Energy 2016, Lisbon, Portugal

Panel Discussion ICAS/ENVIROSENS/ENERGY

(Self)Control of Energy Systems: Challenges and Optimization

Moderator

Steffen Fries, Siemens AG, Germany

Panelists

Alain Tcheukam Siwe, New York University Abu Dhabi, United Arab Emirates

Steffen G. Scholz, Karlsruhe Institute of Technology (KIT), Germany

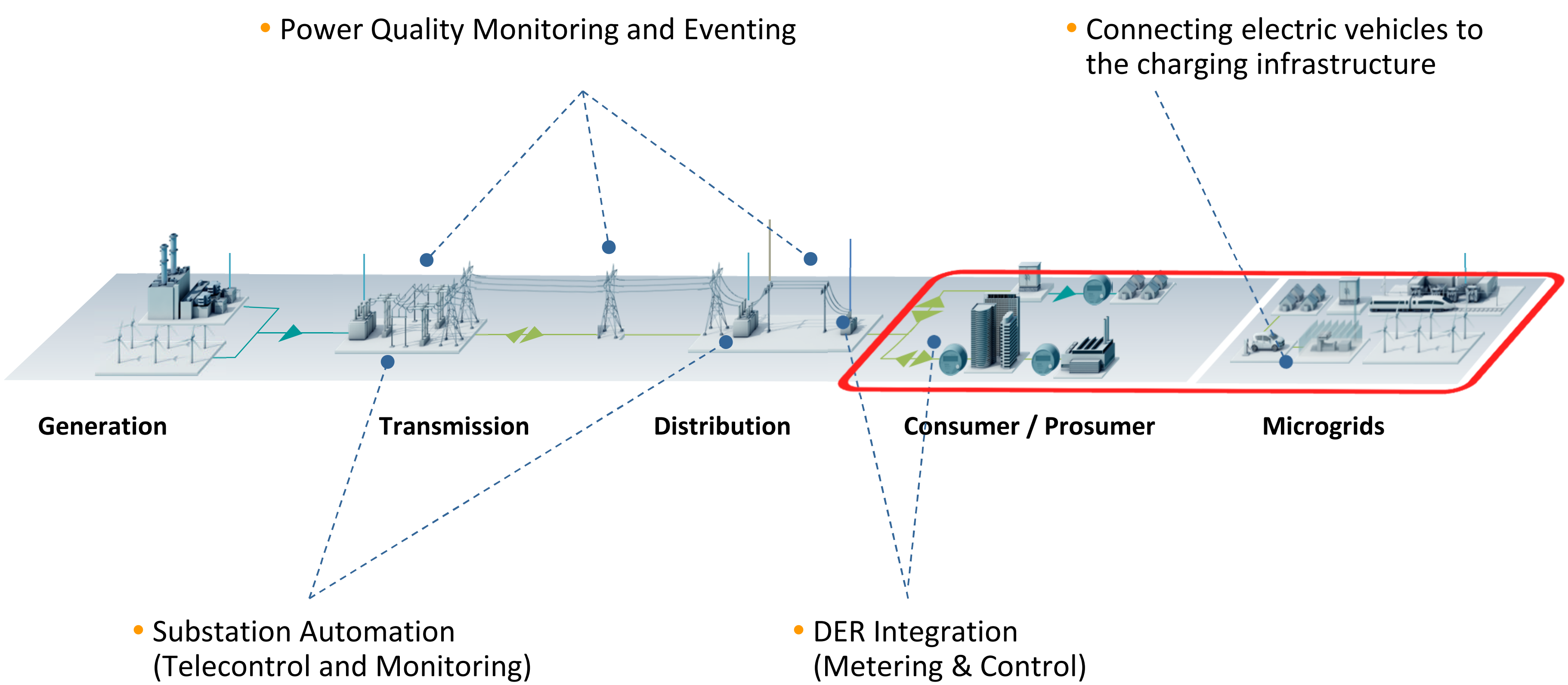
Petre Dini, IARIA, USA

Matthias Vodel, TU Chemnitz, Germany

June 27th, 2016

some initial thoughts on the topic

the energy system value chain



example challenges & solution approaches

- **Reliability and resilience**
  - island mode vs. central control
  - energy storage local vs. feedback to the grid

- **Cyber security**
  - authenticity of equipment and peers - necessary prerequisite for services provisioning
    - system integrity → influence through change of ownership
    - communication integrity and potentially confidentiality (also privacy)

- **Security support through standardization and guidelines (examples)**
  - certificate based end-to-end authentication
  - communication security on transport and/or application level
  - DPI to ensure consistency of communication
- **Security support in products (example)**
  - manufacturer based certificates provided during production
  - allows for automated bootstrapping of operational credentials
  - eases serviceability for service technician in the field

topics from the panelists

Alain Tcheukam Siwe, New York University Abu Dhabi, United Arab Emirates

Distributed power network

1. **Energy Cost Saving Tips in Distributed Power Networks**
2. **Mean-Field-Type Games for Distributed Power Networks in Presence of Prosumers**

Steffen G. Scholz, Karlsruhe Institute of Technology (KIT), Germany

the German "Energiewende" – the major problems to solve...

and the contribution of the KIT Energy Lab 2.0

Petre Dini, IARIA, USA

Energy storage

1. **small scale and large-scale;**
2. **sources balancing and supply optimization**

Matthias Vodel, TU Chemnitz, Germany

1. **Self-Control Approaches – Total Cost of Ownership**
2. **To Be (Green) or Not to Be (Green) – The Dark Side of Power Grids**

summary of discussion

- **Green energy was seen as a complex topic, as it cannot only be viewed in a larger context, not only producing the energy through renewables, but also taken into consideration the means to produce the infrastructure necessary to store, transport, and handle green energy.**
- **Market was seen as one option to influence prosumer behavior to handle energy as sparse resource. Also education to make prosumers and consumers aware that energy production influences the life auf all. Here especially it was mentioned, that the current energy price alone may not be sufficient to make people change their energy consumption behavior.**
- **As energy is globally needed, solving the handling of green energy cannot be restricted to a single country to avoid shifting the problems to poorer countries.**
- **Technology will support th further development of green energy. Scientist shall be able to bring consequences connecting with green energy production, transport, and consumption down to an understandable point .**

1. Energy Cost Saving Tips in Distributed Power Networks

2. Mean-Field-Type Games for Distributed Power Networks in Presence of Prosumers

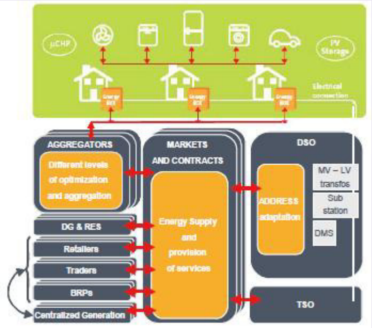
Alain Tcheukam

IARIA16

NEW YORK UNIVERSITY

Distributed power network: prosumers

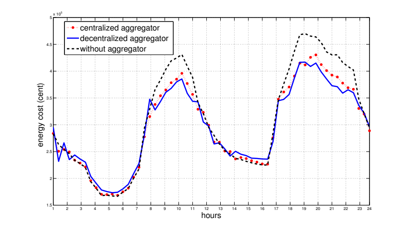
Energy efficiency: framework



Approach

DIPONET: combined learning and optimization algorithms

aggragartor's impact



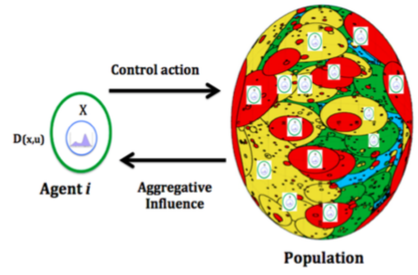
Mean Field Type Game in Distributed Power Network

Payoffs and dynamics coefficient

depend also on:

- the distributions of states
- the distribution of actions

Idea behind



Toward an Interaction model

Producer: optimal production strategy

$$
\begin{cases}
(*) \quad \inf_{s_j, e_j} L_j(s_j, e_j, T) \\
L_j(s_j, e_j) = l_{jT}(e(T)) \\
+ \int_0^T l_j(D_j(t) - S_j(t)) + \frac{\rho}{2} \sum_k s_{jk}^2(t)\, dt \\
\frac{d}{dt} e_{jk}(t) = c_{jk}(t) - s_{jk}(t) \\
c_{jk}(t) \geq 0. \\
s_{jk}(t) \in [0, \bar{s}_{jk}], \ \forall j, k, t \\
s_{jk}(w) = 0 \text{ if } \ w \text{ is a starting time} \\
\text{of a maintenance period.} \\
e_{j,k}(0) \text{ given.}
\end{cases}
$$

Optimal bidding strategy

Prosumer: optimal bidding price

$$
\begin{cases}
\lambda_i'(x) = \frac{G_i(\lambda_i(x))}{G_i'(\lambda_i(x))} \left[\frac{1}{x - \lambda_i(x)} - \frac{1}{m-1} \sum_{k=1}^{m} \frac{1}{x - \lambda_k(x)} \right] \\
\lambda_i(\min_k p_k) = \min_k \lambda_k, \ \lambda_i(\max_k p_k) = \max_k \lambda_k.
\end{cases}
$$

Thank you

Bibliography

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- Montanari, U. and Siwe, A.T. (2014). Prosumers as Aggregators in the DEZENT Context of Regenerative Power Production. In Proceeding of Self-Adaptive and Self-Organizing Systems (SASO).
- H. Wedde, S. Lehnhoff, C. Rehtanz, and O.Krause, A distributed real-time multi-agent system for decentralized management of electric power.,18th Euromiro Conferene on Real-Time Systems, Dresden, Germany, (2006).
- H. Tembine, Risk-sensitive mean-field-type games with Lp-norm drifts, Automatica, vol 59, Sept. 2015, pp 224-237.
- A. Tcheukam, H. Tembine, Energy cost saving strategies in distributed power networks, International Conference on Electrical Energy and Networks, Feb 18-19, 2016, Nice, France (**best paper award**).
- ADDRESS project, http://www.addressfp7.org/
- H Tembine, Dynamic robust games in mimo systems IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics, 41, 4, pp. 990-1002, 2011
- Kai Yang , Anwar Wali, Outage-Capacity Tradeoff for Smart Grid with Renewables. ACM SIGMETRICS Performance Evaluation Review, Volume 41, Issue 3,Pages 80-82, 2013

Panel Discussion:

(Self)Control of Energy Systems: Challenges and Optimization

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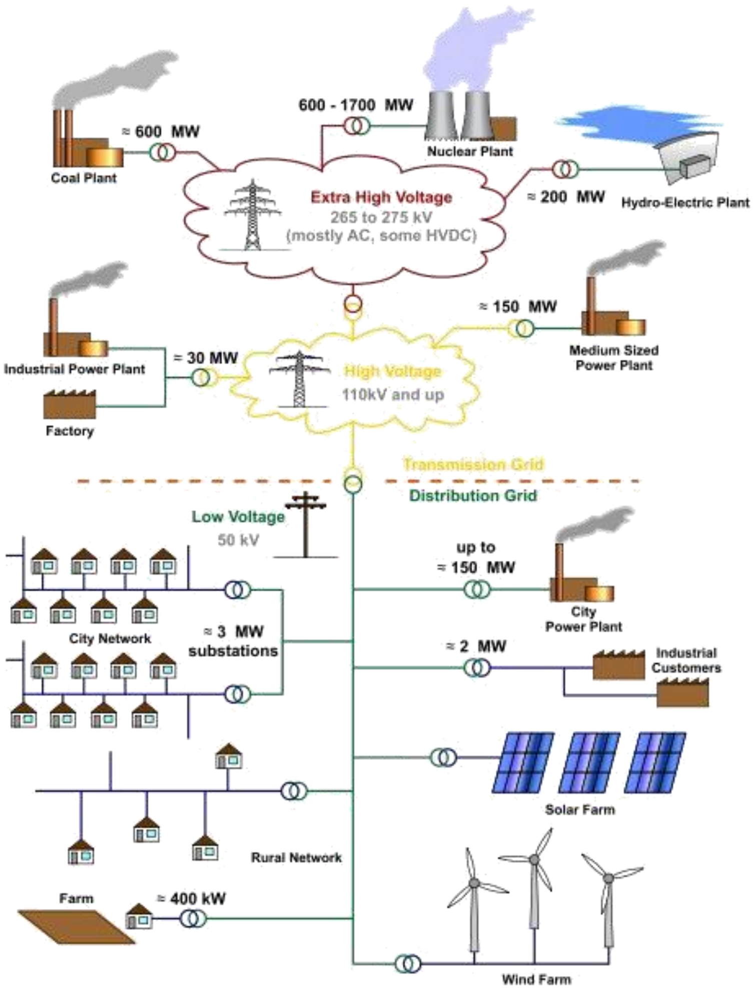
Self-Control Approaches - Total Cost of Ownership

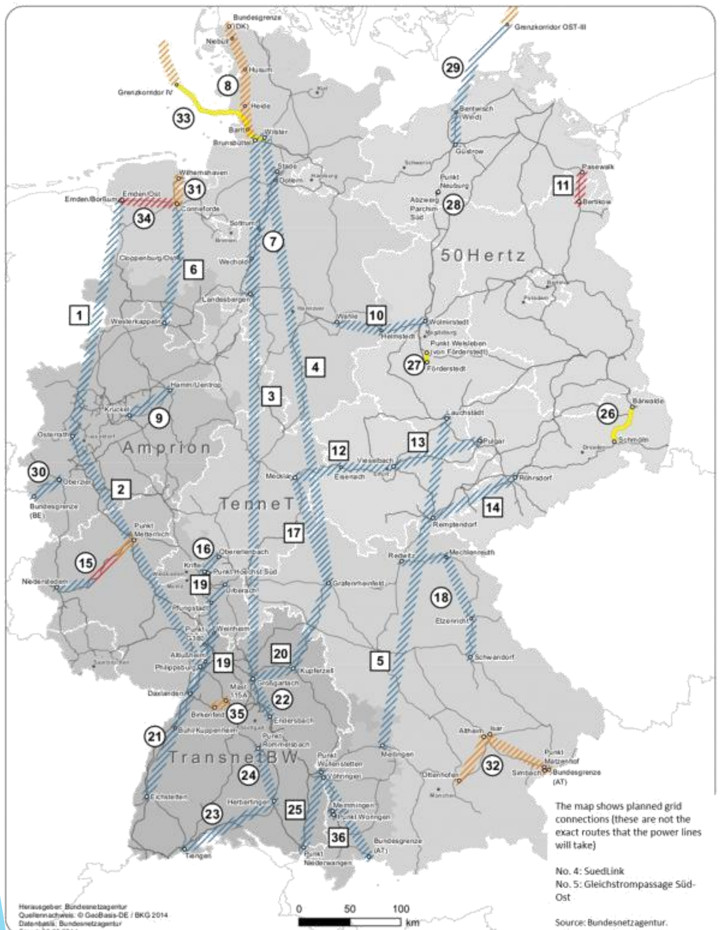


Primary control issues & challenges

- Key intelligence & algorithms
- Balancing metrics
- IT infrastructure for communication (bandwidth, latency, security, …)
- System maintenance
- Backend technologies (storage, distribution, monitoring, …)

Complex systems = Efficient Systems = Green Systems?

To Be (Green) or Not to Be (Green) & The Dark Side of the “Energy Revolution”



- Very specific locations for renewable energy generation
  - Northern area → wind
  - South west → sun
  - South / east → water
- Demand of power is fluctuating (daily, seasonal)
- Massive amount of resources & efforts for upgrading the power grid
- Significant impact to nature
- Technology evolution in progress

→ Technology revolution maybe necessary?
  - Storage
  - Power generation
  - Commercial energy market

Example 1: Wind power station

- 95% of devices with direct gear units
  → operating with strong permanent magnets
- 200kg of noble earths per MW power (neodymium)
- Massive resources for mining
- Mining of neodymium produces significant amounts of radioactive waste… not here, but in Asia / South America
- Lifetime of wind power station normally 20 years

- Problem shifting to countries / locations with the required resources

Example 1 … continue

- The connection of one new wind power station to the „power grid“ takes several 100 tons of cupper, oil and other materials
- The impact of the subsonic noises of wind power stations to humans and living creatures is not clear till now
- Due to fluctuating wind conditions, external energy resources still required
- 2015 → several critical situations, almost resulting in an **entire** electricity blackout
    - Why? → too much power from wind power stations in the given power grid
    - Pay massive amounts of money for selling excessive energy

Green or not green?

Example 2:
eMobility / project eTruck (Sweden)

- Trucks with direct electric interface
- Carbon fingerprints of the vehicle decreases
- Carbon fingerprint for the entire process undefined:
  - Power generation (+ overhead)
  - Power transportation (+ overhead)
- Efforts / ressources for the infrastructure & maintanence
- No flexibility for eTrucks **OR** hybrid trucks (ressources for both technogies)
- Advantages to train lines?

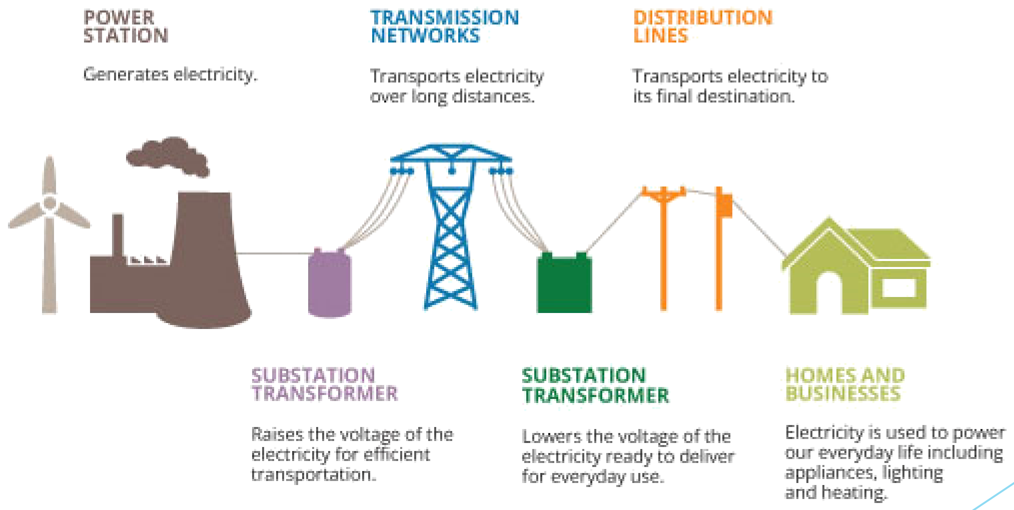
Green or not green?

Example 3:
eMobility & electric cars

- Producation of battery packs (& the used materials) results in massive pollution of our environment
- Strong limited re-use factor for battery cells
- No „realistic“ standardisation / test benches for comparing energy-efficient operation of vehicles & devices
- Green (local) solutions ⇔ Green (global) solutions

Panel discussion – Key questions

1. Do we want self-controlled, non-static defined behaviour for energy systems / power grids?
2. Discussion global vs. local power generation?
3. How critical is the commercial impact to what we want to call „Green Technology“?
4. How green is eMobility & how to become greener?
5. What are key technologies for an energy revolution?



Thanks for listening...

Petre Dini – Panelist – June 27, 2016

Is Energy-storage a Viable Solution?

Petre Dini, IARIA, USA

petre@iaria.org

Panel on ICAS/ENVIROSENS/ENERGY
Topic: (Self)Control of Energy Systems: Challenges and Optimization

Lisbon, June 26-30

→ Towards Energy Storage

- Need for balancing regular energy and clean energy
- Energy storage technologies
  - Picks (balancing)
  - Reliability (back-up)
  - Cost optimization and uniform consumption
- Cost for stored energy (dollar/euro/kilowatt)
- Cost
  - Regular energy + transportation
  - Stored energy + transportation
  - (Regular || Stored) energy + transportation

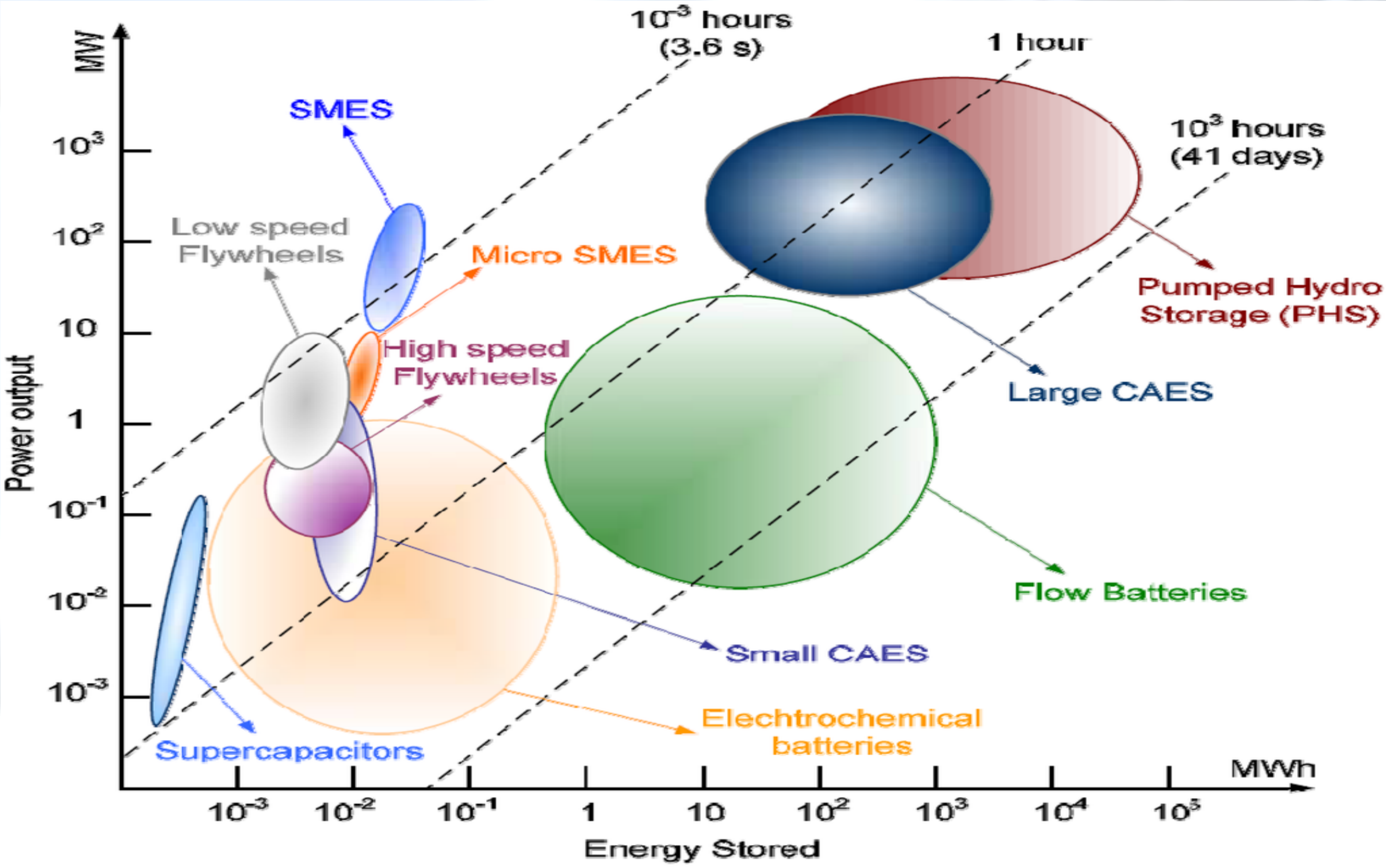
Energy Storage is Here

- **Small scale**
  - **Solar computers**
  - **Wearable devices**
  - **Solar stations**
- **Medium scale**
  - **Computers**
  - **Highway panels**
- **Large scale**
  - **Hospitals**
  - **Emergency activities**
  - **Inter-grids for wireless base-stations wireless**
  - **Inter-solar-power units**

Energy Storage Technologies

- **Solid State Batteries - a range of electrochemical storage solutions, including advanced chemistry batteries and capacitors**
- **Flow Batteries - batteries where the energy is stored directly in the electrolyte solution for longer cycle life, and quick response times**
- **Flywheels - mechanical devices that harness rotational energy to deliver instantaneous electricity**
- **Compressed Air Energy Storage - utilizing compressed air to create a potent energy reserve**
- **Thermal - capturing heat and cold to create energy on demand**
- **Pumped Hydro-Power - creating large-scale reservoirs of energy with water**
- **http://energystorage.org/energy-storage/energy-storage-technologies**

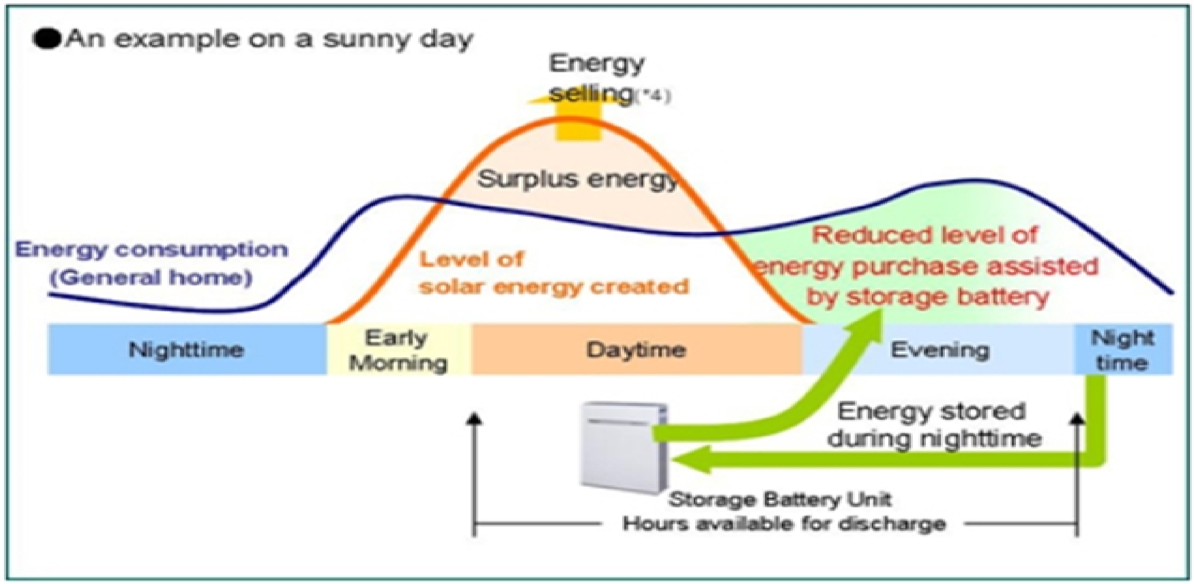
Energy/Power



Consumption balancing

Economy Prioritized Mode

- The user can reasonably reduce peak power demand by making use of the nighttime power supply from the grid without compromising the amenity.
- The user can also enjoy economic advantage of charging the battery using low-cost nighttime power supply and discharging during peak hours. It makes reduction level of energy purchase.



*4: The battery does not discharge any energy while selling the surplus solar energy.

Case study: Skylar

- **Energy Markets [Skylar Energy: American Way, May 2016]**
- **Supply Mix (renewable energy sources, such as solar and wind)**
- **Renewable energy sources are intermittent (not consistently, at demand)**
- **Power storage (utility scale battery systems)**
- **Energy storage market ~ 2% in USA**
- **Battery costs will drop by 40% through 2020**
- **System 2MW –> 150 MW**

Example 1

http://energystorage.org/energy-storage/case-studies/aes-energy-storage-angamos-battery-energy-storage-system-bess

AES Energy Storage Angamos Battery Energy Storage System (BESS)

544MW thermal power plant in the town of Mejillones in Northern Chile

Example 2

- **Earning Revenue via Multiple Value Streams: Kaheawa Windfarm Dynamic Power Resource (DPR®) Energy Storage**

First Wind built a second phase to the Kaheawa Wind Project (KWP II) adding an incremental 21 MW of wind generation on the island of Maui on the Maui Electric Company's 69 kV electric system.

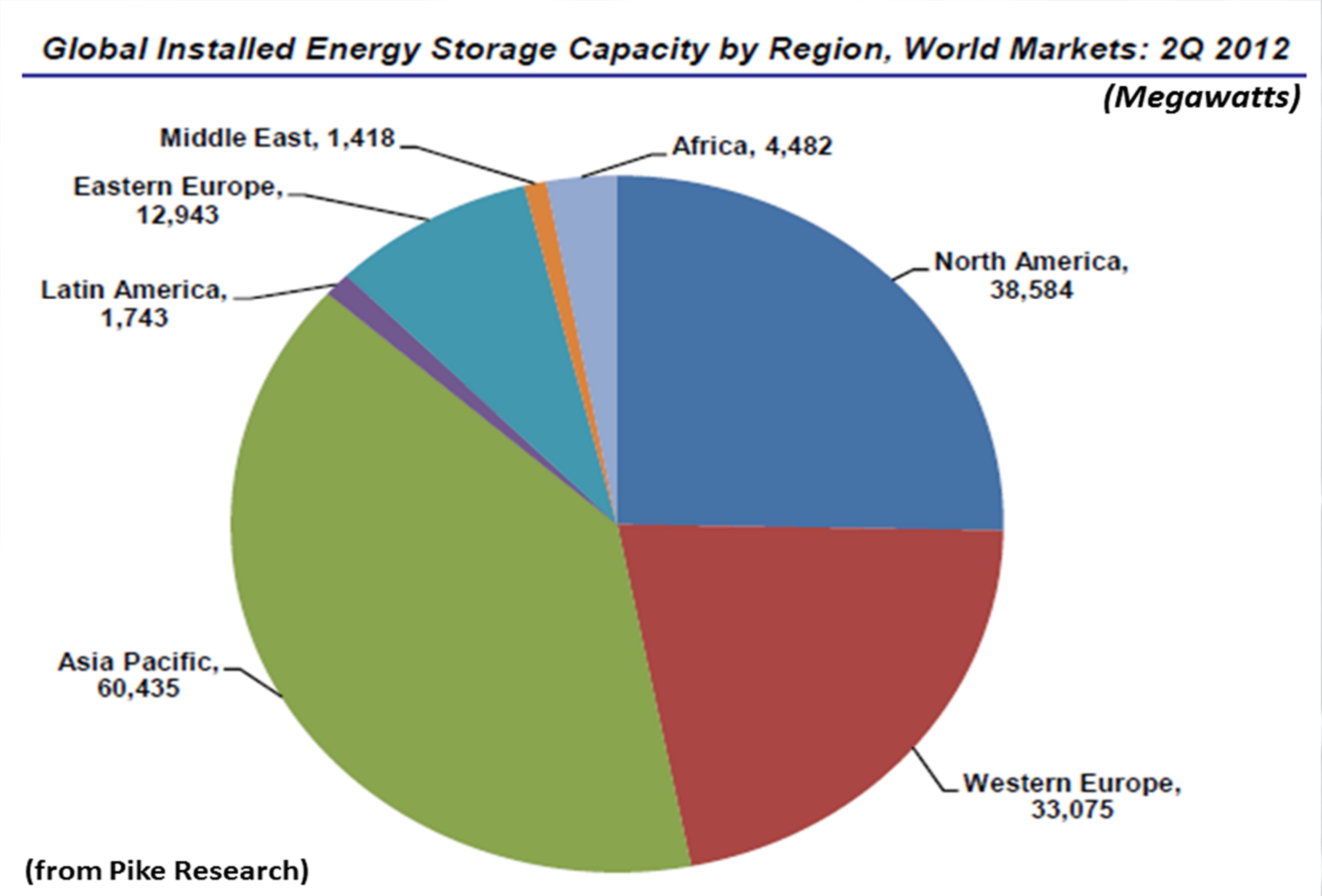
In order to mitigate the effects of wind volatility on an island grid, Xtreme Power designed a 10 MW Dynamic Power Resource® (DPR) to integrate with the 21 MW KWP II facility operating on a 80-200 MW grid.

Example 3

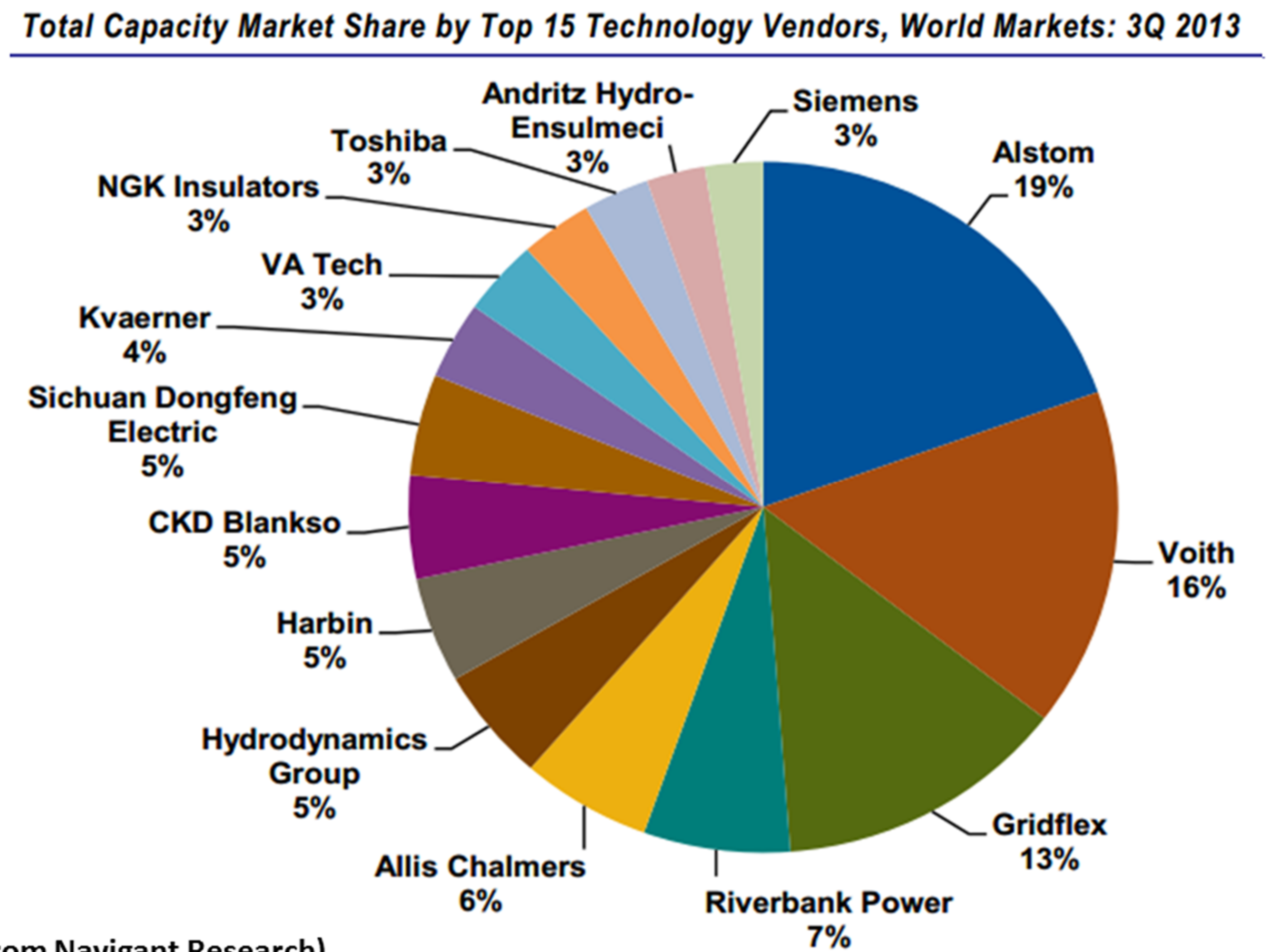
- [Long-Duration Energy Storage on a Grid Scale: Highview Power Storage LAES]

- **Liquid Air Energy Storage (LAES) is sometimes referred to as Cryogenic Energy Storage (CES). The word "cryogenic" refers to a gas in a liquid state at very low temperatures. The working fluid is Liquefied Air or Liquid Nitrogen (78% of air). The systems share similar performance characteristics to pumped hydro and can harness industrial low-grade waste heat/waste cold from co-located processes, converting it to power. Size range extends from around 5MW/15MWh to >50MW/250MWh and with capacity and energy being de-coupled, the systems are very well suited to long duration applications.**

Statistics i



Statistics ii



(from Navigant Research)

Technologies and costs i

TECHNOLOGIES

http://www.iec.ch/whitepaper/pdf/iecWP-energystorage-LR-en.pdf

COST FOR EVERGY STORAGE: $/KW

http://prod.sandia.gov/techlib/access-control.cgi/2011/112730.pdf

http://www.osti.gov/scitech/servlets/purl/453759/

http://www.sciencedirect.com/science/article/pii/S0306261914010290

Technologies and costs ii

- Long-duration storage,
frequent discharge, storage: 4-8 h, 1 cycle/day x 250 days/year

Long-duration storage,

- infrequent discharge, storage: 4-8 h, 20 times/year

Short-duration storage,
frequent discharge, storage .25-1h , 4 x 15 minutes of cycling x (250 days/year = 1000 cycles/year)

Short-duration storage,
infrequent discharge, storage .25-1h , 20 times/year

- ? ROI + 5, 10, ? Years
- Environmental impact | cost of maintenance
- Health impact | cost of health insurance

- Costs of energy storage systems depend not only on the type of technology, but also on the planned operation and especially the hours of storage needed. Calculating the present worth of life-cycle costs makes it possible to compare benefit values estimated on the same basis.

Challenges

- **Costs**
  - **Technology**
  - **Applications**
- **Social acceptance**
  - **Environmental studies**
  - **Ecology**
  - **Health**
- **Governmental enforced regulations**
  - **Green certificate**
  - **Cost compensation**

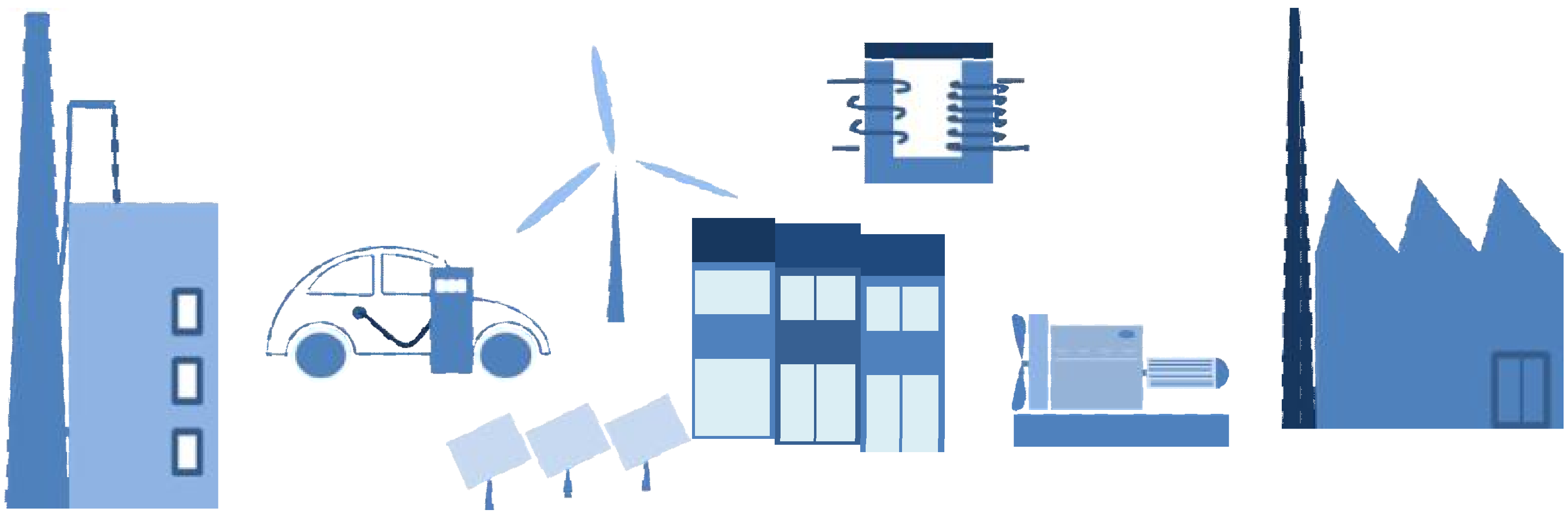
Thanks

Thanks

WWW.IARIA.ORG

The German “Energiewende” –Challenges A Concept for the Control, Monitoring and Visualization Center in Energy Lab 2.0

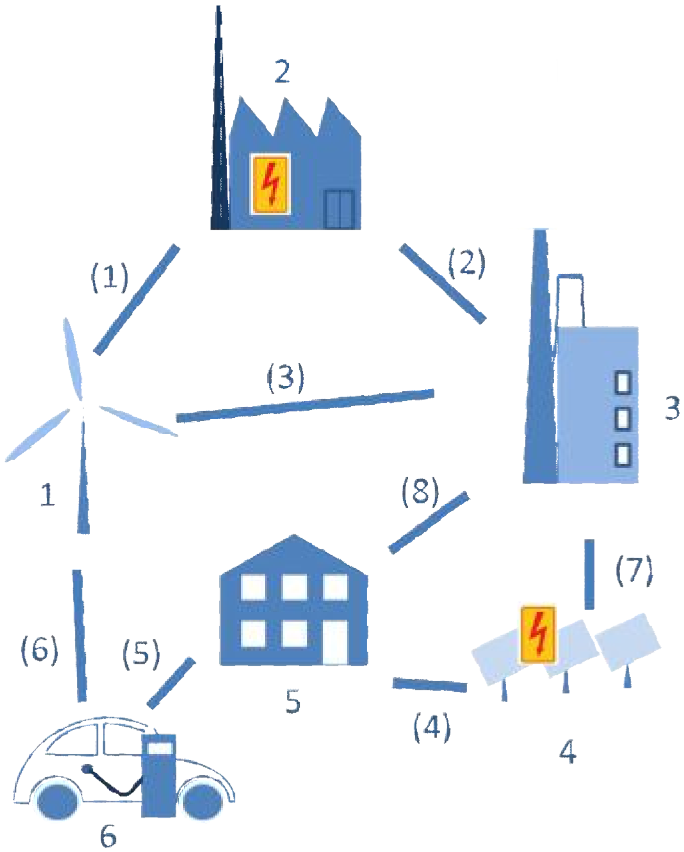
Institute for Applied Computer Science (IAI)

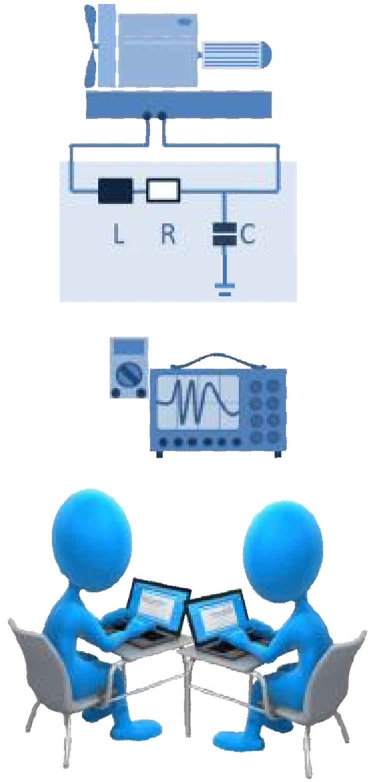


The German “Energiewende”- The Mission and Challenges

- Targets for 2050:
- Minimum of 80 % renewable electrical energy
- To reduce the usage of primary energy carriers to 50% (compared to 2008)
- Reduction of global warming gases by 80 to 95 % (compared to 1990)
- In total: a minimum of 60 % of total energy consumption covered by renewable energy sources

Grid Lab Research and Usage



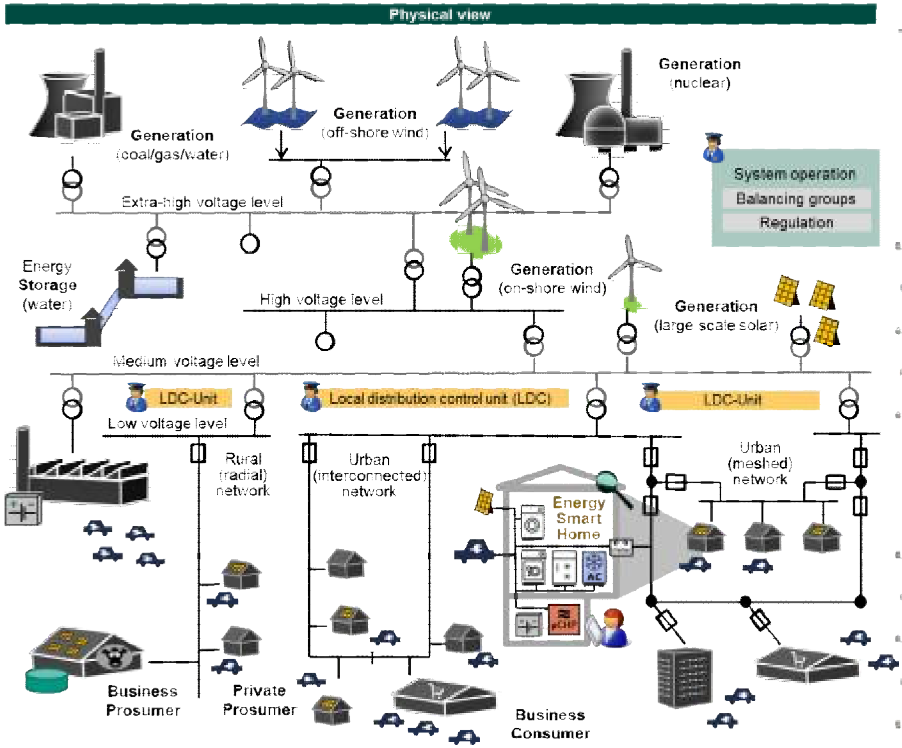


1. Develop flexible components, control algorithms and IEDs for smart grid applications
2. Provide a test laboratory, where solutions can be tested under critical conditions
3. Hands-on laboratory for (PhD) students

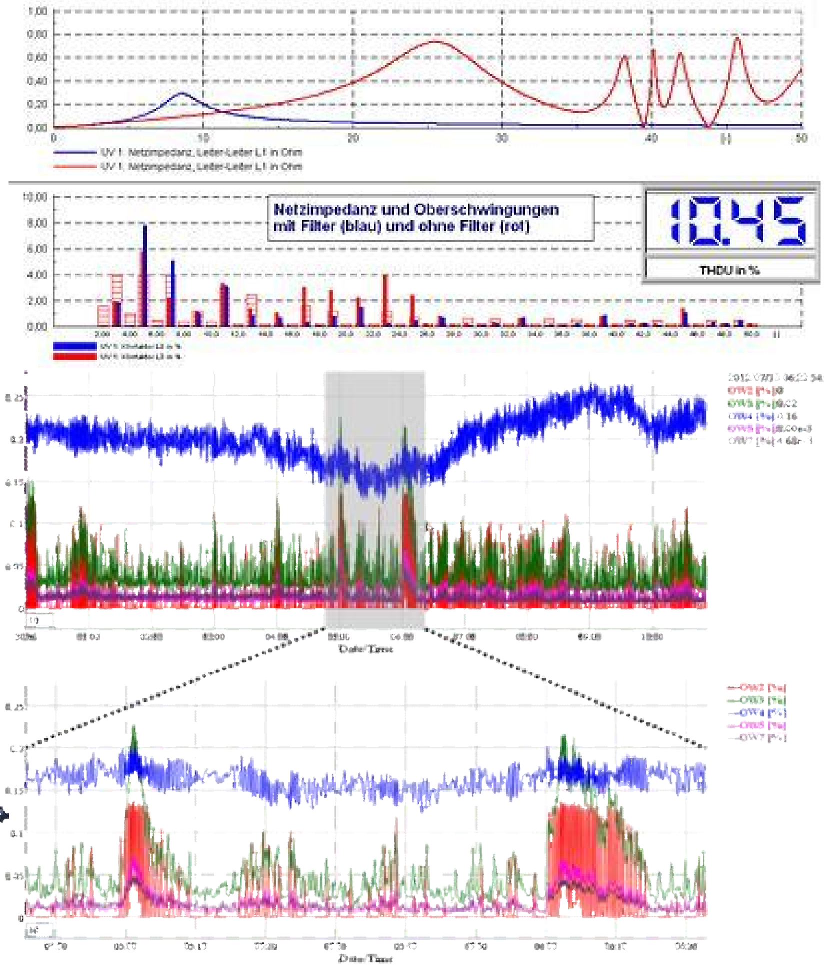
Energy Grids Simulation & Analysis Laboratory

Karlsruher Institut für Technologie

Grid and technical plant modelling (generators, consumers, prosumers); simulation with co-simulation framework



Stability analysis



Panel discussion.. a few provocative statements…

- “ all you need is a intelligent (self) controlled energy supply grid…”
- “all you need is smart energy loads …”
- “ energy storage capacities will create the link between sources and demand…”
- **…unfortunately: you need all …**

THX…