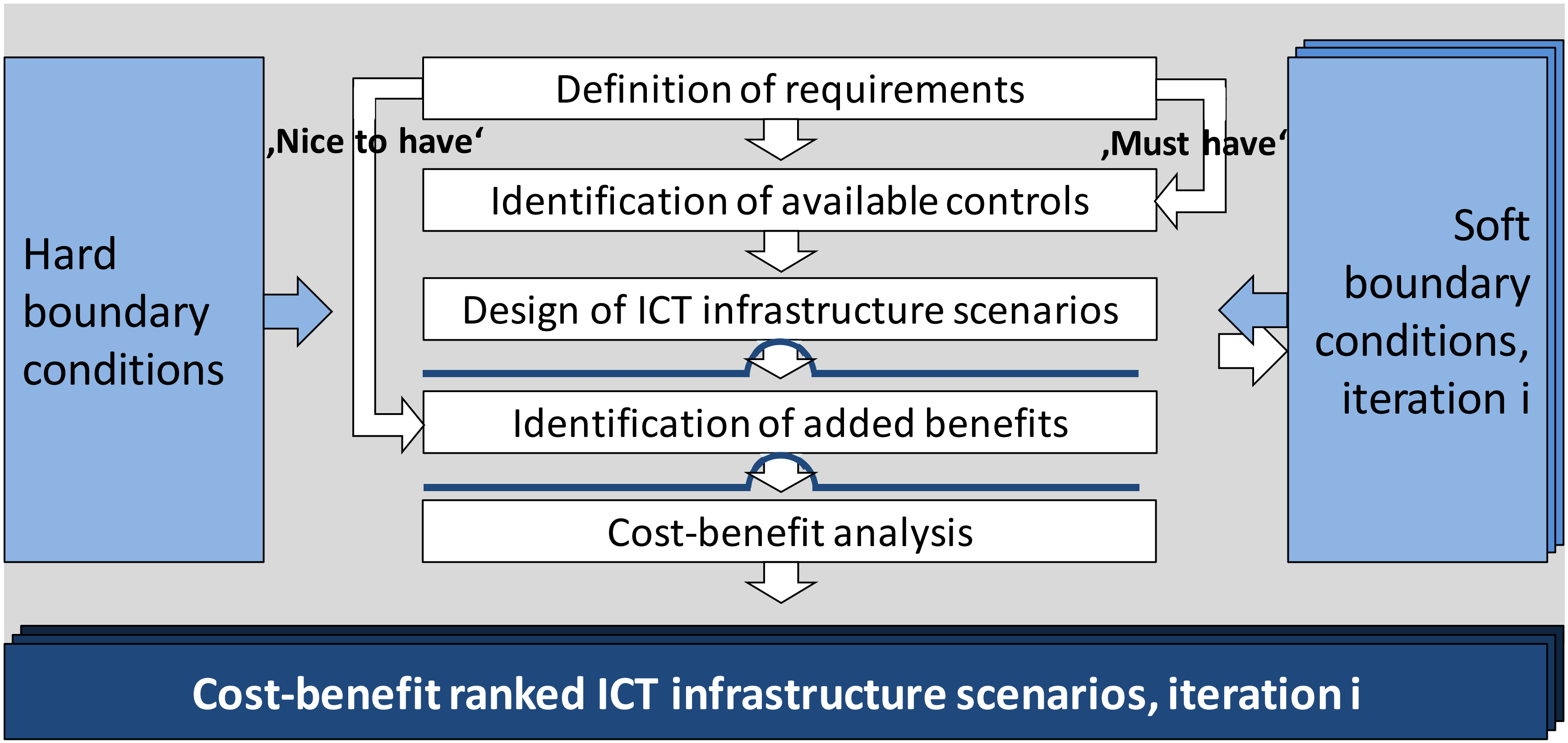


Case Study for Germany: - Design Step 4: Identification of Added Benefits

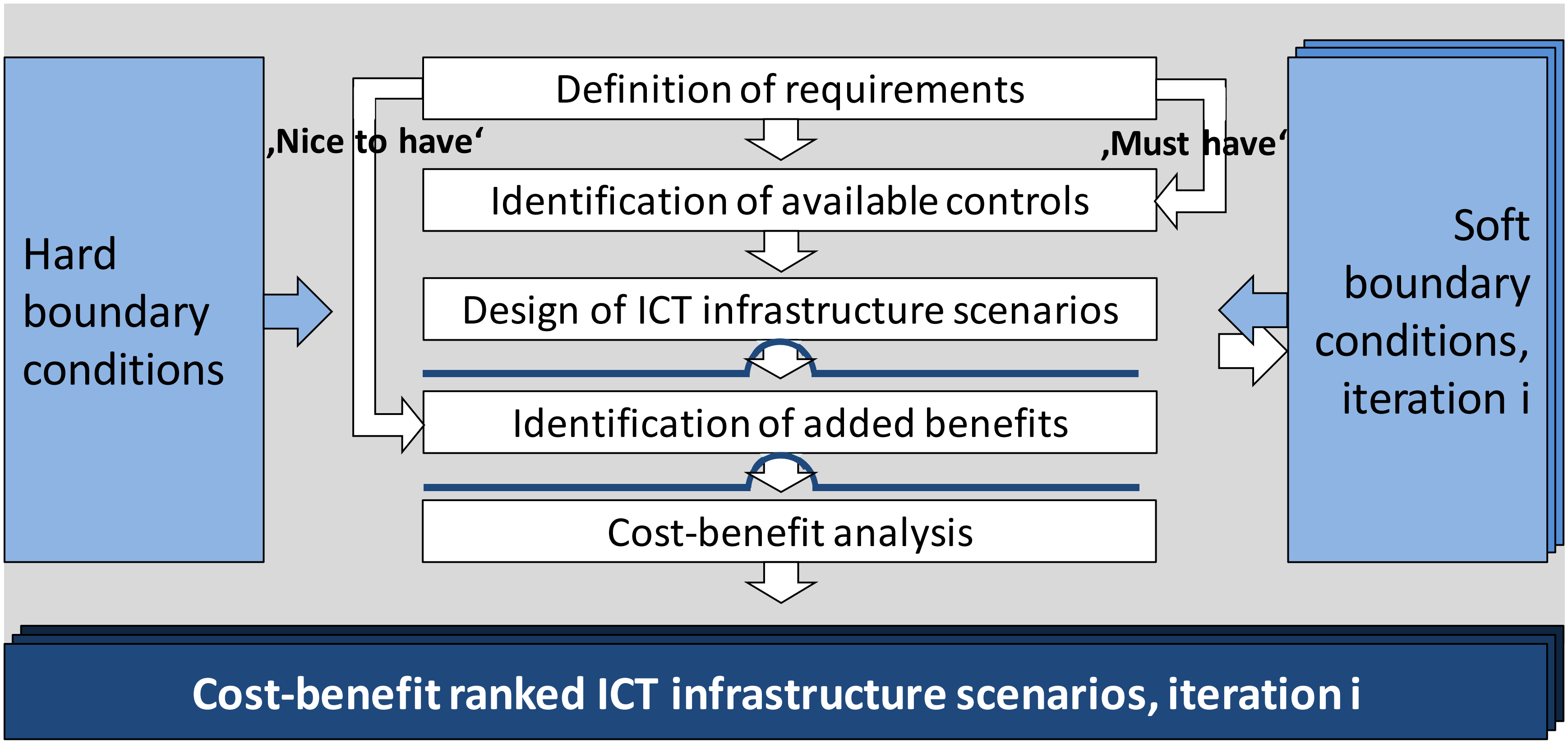
Iteration n°	ICT Scenario n°	ICT Infrastructure Description	DSO Access	VPP Access	Manufacturer / Plant Operator Access
3	10	Cl I: local U control Cl II: radio ripple control	No Yes	No No	No No
3	20	Cl I: local U control Cl II: GPRS / UMTS	Yes (via Op.) Yes	No No	Yes No
3	30	Cl I: GPRS / UMTS Cl II: GPRS / UMTS	Yes Yes	No Yes	Yes Yes
3	…				

Cl I: PV < 30 kWp
Cl II: PV 30 to 100 kWp

→ **Sc. 20, 30: DSO has access to local U control settings**

→ **Sc 30: VPP access to larger plants possible**

Case Study for Germany - Design Step 5: Cost-Benefit Analysis



Summary: Design of appropriate ICT infrastructures for smart distribution grids

Design process has been proposed, based upon:

- Distinction of ‚must have' and ‚nice to have'
- Careful reflection on durability of boundary conditions
- Consideration of synergies between potential stakeholders
- Relaxation of soft conditions and requirements

→ **List of cost-benefit ranked alternative ICT infrastructure scenarios**

Thank you for your attention!

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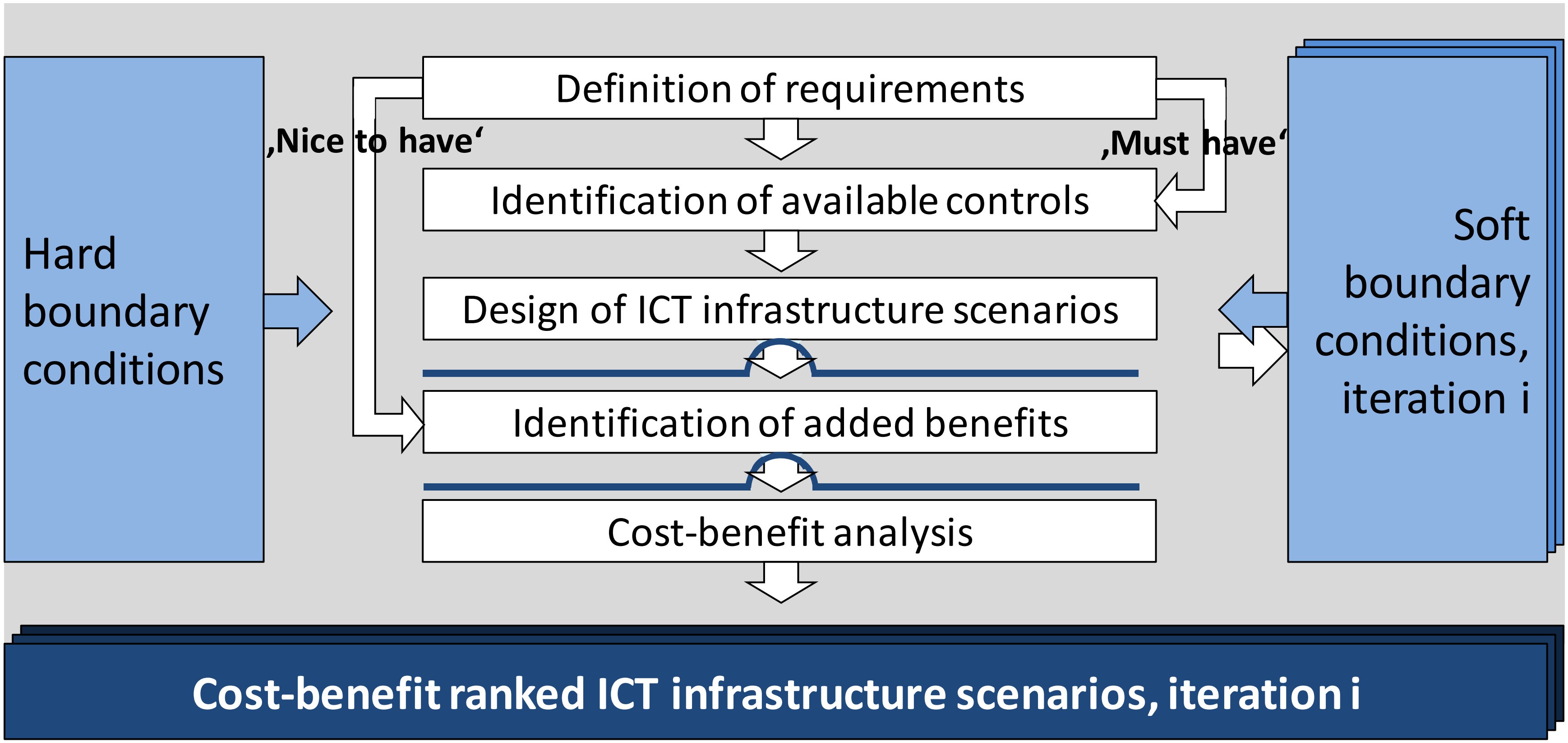

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