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Smarter Grids for Mastering the Energy Transformation

Dr. Christoph M. Flath

VDI-ARISAL Meeting
Hager Electro S.A.
21st March, 2014

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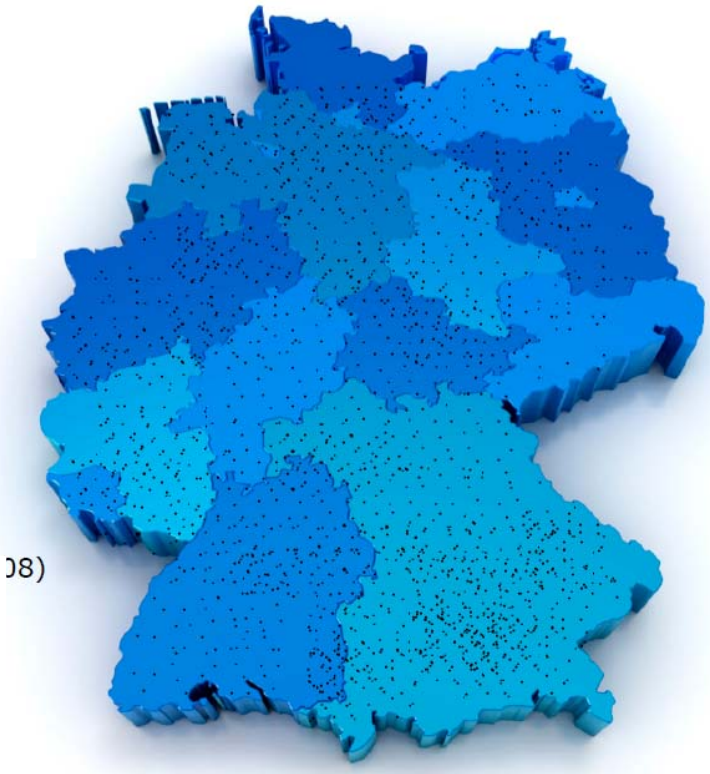
Department of Economics and Business Engineering

Germany‘s generation footprint has become decentral and renewable

32,000 µ-CHP

180,000 heat pumps (2008)



)08)

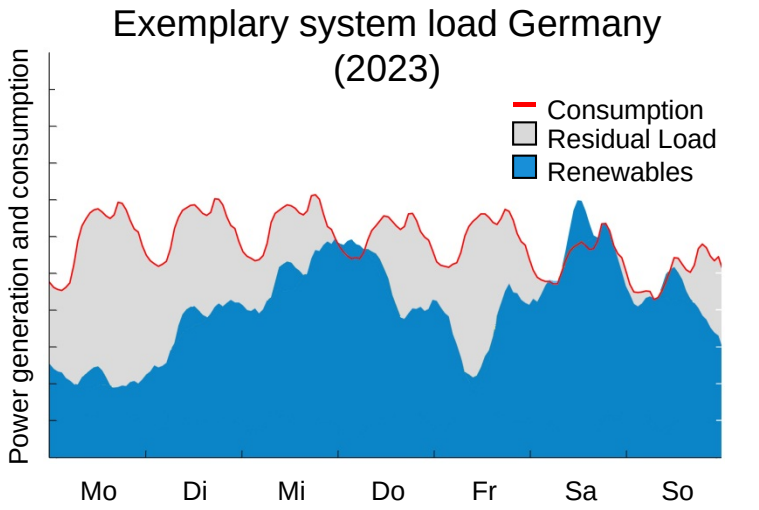
23,000 wind turbines

1.3 million PV installations

Quellen: Bundesnetzagentur, BMWi, Deutsche Energieagentur (Dena), Fachagentur Nachwachsende Rohstoffe e.v. (2013)

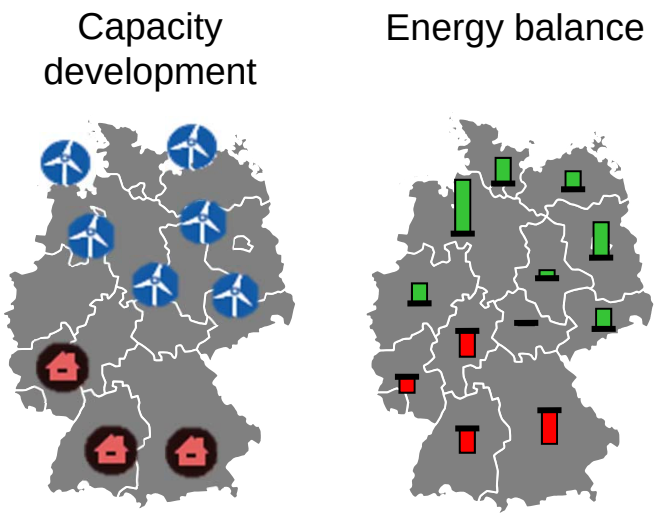
Grid challenges due to the energy transformation

Temporal



Source: Agora Energiewende

Spatial



Source: Netzentwicklungsplan Strom 2013

Exemplary investment needs in Germany:

Distribution grids (until 2030)	27.5 – 42.5 bn EUR
Transmission grids (until 2023)	~20 bn EUR

Source: dena Verteilnetzstudie 2012; Netzentwicklungsplan Strom 2013

Can we use current capacities in a smarter way?

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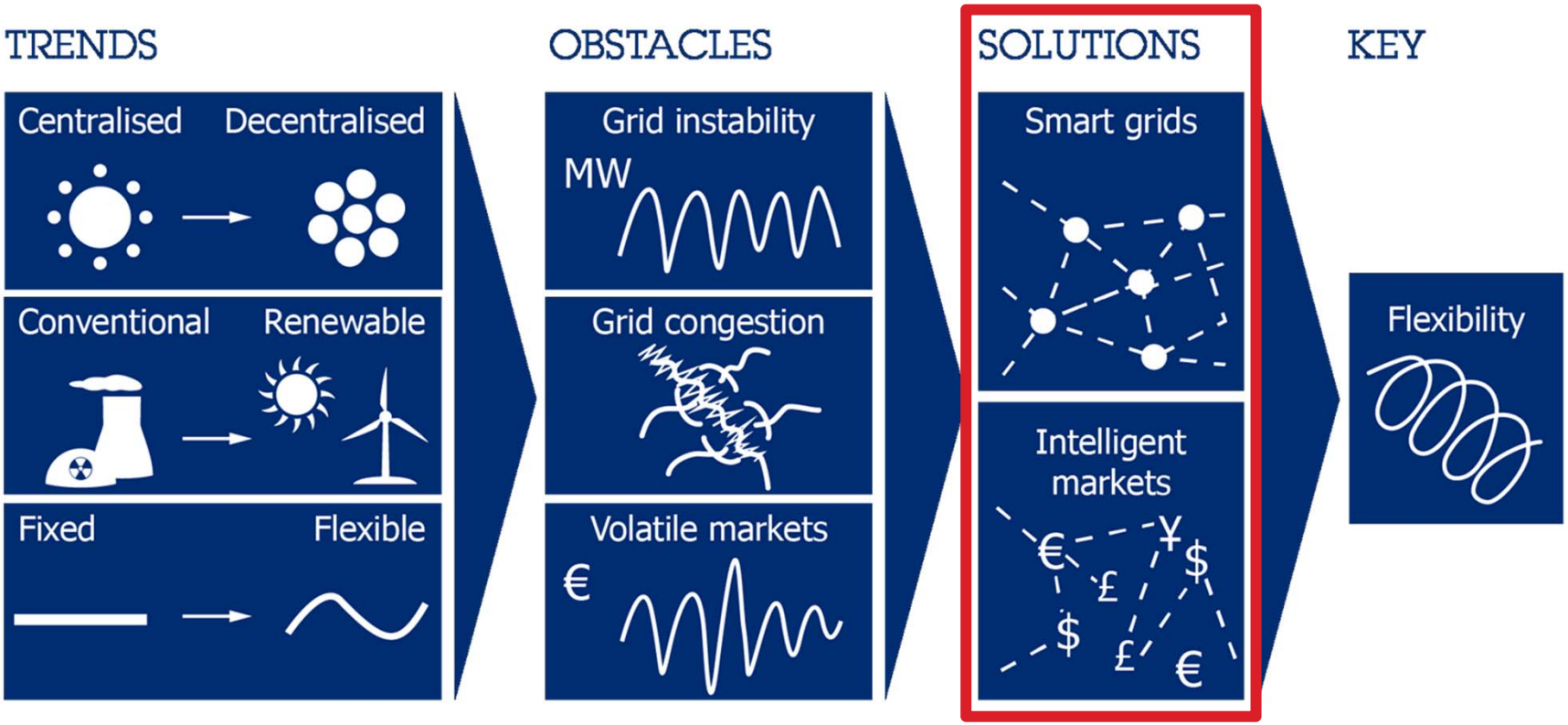
The power system requires a fundamental change to its operational paradigms



Source: Entelios

Demand Response

Standards

Smart Homes

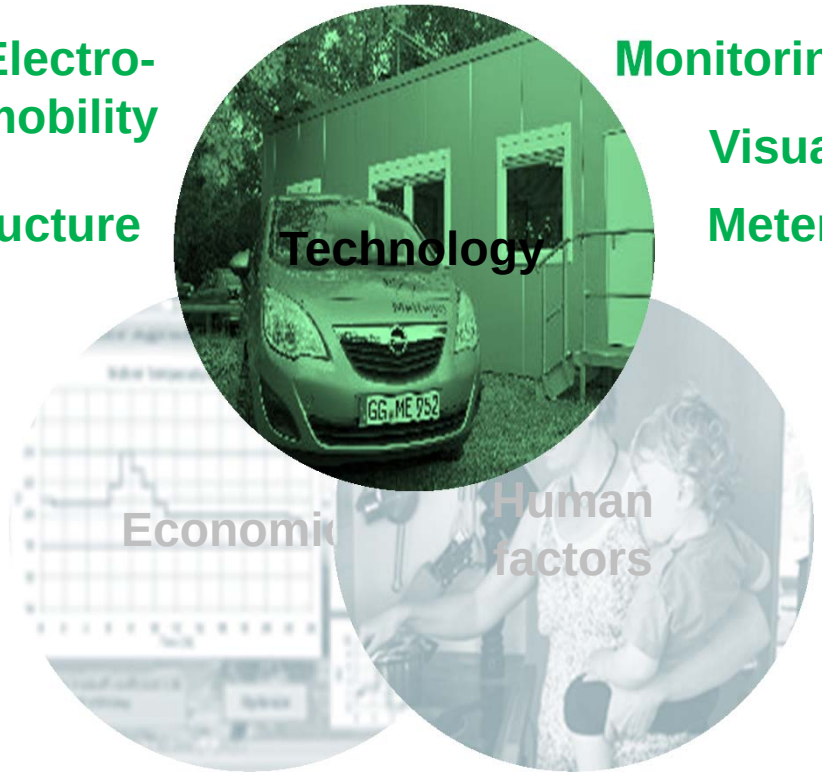
Electro-mobility

Monitoring & Control

Visualization

Infrastructure

Metering



CNET › News › Internet & Media › Google closes $3.2 billion purchase of Nest

Google closes $3.2 billion purchase of Nest

The acquisition brings with it the Learning Thermostat and the Protect smoke and CO detector as Google looks to make its mark in the smart home.

BMW's i3: A Bold Bet on the Future of Transportation

BY DOUG NEWCOMB NOVEMBER 14, 2013 6 COMMENTS

The all-electric i3 is designed not for the BMW faithful, but rather an entirely different customer.

BUSINESS REPORTER

DISTRIBUTED WITH The Daily Telegraph | The Sunday Telegraph

Smart Grids: The home of the future

18 February 2014 • By Dave Baxter

As smart grids become a reality, experts predict they're laying th for the truly connected smart home.

With Record 2013 Revenues, EnerNOC Goes on European Buying Spree

Germany's Entelios and Ireland's Activation Energy added to leading U.S. demand response provider's portfolio.

Jeff St. John
February 14, 2014

Smart homes are smart nodes in smart grids

Connected appliances

- Smart Meter
- Remote monitoring and control
- Feedback and visualization of current states
- Optimal scheduling of loads (e.g., price-based, grid-oriented)

Integrated energy management

- Decentral generation from PV panels and CHPs
- Optimized usage of local generation through coordination of loads
- Heterogeneous storage systems

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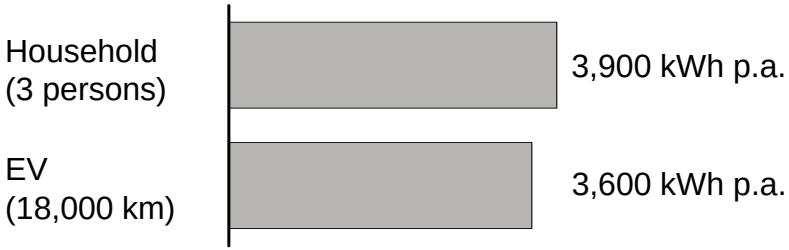
Electrification of individual transportation: challenge and opportunity

Large loads

- Annual EV electricity consumption comparable to a three person household
- Grid integration of central importance



Flexible loads & storage

- On average, cars are standing 90% of the time
- Flexibility with respect to charging
- Energy feedback into grid (V2G)

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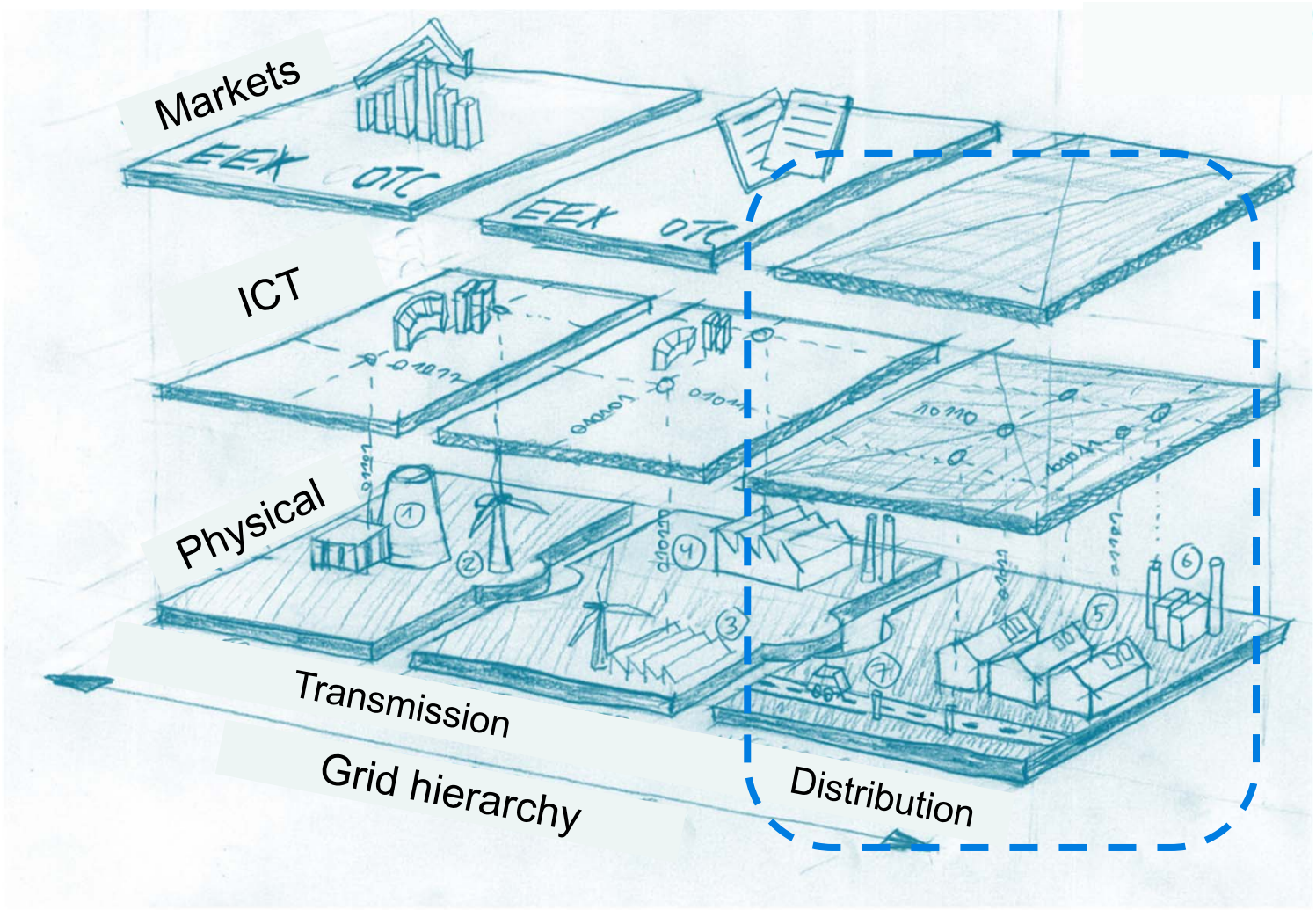
Lack of smart grid infrastructure inhibits creation of new business models and markets



Source: BDI IdE

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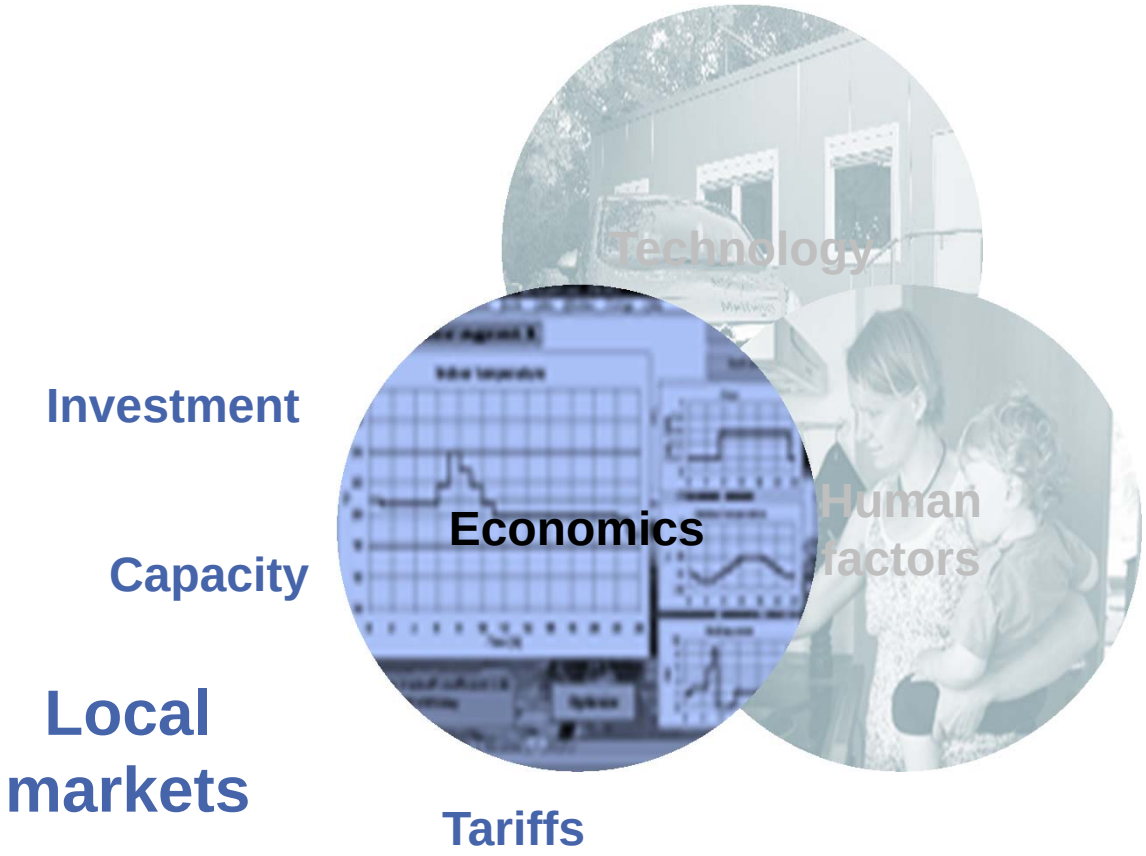
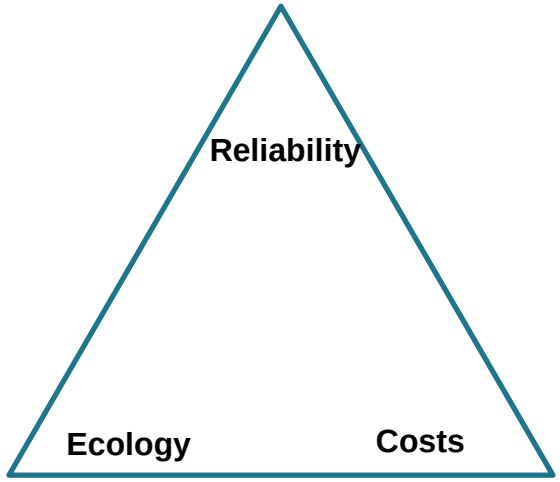

Technology
Human factors
Economics
Investment
Capacity
Local markets
Tariffs

Energy systems can no longer ensure its primary objectives

Handelsblatt
(January 15th, 2014)
"EnBW wanted to shut down four power plants because they are no longer profitable. However, the Federal Network Agency rejected these requests: The power plants are indispensable for a secure energy supply. "

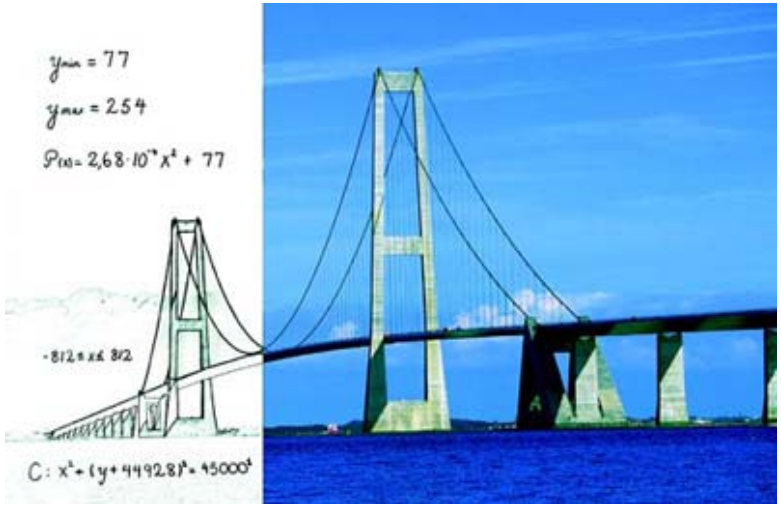


Süddeutsche Zeitung
(January 7th, 2014):
"**Germany has reached the highest level of generation from lignite since reunification**. Consequently, CO_2 emissions are rising – despite billions of investments in wind and solar energy."

Die Welt
(February 2nd, 2014)
"**German electricity prices are 48% above the EU average**: […] The government has failed to protect the industry in international competition. The expectation of price stability is unrealistic."

Market design – an engineering approach

- To create markets that fulfill envisioned requirements, an engineering approach is required



Design of a bridge

Theoretical model: Closed-form solutions describing gravity effects on a rigid beam → elegant, general

Additional factors: Material science, meteorology, ground analysis, etc.

→ Evaluation by means of simulations

Design of a market

Theoretical model: Perfect competition, no uncertainty → elegant, general

Additional factors: “Irrational” behavior of participants, interactions with other systems, imperfect competition, uncertainty

→ Evaluation by means of simulations or experiments

Source: Roth 2002

Recipe for a smart grid market

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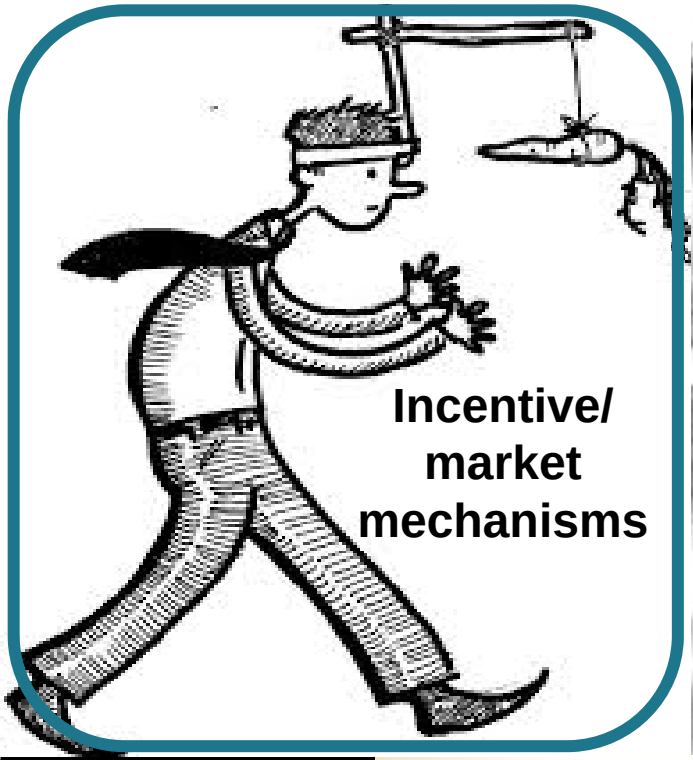
Standardized products


Incentive/ market mechanisms


Quality measures


LAW
Regulation and laws


Human behavior

Current retail operations do not reflect the complexity of the power system

Linear tariffs with annual billing

Bezeichnung	Ab	Bis	Menge	Preis	Betrag
Arbeitspreis - M-Strom kompakt	27.06.2003	31.12.2003	1.499 kWh	12,84 Ct/kWh	192,47 EUR
	01.01.2004	28.06.2004	1.442 kWh	13,36 Ct/kWh	192,65 EUR
Grundpreis	27.06.2003	31.12.2003	188 Tage	62,59 EUR/365	32,24 EUR
	01.01.2004	28.06.2004	180 Tage	67,24 EUR/365	33,16 EUR
Netto					450,52 EUR

- Cost aggregation
- Grid costs per kWh
- Rudimentary options for customers to participate

New pricing schemes needed

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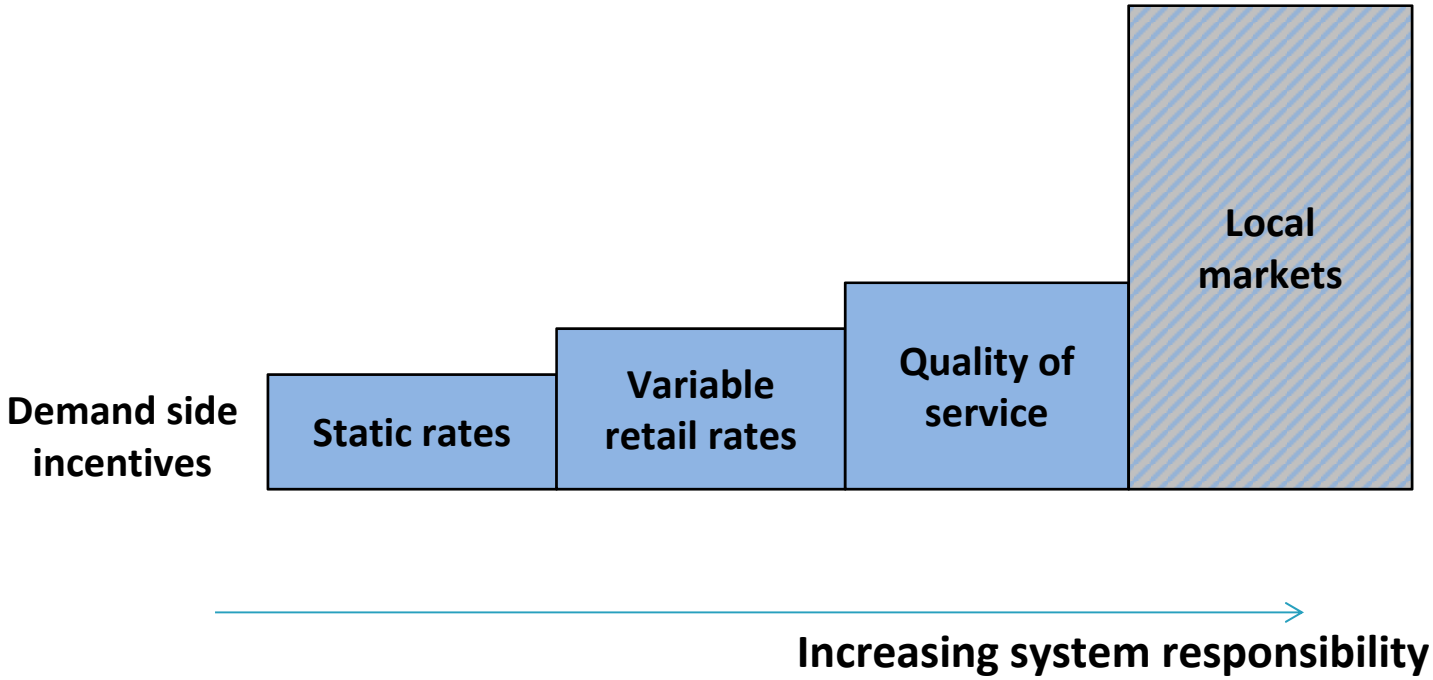
New pricing schemes transfer responsibility in exchange for saving potentials



Establishment of proper incentives for offering demand-side flexibility

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Information

Privacy

Participation

Feedback

Transparency

Incentives

Low customer participation due to transactions costs and intransparency

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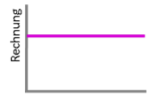
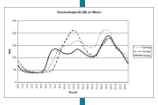


Linear tariffs



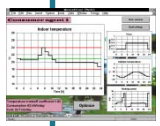
Standard load profiles

No demand participation

Information systems

Variable tariffs & demand response

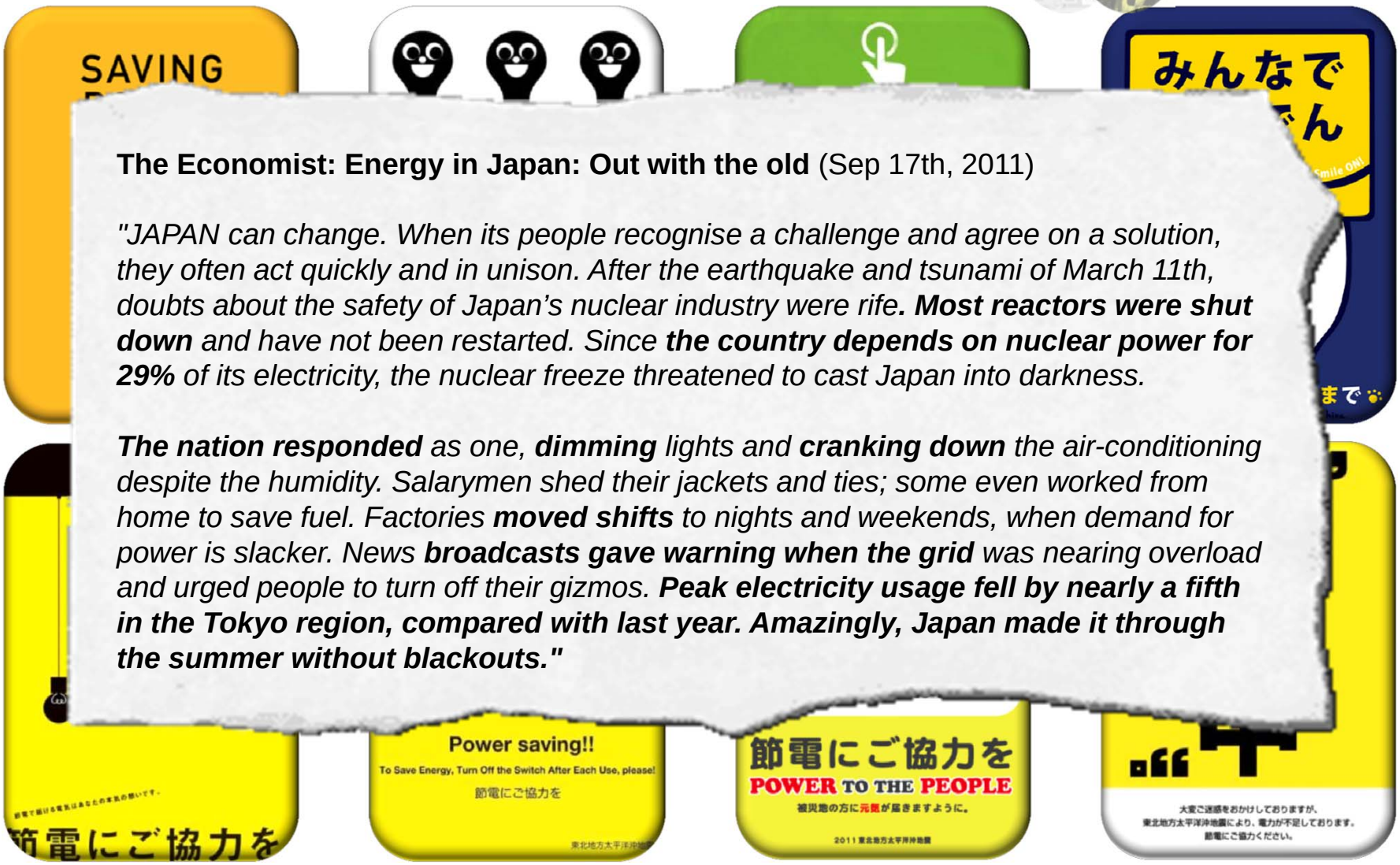
Regional power markets



New business models

Information and incentives facilitate the creation of new energy services

Energy-saving artworks in Japan



The Economist: Energy in Japan: Out with the old (Sep 17th, 2011)

*"JAPAN can change. When its people recognise a challenge and agree on a solution, they often act quickly and in unison. After the earthquake and tsunami of March 11th, doubts about the safety of Japan's nuclear industry were rife**. Most reactors were shut down** and have not been restarted. Since **the country depends on nuclear power for 29%** of its electricity, the nuclear freeze threatened to cast Japan into darkness.*

The nation responded** as one, **dimming** lights and **cranking down** the air-conditioning despite the humidity. Salarymen shed their jackets and ties; some even worked from home to save fuel. Factories **moved shifts** to nights and weekends, when demand for power is slacker. News **broadcasts gave warning when the grid** was nearing overload and urged people to turn off their gizmos. **Peak electricity usage fell by nearly a fifth in the Tokyo region, compared with last year. Amazingly, Japan made it through the summer without blackouts."

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Smart metering and sensors are key to active customer involvement

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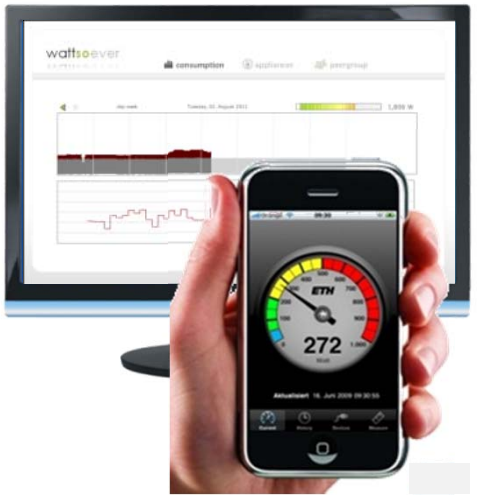
Today

- Minimal information on consumption and costs
- Annual metering and billing
- Very low transparency

Tomorrow

- Transparency and consumption control through portals and mobile devices
- Improved adaption of consumption to exogenous signals (e.g., prices)



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In the future: Sensing and metering as an “experience”

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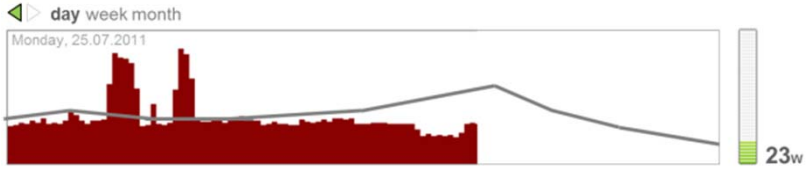
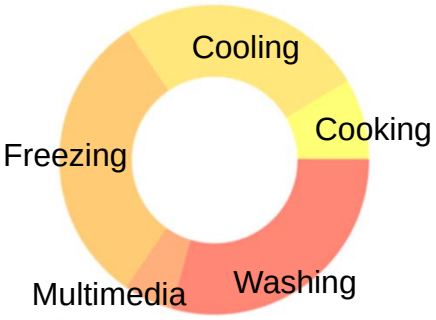
Visualization and identification

Personalized load curves (benchmarking)



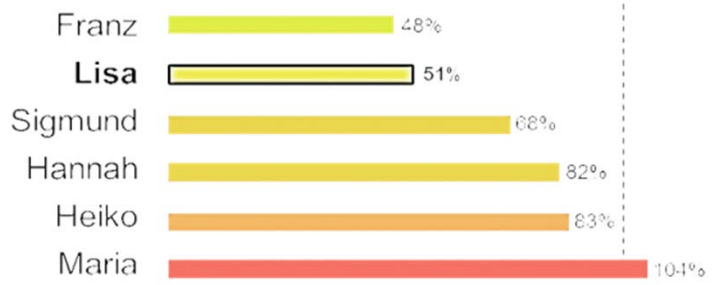
Activity consumption shares



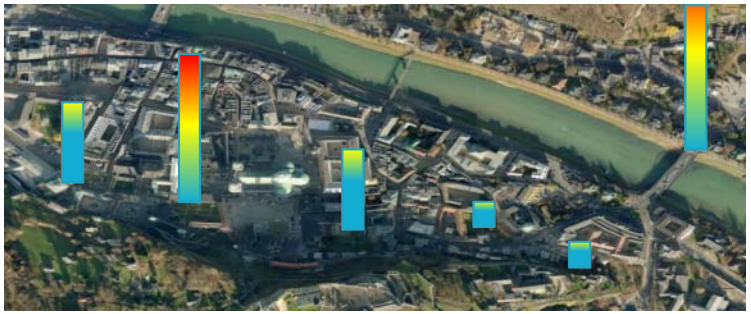
Active appliances

Social rankings

Reference peer group



Regional load situation



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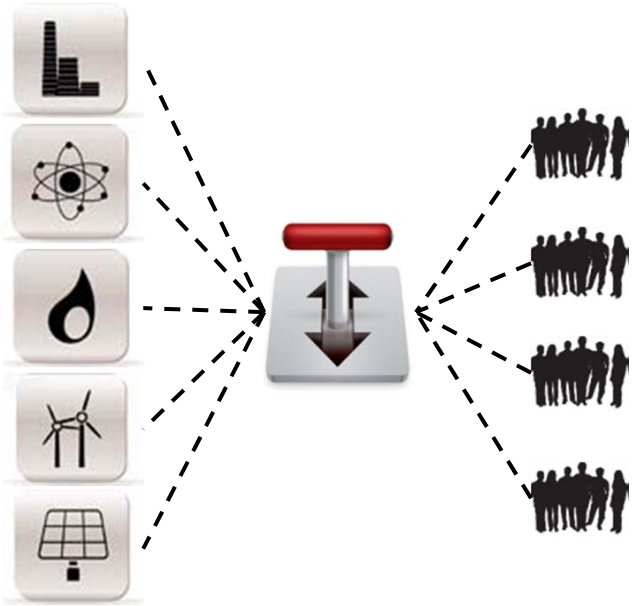
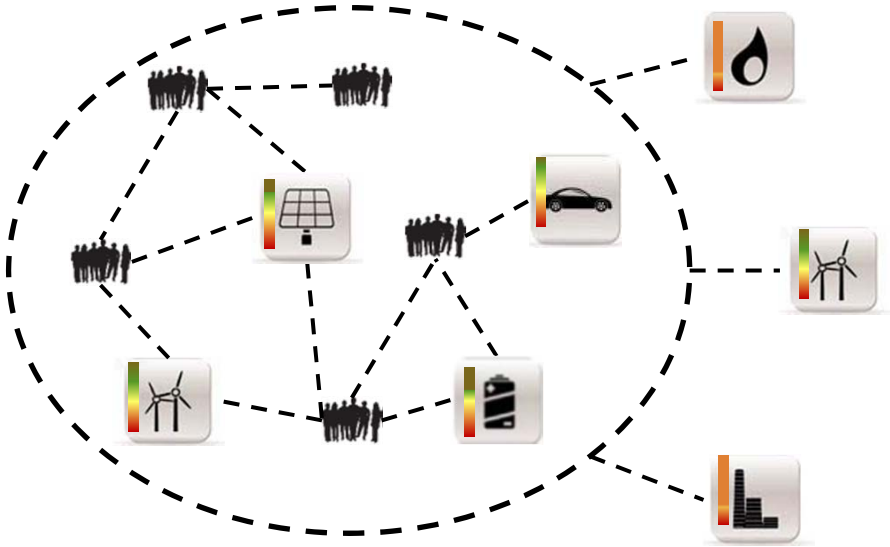
Active engagement of smart nodes to create the future power system

Centralized system



- Passive demand side
  - Intransparent
  - Limited acceptance

„Smarter Energy Future“



- Active Prosumers
- Group formations and monetary and non-monetary incentives
  - Increased acceptance through economic integration

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