NEW APPROACHES FOR ENERGY MANAGEMENT: INCENTIVES, INTEGRATED SYSTEM PLANNING AND OPERATION AND GRID INTEGRATION

Bixpo 2018

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FRAUNHOFER IEE
ENERGY ECONOMICS AND ENERGY SYSTEM TECHNOLOGY

The Fraunhofer IEE in Kassel researches in the fields of energy economics and energy system technology.

Our service portfolio deals with current and future challenges faced by the energy industry and energy system technology issues.

We explore and develop solutions for sustainably transforming renewable based energy systems.

- Personal: approx. 360
- Annual budget: approx. 25 Mio EUR
- Director: Prof. Dr. Clemens Hoffmann

BUSINESS UNITS AND BUSINESS FIELDS

Energy Economics

- Analyses and consultancy in energy economics
- Energy meteorolgy information system
- Virtual power plants
- Wind resource assessment with LiDAR
- Training and knowledge transfer

Energy System Technology

- Grid planning and operation
- Decentralized energy management
- Power electronics and drive technology
- Hardware-in-the-loop systems
- Plant engineering
- Measuring and testing
- Training and knowledge transfer

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Digitalization, decentralized energy systems and e-mobility provide new opportunities for prosumer oriented energy management.

Smart home

Interoperability

Interfaces

Open source

Flexibility

Data security

Building automation

IoT

Optimization

Smart grid

ML

AI

Web services

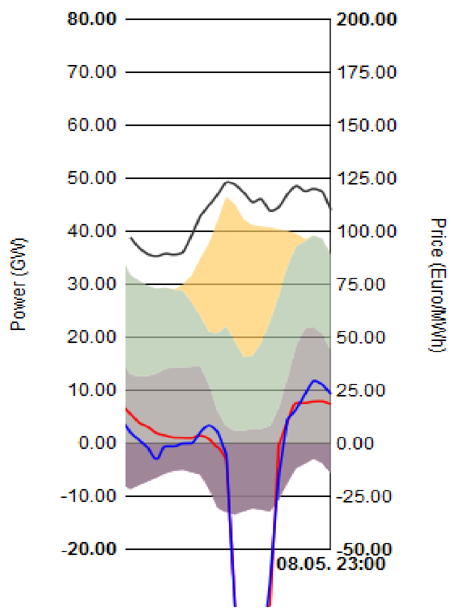
Usability

Smart meter

Pictures: Tesla, SMA, Vaillant

Changing drivers for sizing and operation of RES increase the complexity of planning and operation for all involved actors.

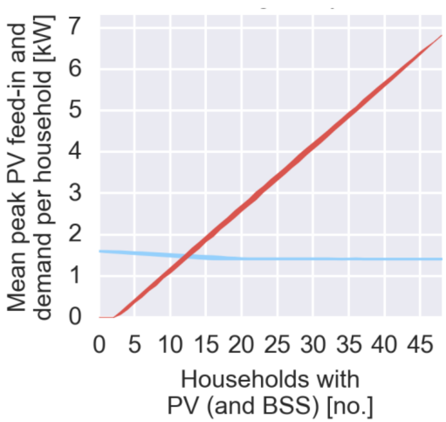
Changing price signals*



Changing feed-in tariff

- Continuous adjustment according to PV installation rates
- Unclear if fixed FIT exists after 52 GW cap for PV has been reached (now: 45 GW)

Grid integration



*Source: energy-charts

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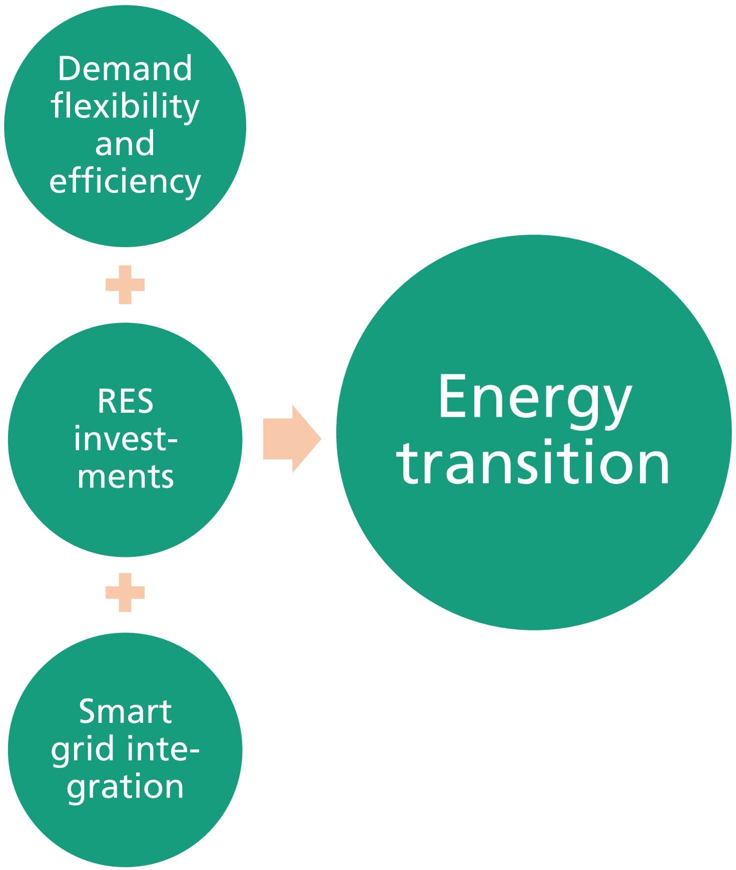
A threefold approach is proposed to enable better RES integration and improved energy management for prosumers.

- New incentives for demand flexibility and automation of energy management
- Data-driven investment and operation decisions in RES, microgrids and e-mobility
- Improved grid integration of RES through optimal control and grid planning



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Agenda

- social energy management
- RES investment and operation
- Smart grid integration

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sema aims at motivating the adoption of different energy consumption patterns and facilitating energy savings.

sema (social energy management):

- Platform enabling participants to optimize their energy consumption through room heating management and electricity monitoring
- Personalized feedback on energy usage and points for adjusted energy consumption
- Electricity demand:
  - High RES generation = high sema level
  - More points for energy consumption when sema levels are high
  - ➢ Motivation for higher demand flexibility according to RES generation

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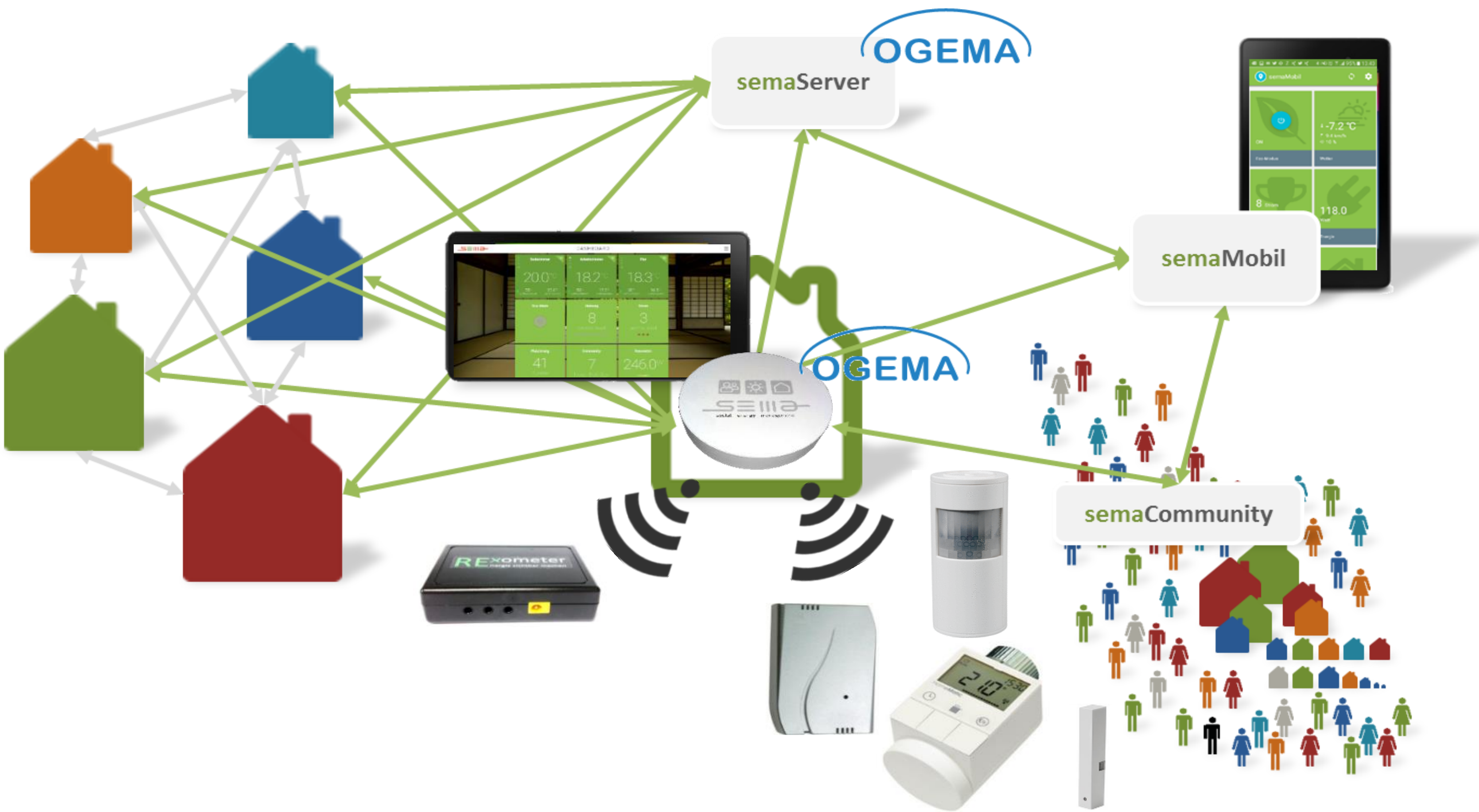
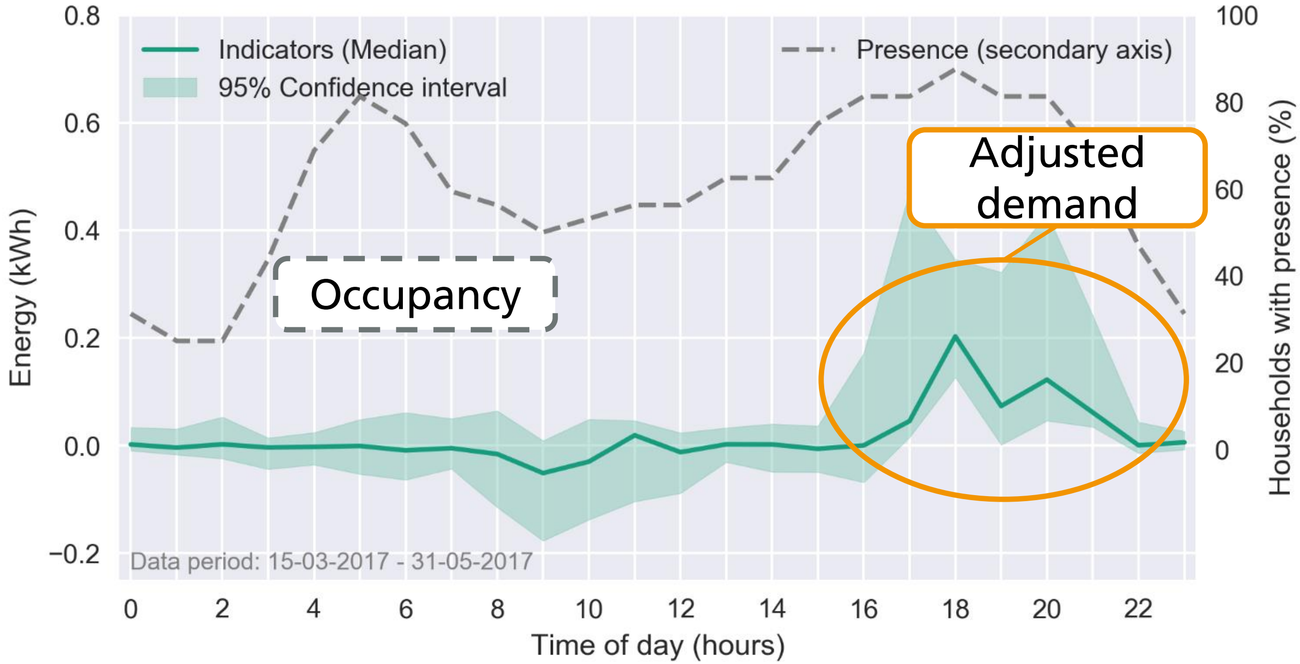
sema runs on the open-energy management platform OGEMA developed by Fraunhofer IEE.



Source: Engel (2018)

sema incentivizes shifting demand according to RES generation, but is limited by participants' occupancies.

Comparison of electricity demand with low and high sema levels



- Up to 50 % more demand in certain evening hours

Source: Dörre (2018)

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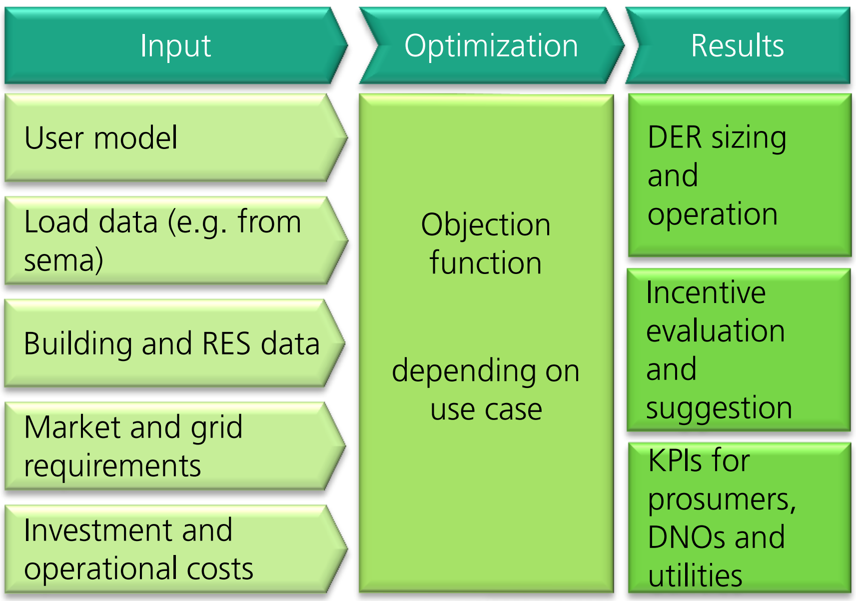
Optimally configured and operated decentralized energy systems provide a chance to generate value added for prosumers.

OptIn for optimal sizing and operation of DER, microgrids and e-mobility



Forecasts for load and prices for model-predictive controller

Case studies:

- Optimal sizing and operation of residential PV systems with battery storage systems and heat pumps for different incentives
- Interdependencies between incentive design, sizing, operation and grid integration

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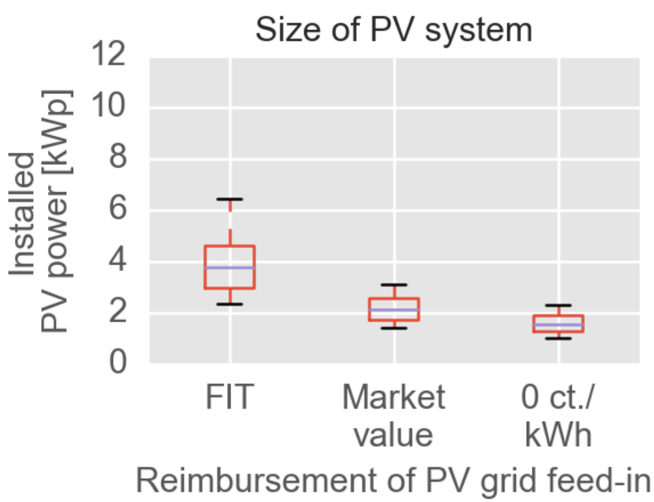
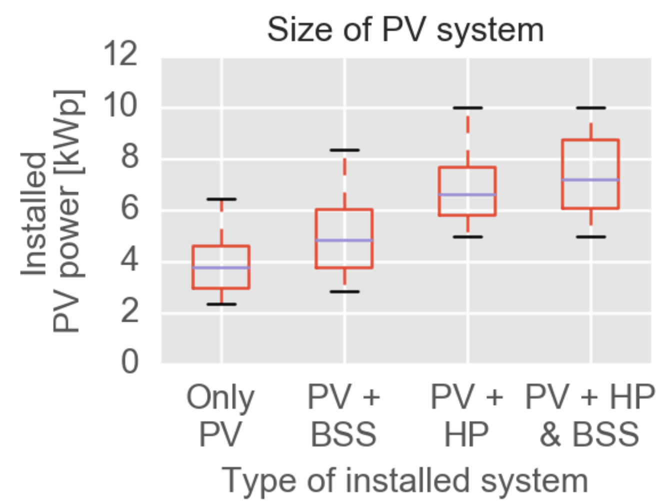
How do changing incentives impact the sizing and grid integration of residential PV systems?

Impact of reimbursement of PV grid feed-in on PV system size:



➡ Rooftop PV potential might not fully captured in zero-FIT world

Impact of BSS and heat pumps on PV system size:



➡ Sector coupling as a chance

Source: Appen (2018)

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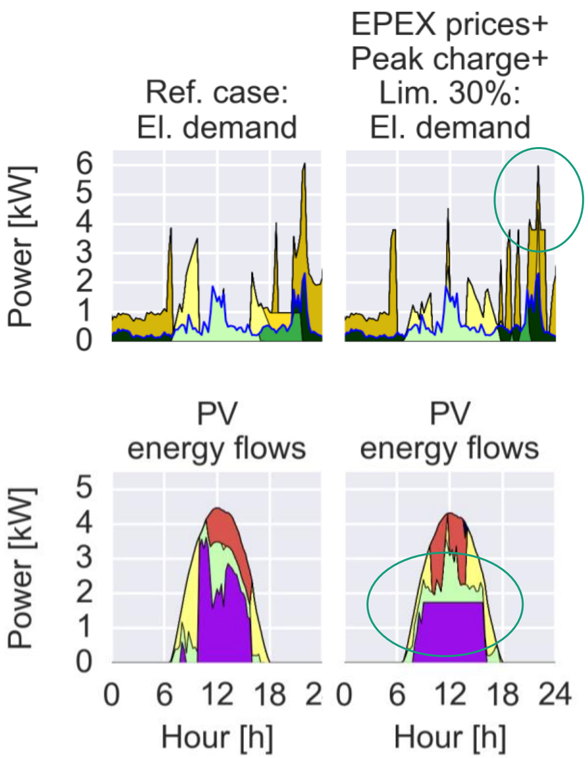
Optimized control of decentralized power-heat-storage systems ensures such systems benefit from new incentives.



- New incentives for operation of PV BSS battery and heat pump operation (market prices, peak charges and feed-in limits)
- Combination of price and feed-in limit incentives to ensure a grid-friendly operation of decentralized power-heat-storage systems

Source: Appen (2018)

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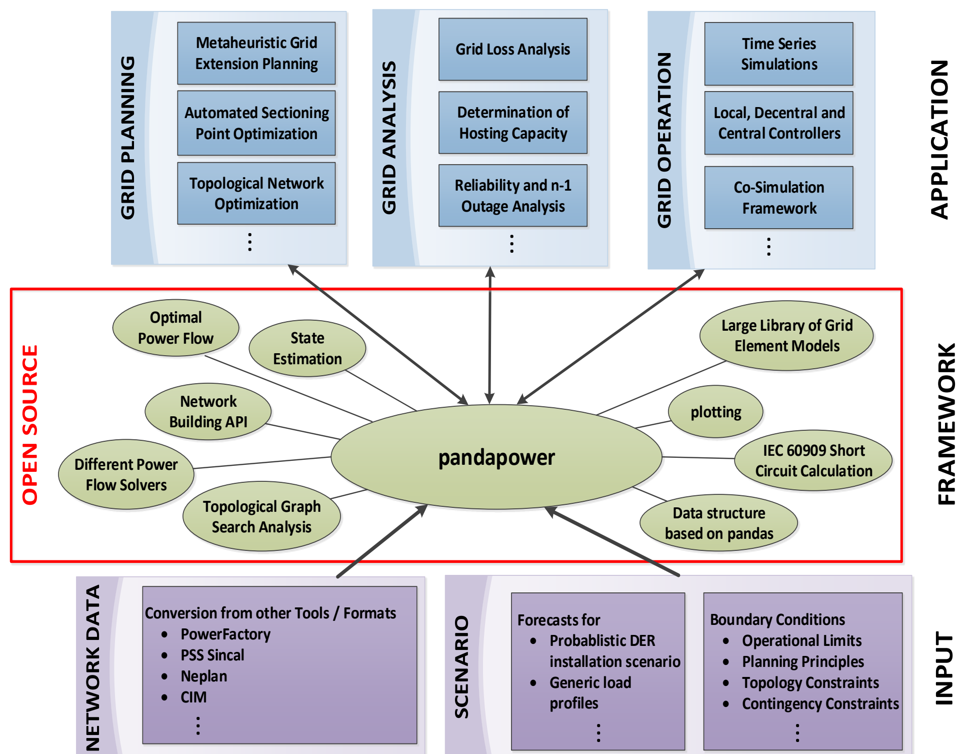
Grid planning requires tools that are able to handle the complexity of the future power system and automate the analyses.

Grid planning of the future:

- Complexity of grid planning is increasing (PV growth, regulatory framework, BSS, HPs)
- New control options of inverters and new smart grid technologies

Pandapower*:

- Extensive model library
- Power system analysis
  - Power flow & OPF
  - State estimation
  - Short-circuit calculation
  - Topological graph searches

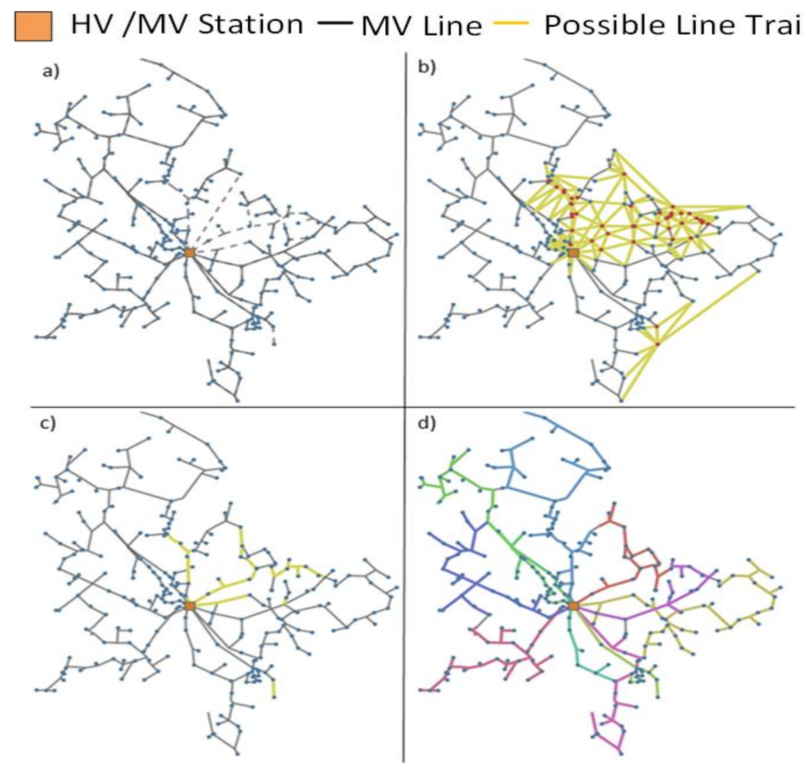


Source: Thurner (2018)

Pandapower comprises modern grid planning approaches to identify cost-optimal solutions for various planning problems.

Network topology optimization*

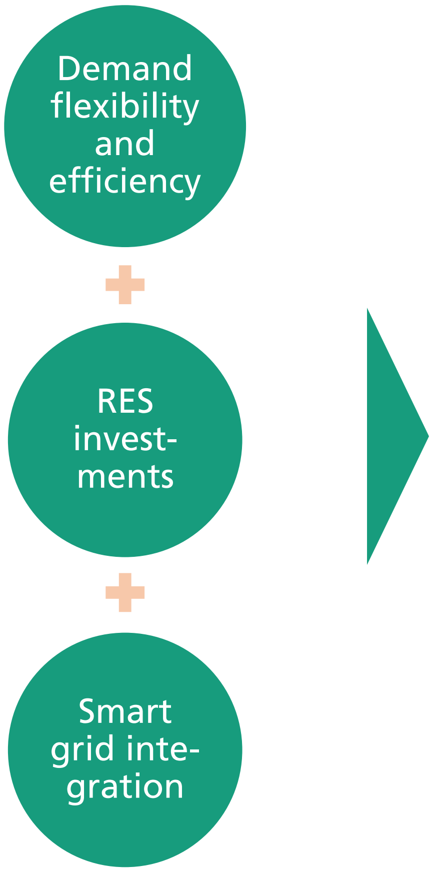
- Typical constraints:
  - Topological constraints (radial, all nodes supplied, n-1)
  - Load flow constraints (voltage, loading)
- Research questions:
  - Integration of grid reinforcement and asset management
  - Validation of planning principles
  - Supporting the network planning process



a) Initial network with lines to remove (dotted)
b) Line trails considered for new network structure
c) Optimized network structure
d) Feeder sectioning in optimized network structure

Source: Thurner, Results from ANaPlan project (2018)

Demand flexibility and improved grid integration can only be achieved through new planning and control approaches.



- User-focused approaches for energy management, energy efficiency and grid integration:
  - New incentives for digital engagement and non-monetary approaches, e.g. sema
  - Open-source energy management via OGEMA
- Optimization models for integrated planning and operation of decentralized energy systems and microgrids:
  - Strategic stakeholder behavior and interdependencies
  - Data-driven investment decisions using OptIn
- Automation of grid planning:
  - Increasing complexity and new control approaches
  - Optimized grid planning using pandapower

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- L. Thurner, A. Scheidler, F. Schäfer et. al. “pandapower - an Open Source Python Tool for Convenient Modeling, Analysis and Optimization of Electric Power Systems”, IEEE Transaction on Power Systems, 2018.
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OGEMA – Smart Energy Platform for Buildings

OGEMA

Key features of OGEMA

Public Software Platform

- Open-Source framework
- Developed by Fraunhofer institutes IWES, IIS
- All interfaces public

Runtime Environment

- Java / event based
- Software Development Kit
- High level of IT security and data privacy

Modular EM-System

- Fast, efficient development of new modules
- Re-use of existing solutions in new systems
- Management of modules via OGEMA Appstore

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