LUT
Lappeenranta
University of Technology

Sähkömarkkinoista tutkittua
–
Sähkömarkkinat ja energiamurros

D.Sc. (tech.) Samuli Honkapuro
Associate professor
LUT School of Energy Systems
Lappeenranta University of Technology
FINLAND

Samuli.Honkapuro@lut.fi

Electricity Market, objectives

Security of supply, self sufficiency

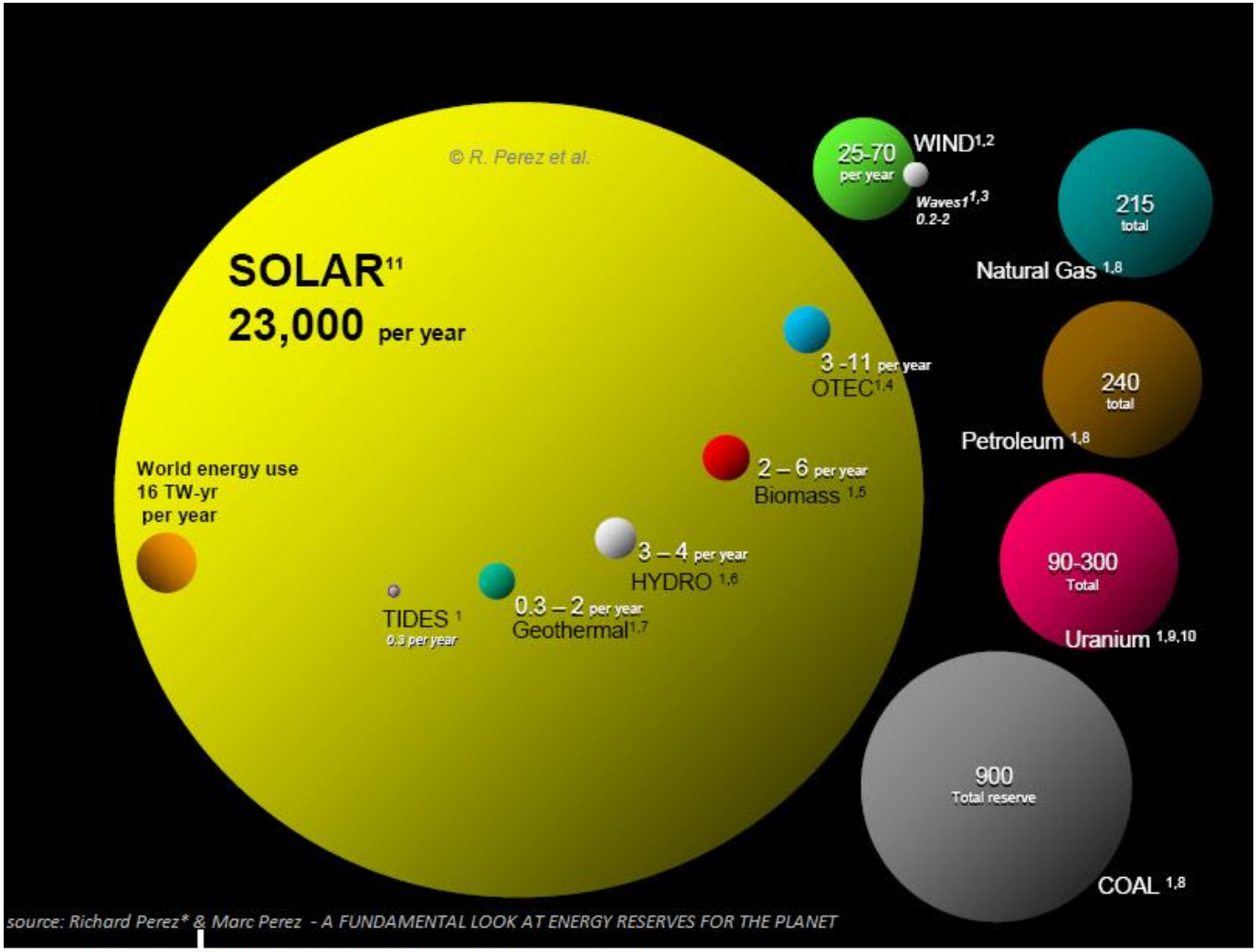
Competitiveness €

Climate

Technical requirement; keep power balance in every second

Production = consumption

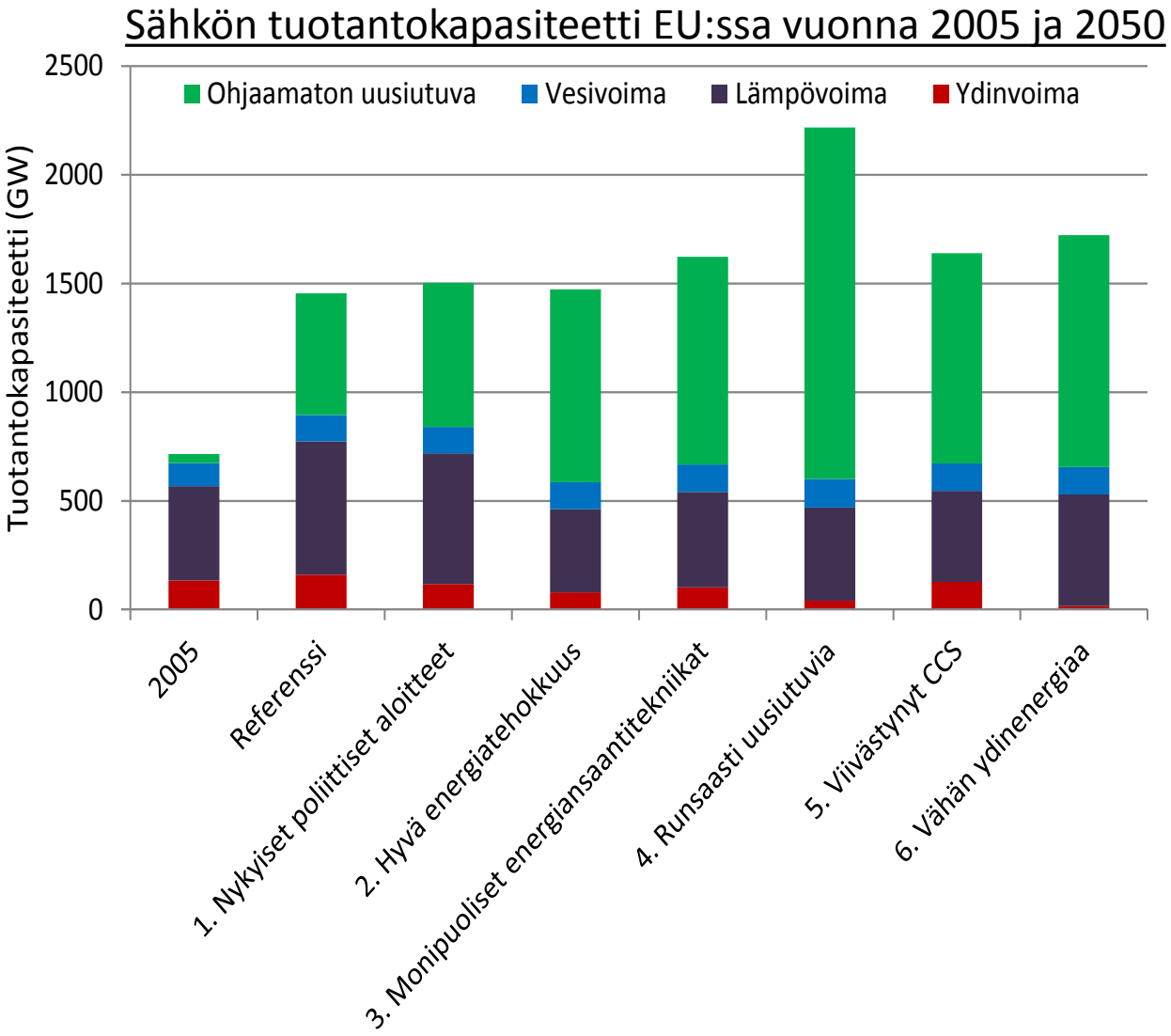
Global energy resources



Comparing finite and renewale planetary energy reserves)Terawatt-years).
Total recoverable reserves are shown for the finate resources.

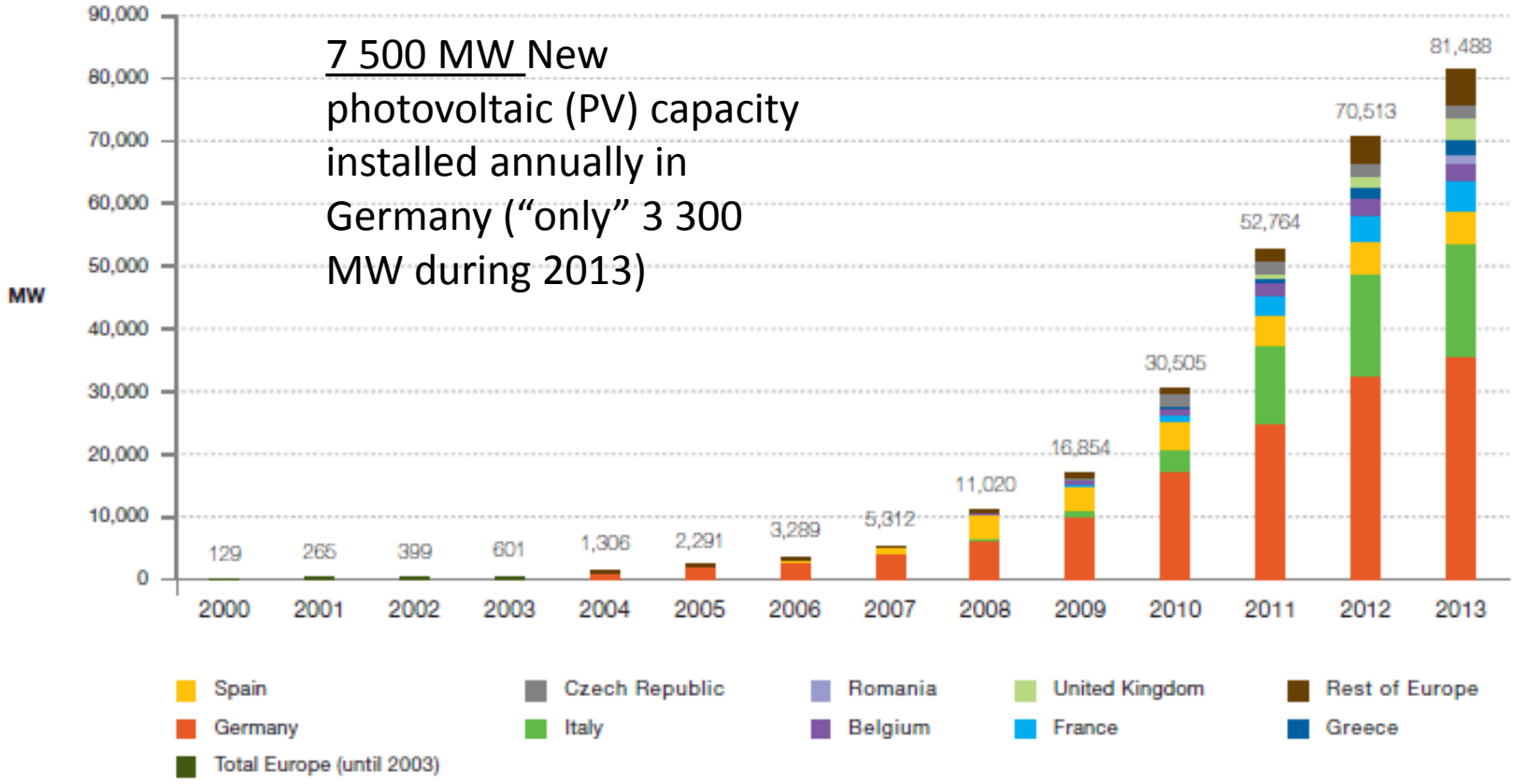
Lähde: Richard Perez & Marc Perez, ”A Fundamental Look at Energy Reserves for the Planet”

EU Energy Road Map 2050 skenaariot



Lähde: EU Energy Road Map 2050

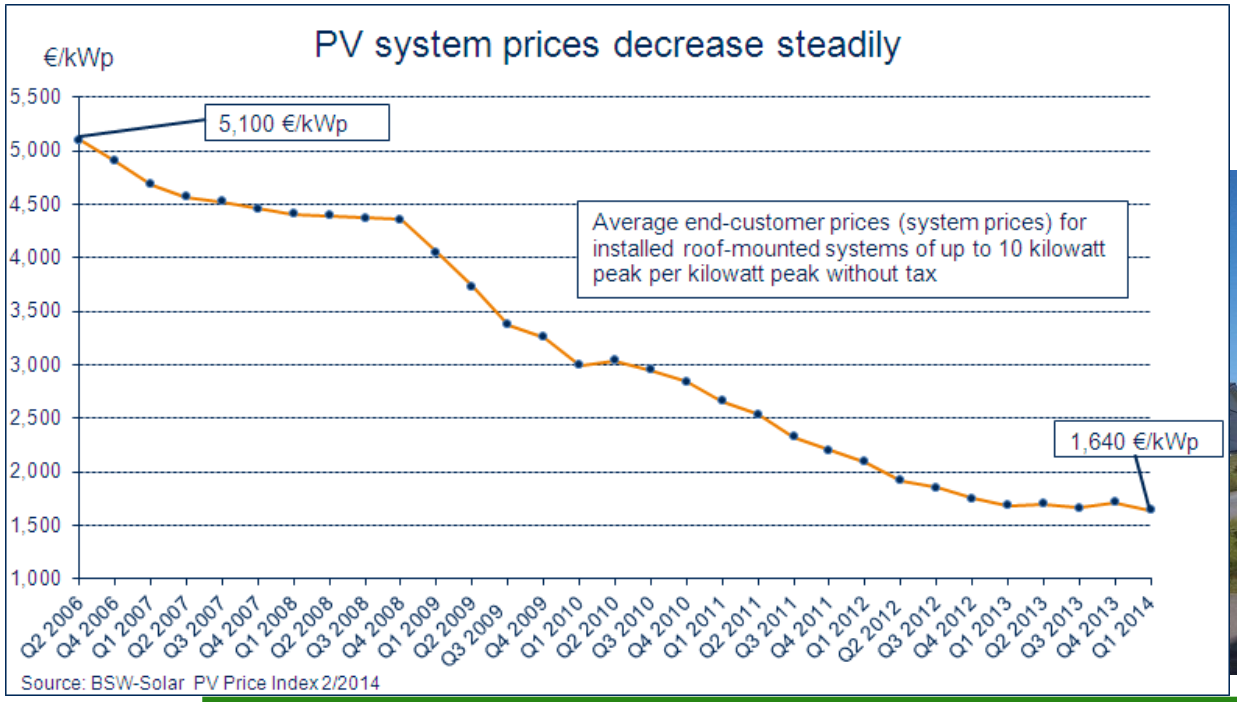
Evolution of European PV cumulative installed capacity 2000-2013



EPIA: Global Market Outlook for Photovoltaics 2014-2018

Solar power in Germany

Installed capacity 38 200 MW (31.12.2014)
http://www.sma.de/en/news-information/pv-electricity-produced-in-germany.html



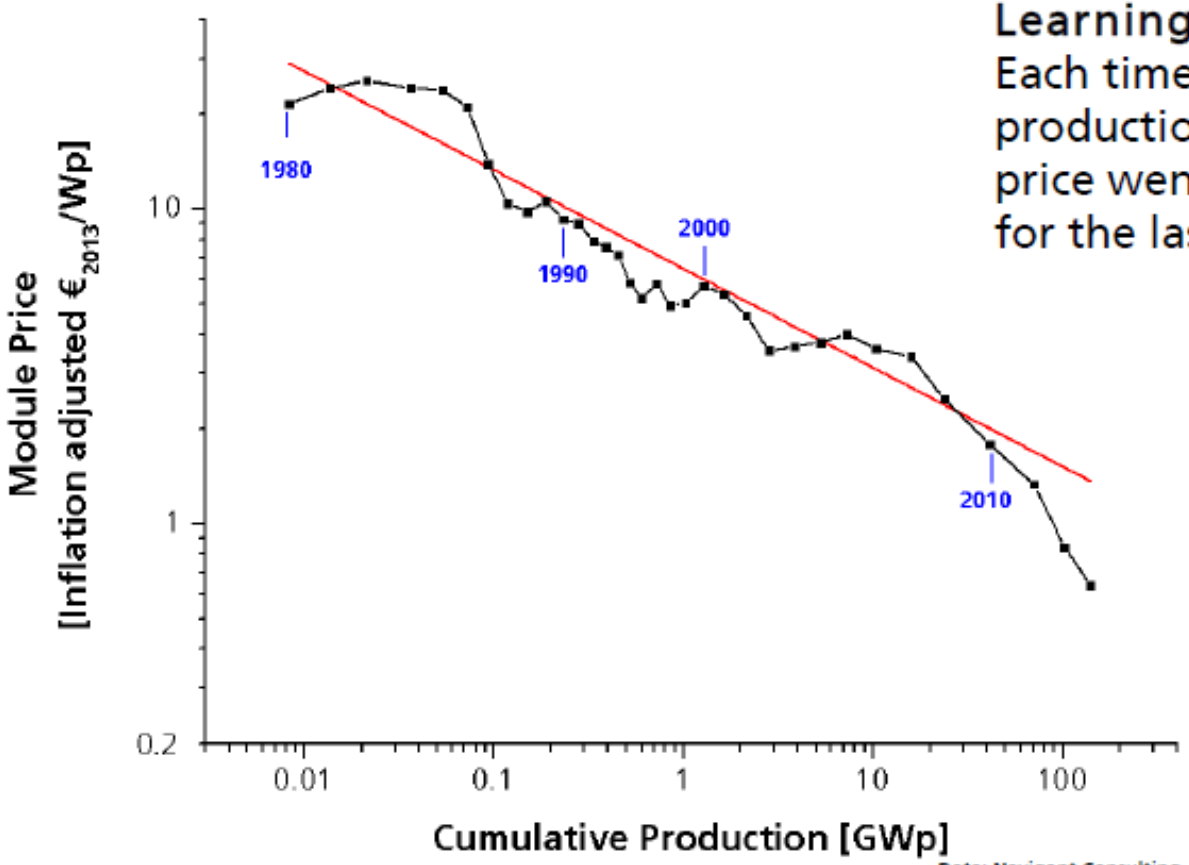
"Power to the people"

Feed-in tariff (nowadays reduced)

Price of PV-cells, more than 60 % reduction per 5 years

Wind power in Germany; 33 GW, 47 TWh/a (2013)

Price Learning Curve (all bulk PV Technologies)

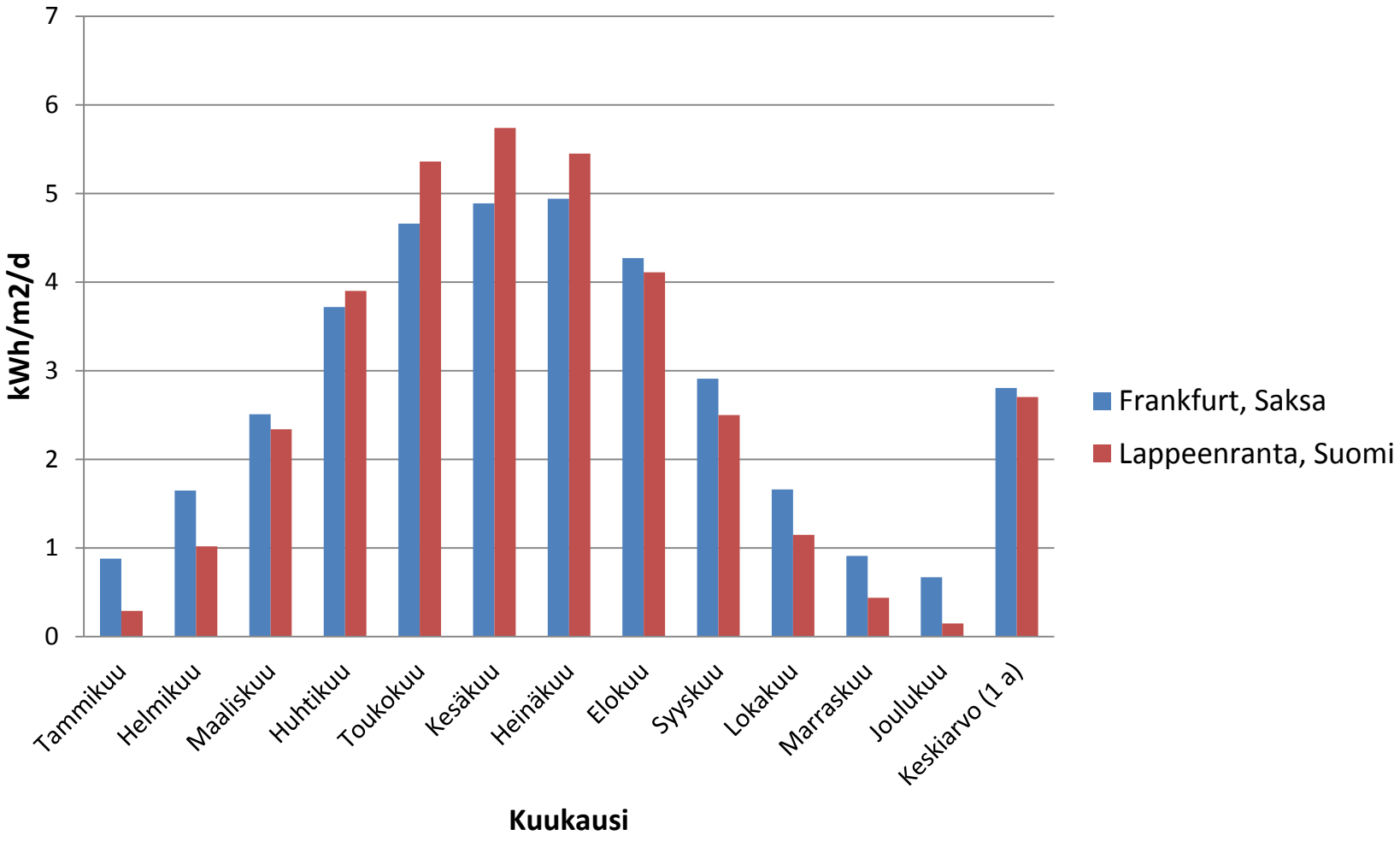


Learning Rate:
Each time the cumulative production doubled, the price went down by 20 % for the last 33 years.

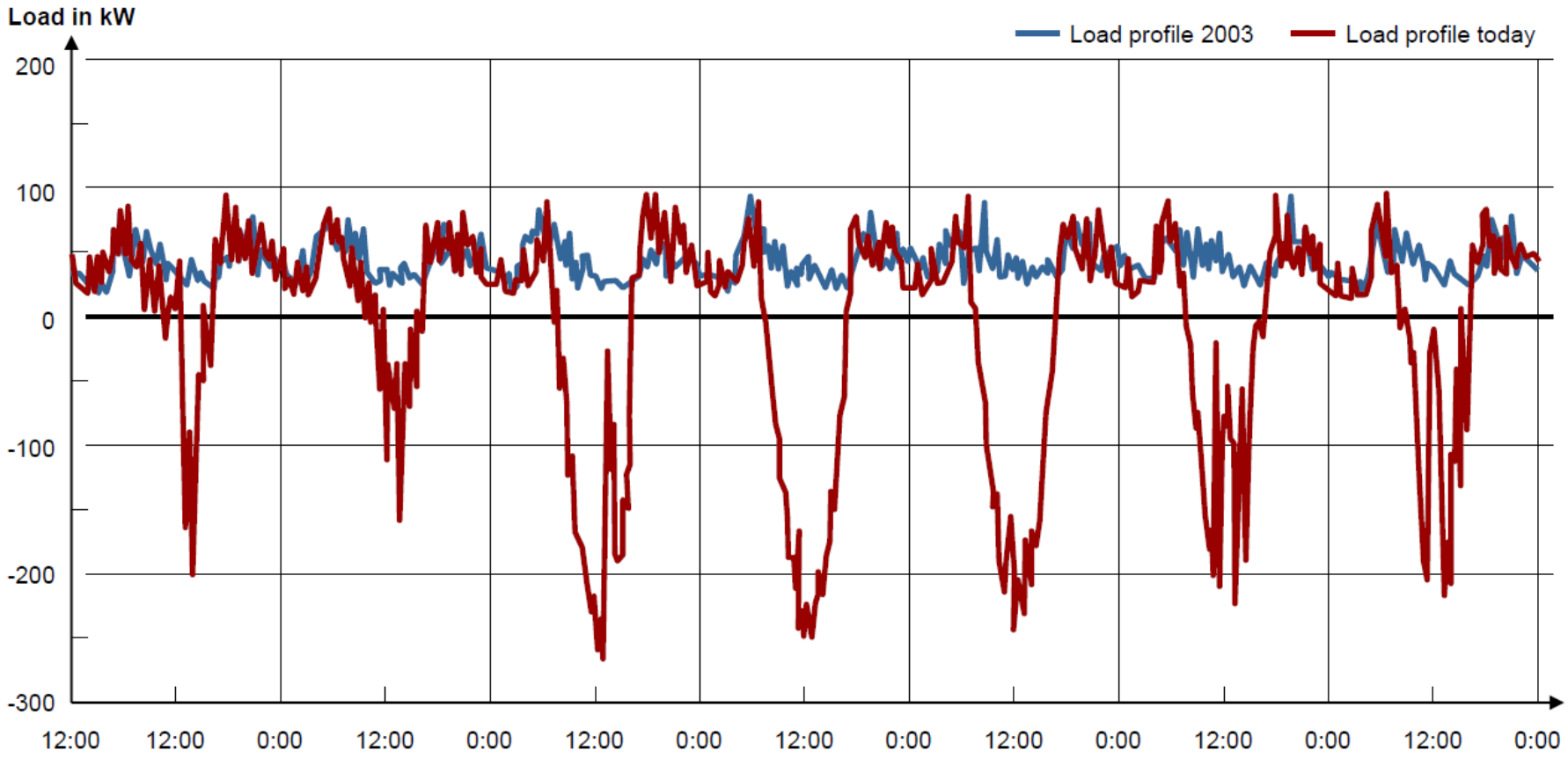
Data: Navigant Consulting, EuPD, IHS, pvXchange. Graph: PSE AG 2014

Fraunhofer ISE

Potential of solar power, kWh/m2/day

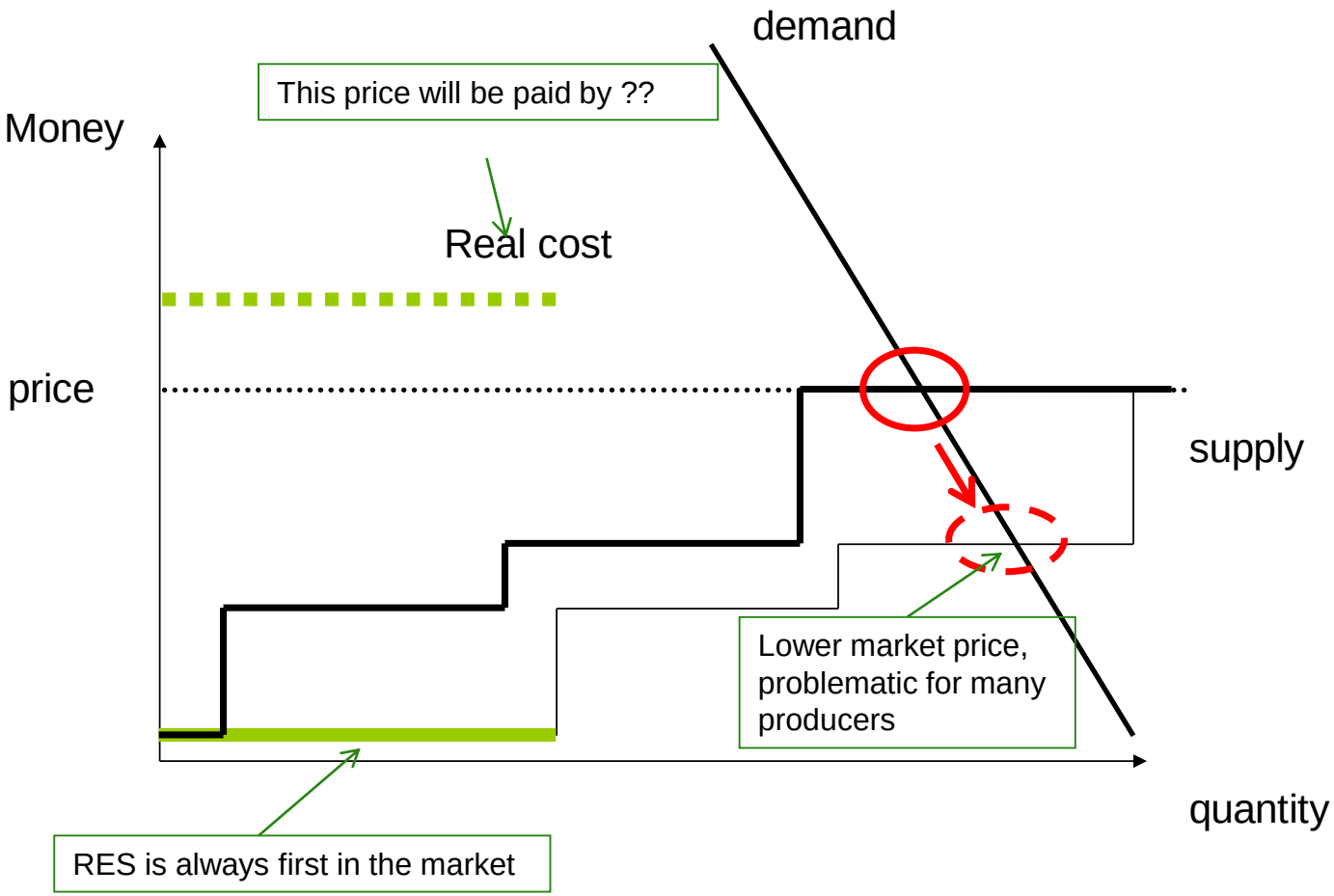


Weekly loading of a transformer station in the rural area the LEW-Verteilnetz GmbH – 2003 and today

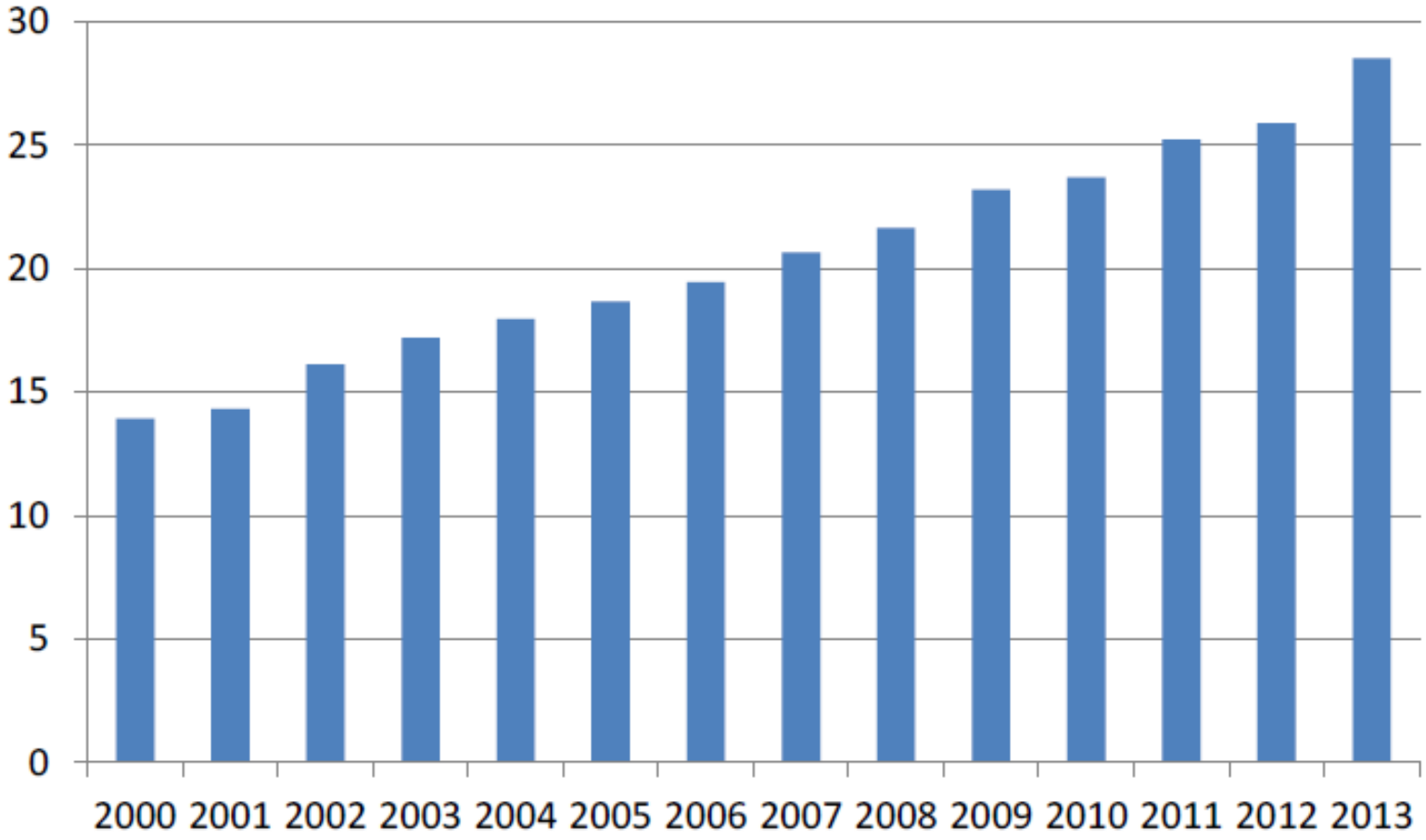


Source:http://w3.siemens.com/smartgrid/global/en/Events/SmartGridEurope/Documents/Conference%20presentations/Technology%20Plaza/121011_Smart Utilities_AMS_RE_v6.pdf

Impact of subsidied renewables on market price of electricity

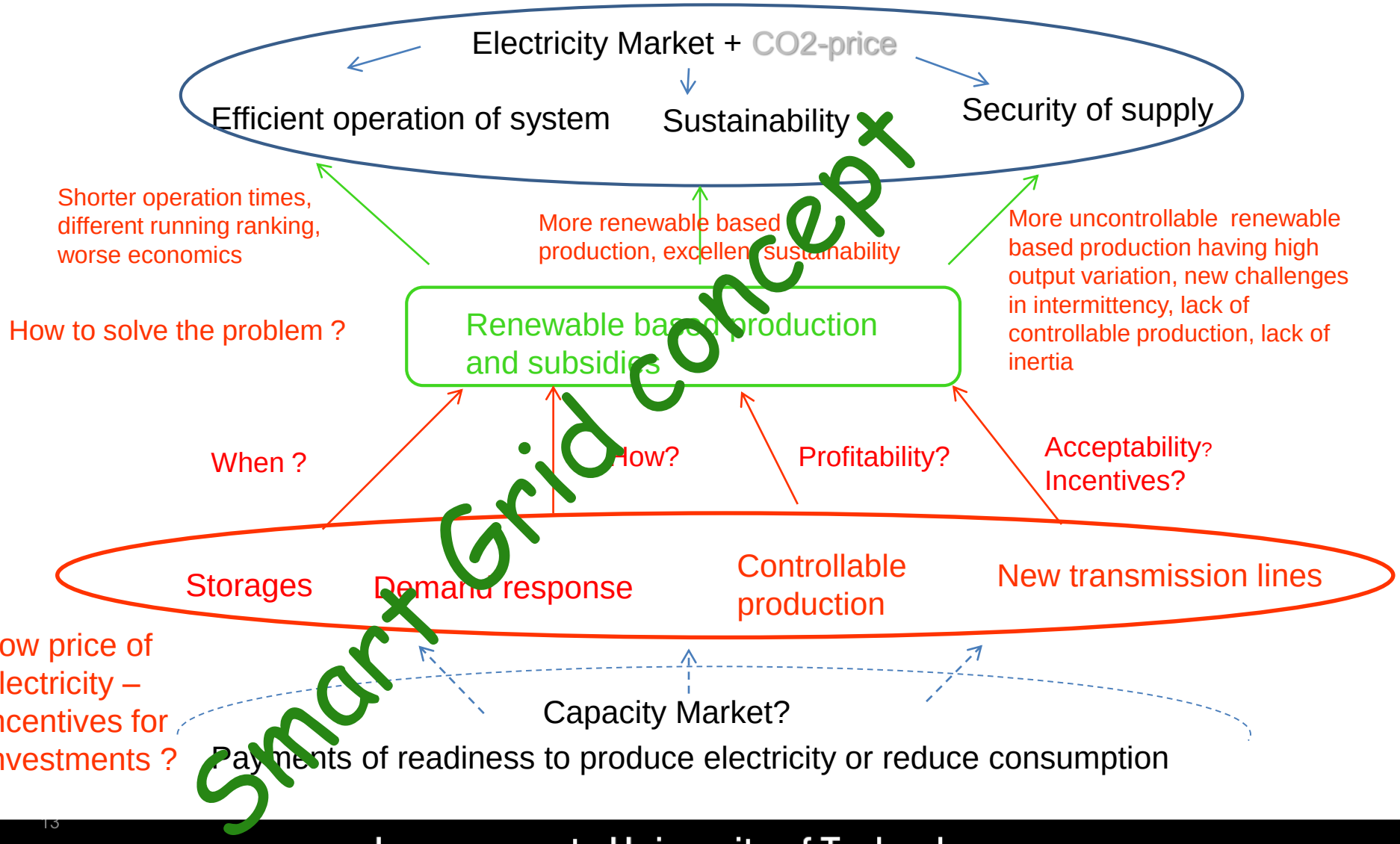


Sähkön kuluttajahinnan kehitys Saksassa (snt/kWh)



Lähde: Petri Hakkarainen: Energiakäänne – mistä Saksan energiapolitiikan mullistuksessa on kyse?

Renewables, security of supply and efficiency



Smart Grids - Future Energy Systems

Distributed energy resources with fully integrated network management

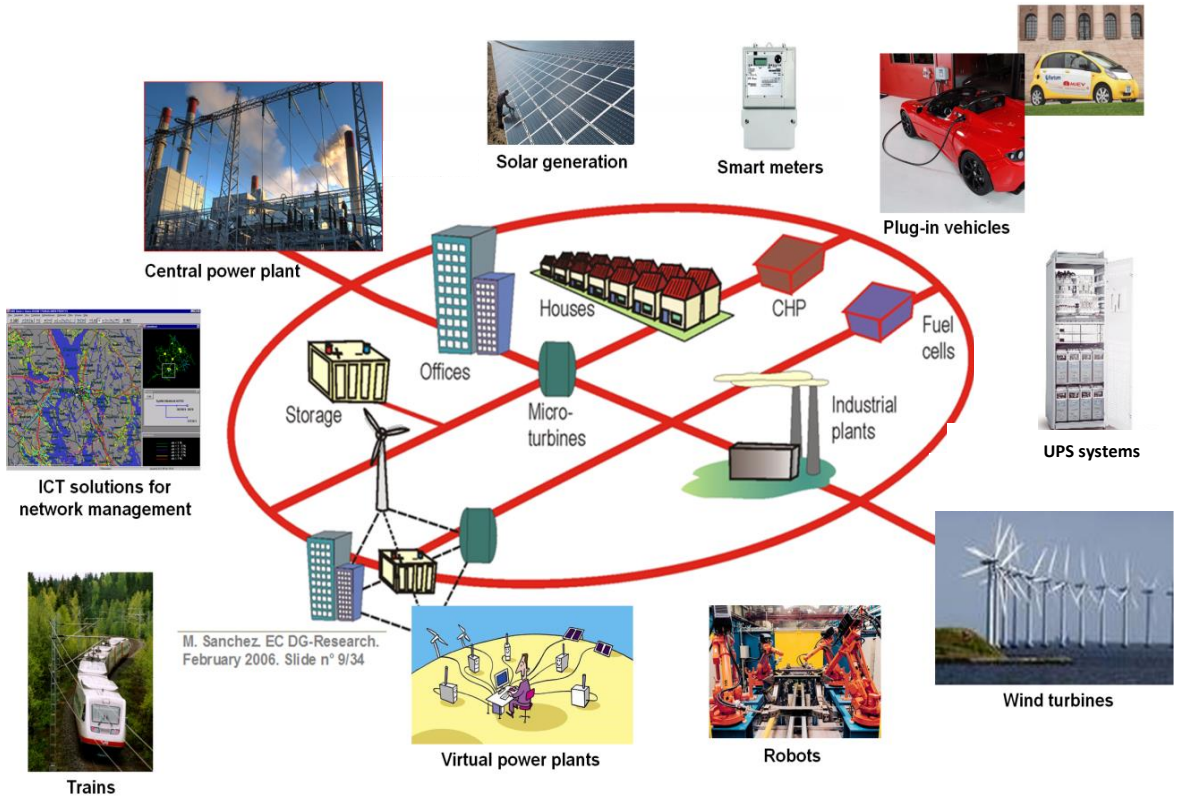
Smart grids has **two main functions**

1) Enabler of energy-efficient and environmentally friendly open energy market

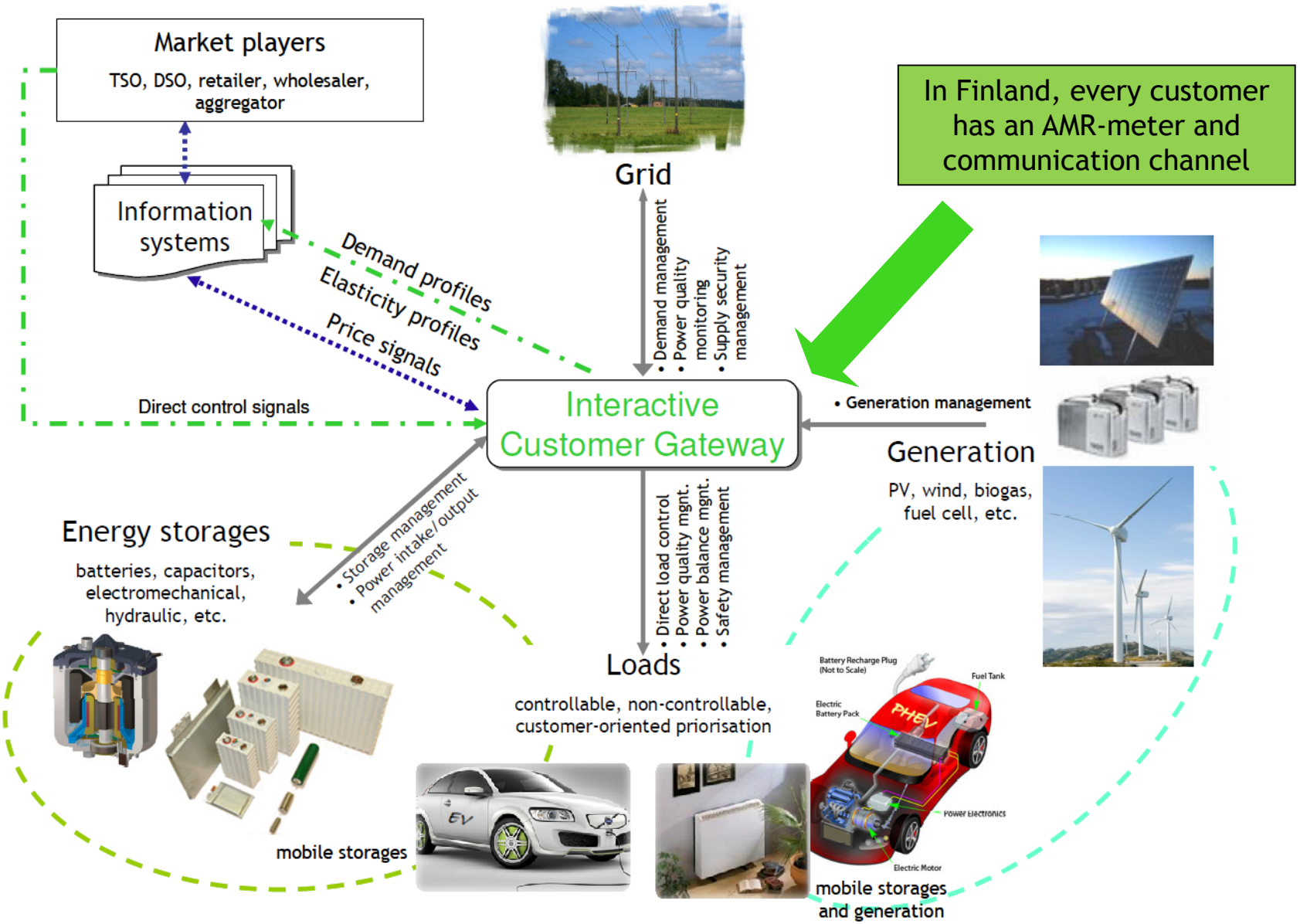
- interactive customer interface, integration of active resources, demand response, storages, common market models and comprehensive ICT solutions

2) Critical infrastructure of society

- fault and major disturbance management
- self-healing networks
- island operation and microgrids



Smart grids and interactive customer gateway



Demand Response (DR)

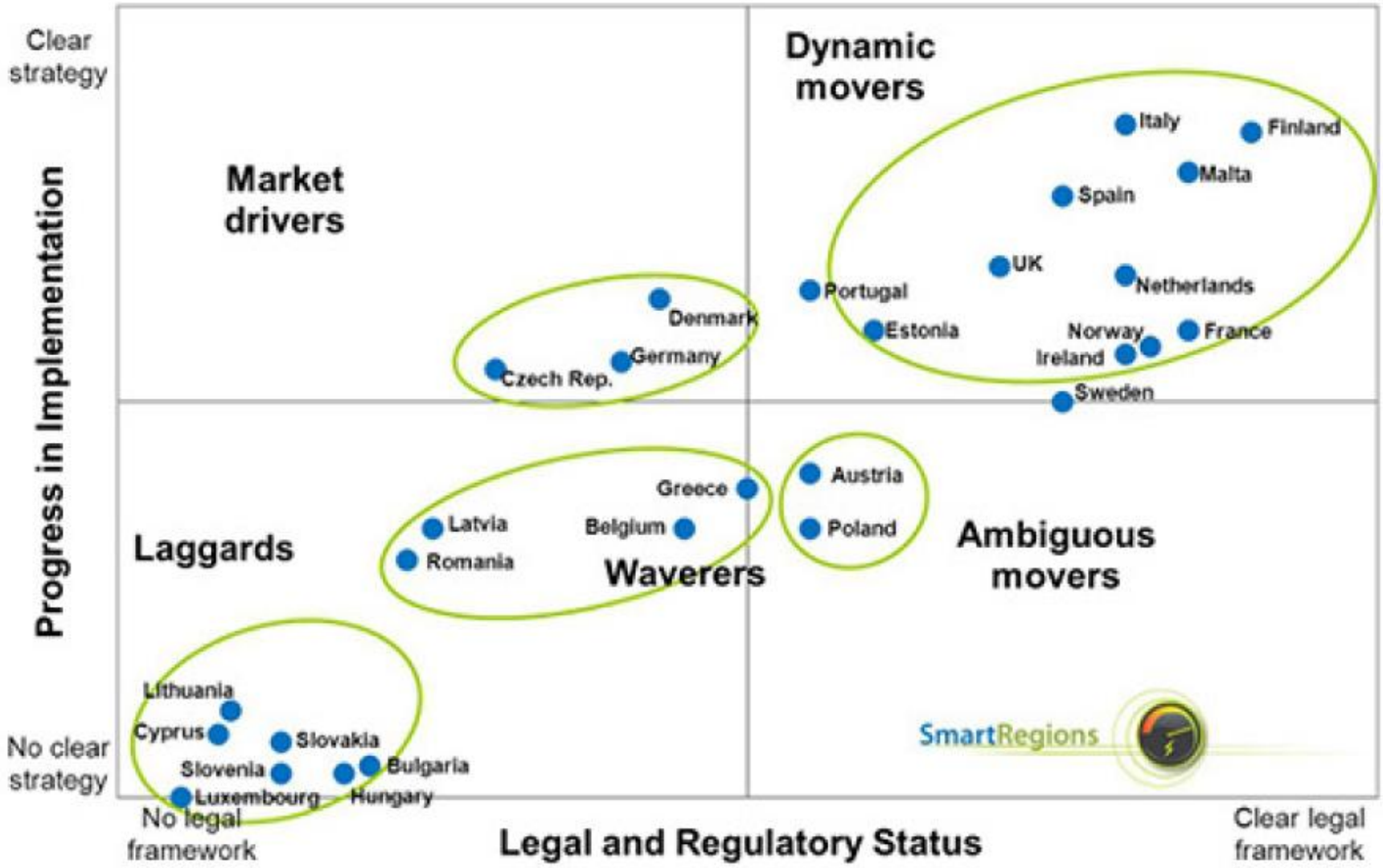
Background

- Finland is a leading country in smart meter implementation, penetration level of smart meters almost 100 %
- Balance settlement is based on measured hourly consumption of end users
- About 1.8 GW of ready-to-control heating loads exist (for comparison; nation level highest peak load 15 GW)
- Existing market places for flexible resources (day-ahead, intraday, balance power, frequency controlled reserves)

Key research topics and outcomes

- Technical and economic potential of DR in different market places
- Optimization strategy and multi-use potential of the flexibility resources → impacts of market based DR for DSOs and conflicts of interests between stakeholders
- Customer behavior → How to get customers involved in DR
- Pricing structures → How to ensure the fair sharing of costs and benefits → feasibility and impacts of power based distribution tariffs

Smart meters in Europe



http://www.smartregions.net/

Demand response – Optimization of the usage of the flexible resources


Controllable loads


Micro-generation


Energy storages


Electric vehicles

Flexible generation

HVDC links

Flexible resource

- Customer
  - Energy cost minimization
- DSO
  - Peak power limitation
- Retailer
  - Spot-markets
    - Elspot-market
    - Elbas-market
  - Balance management
- TSO
  - Balancing power market
  - Reserve power market
    - Frequency controlled normal operation reserve
    - Frequency controlled disturbance reserve
    - Automatic Frequency Restoration Reserves
    - Fast disturbance reserve

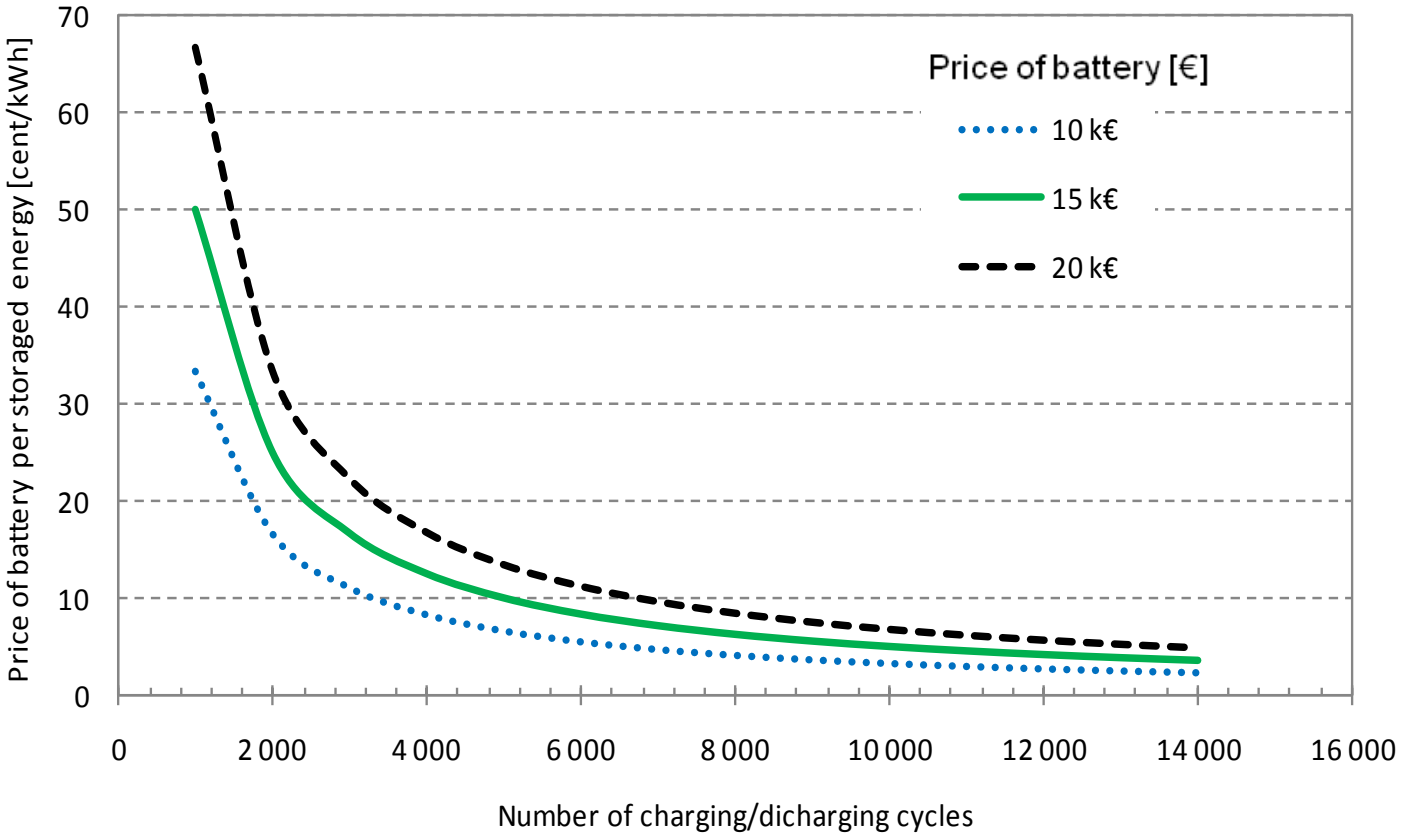
- Forecasts (loads, generation, storages)
- Measurement & control

- Optimization of DER usage
- Decision of market places, bidding process

Conflicting interests or beneficial co-operation between stakeholders?
Local or global optimum?

Economics of batteries, example

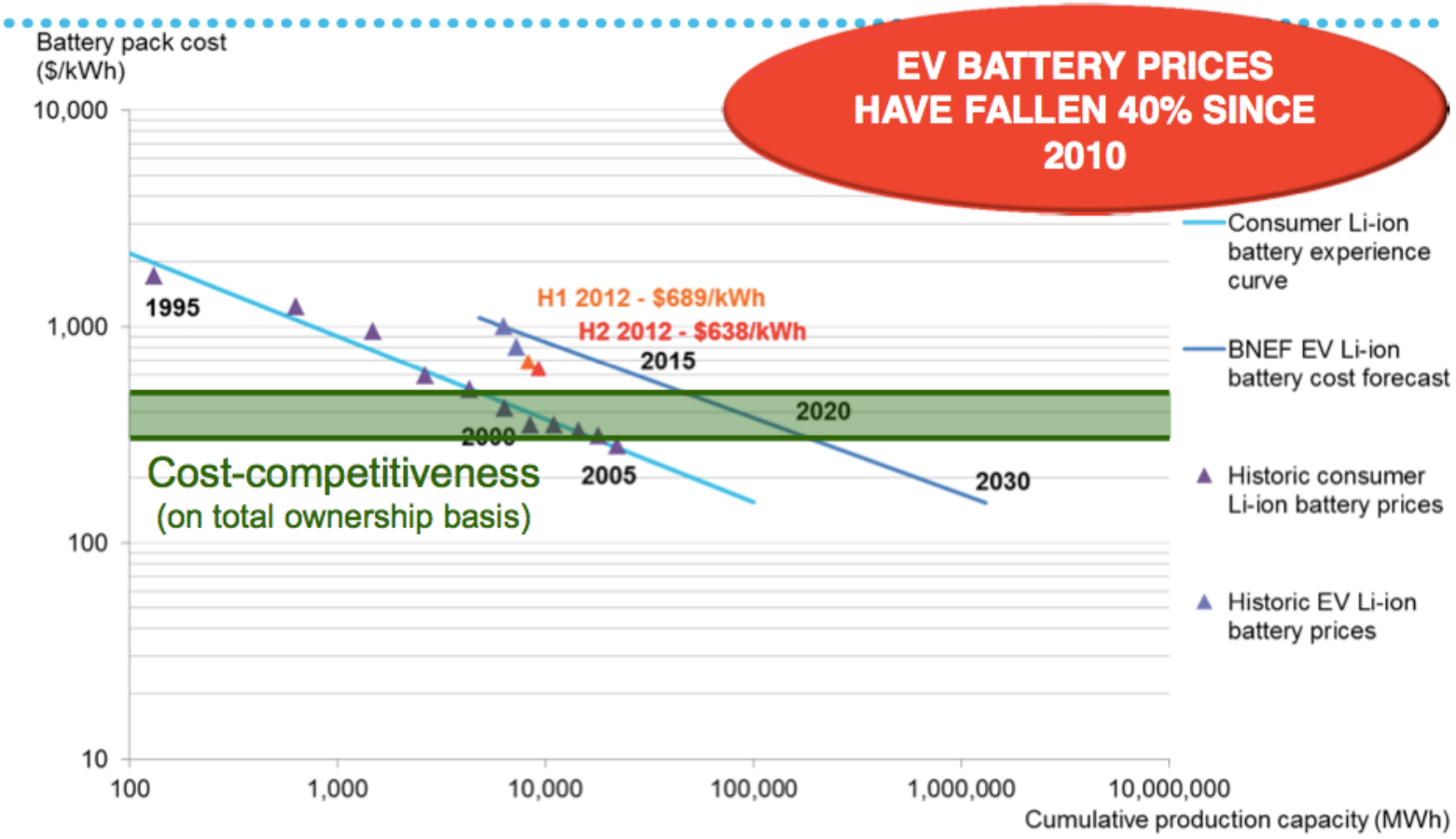
Price of batteries (30 kWh) used as an energy storage



If the price of a battery pack is 10 000–20 000 € and the lifetime is 2000–4000 cycles, the investment price per discharged energy is 8–33 cent/kWh

Lähde: Jukka Lassila / LUT

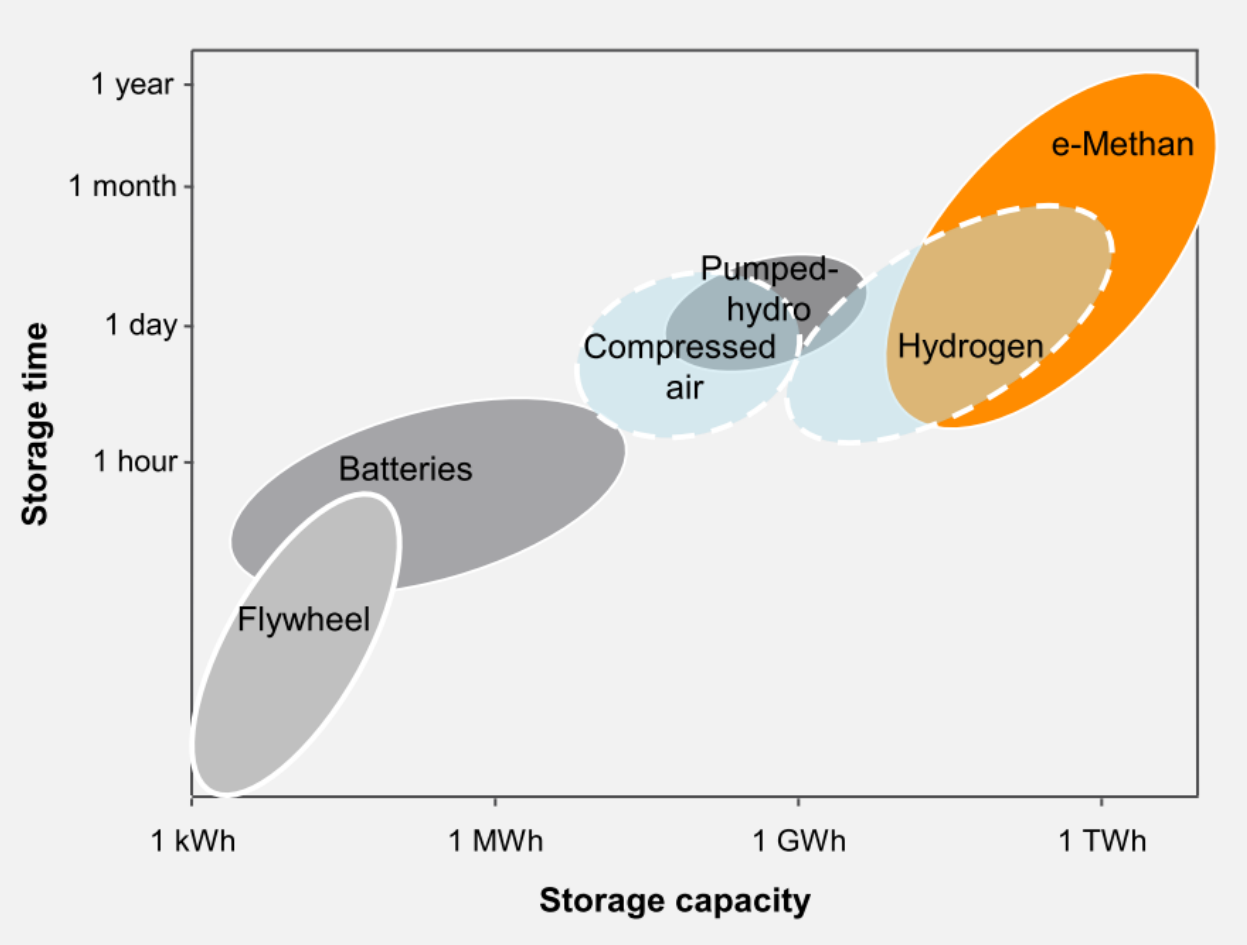
LITHIUM-ION BATTERY EXPERIENCE CURVE



Source: Battery University, MIIT, IIT, Bloomberg New Energy Finance

Learning curve: Price decrease 20 % as capacity is doubled

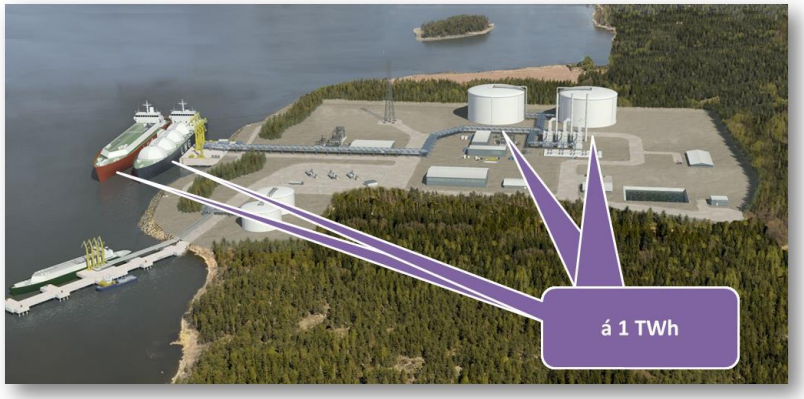
Storage capacity vs time of different energy storage types



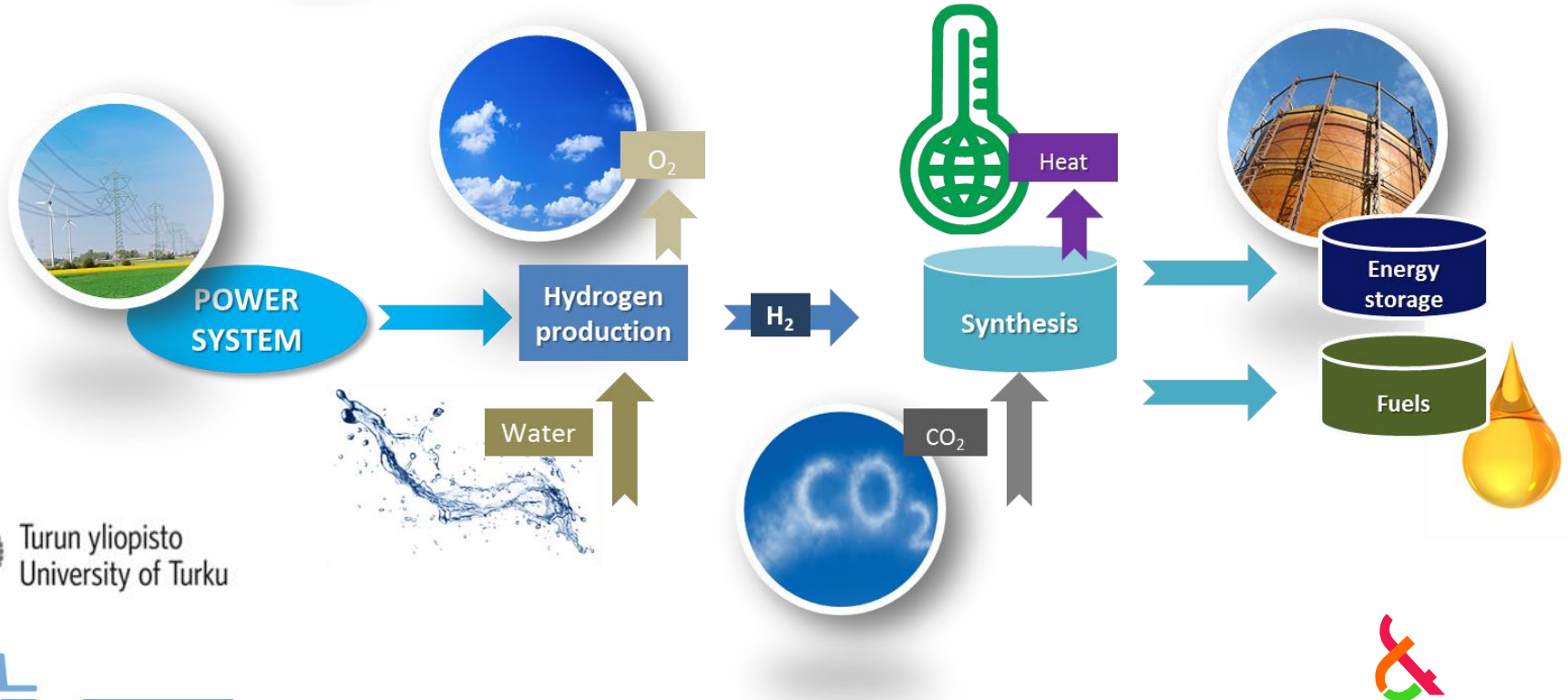
Source: ETOGAS smart energy conversion, "Power to Gas: Smart energy conversion and storage", Q2/2013.

Energy storages
NEO-CARBON

NEO-CARBON ENERGY



Source: Gasum



Turun yliopisto
University of Turku

VTT

http://www.neocarbonenergy.fi/

Open your mind. LUT.
Lappeenranta University of Technology

Recent doctoral theses in electricity markets in LUT

- Salla Annala, 10/2015. Households' willingness to engage in demand response in the Finnish retail electricity market: an empirical study
- Olga Gore, 9/2015. Impacts of capacity remunerative mechanisms on cross-border trading
- Mari Makkonen, 8/2015. Cross-border transmission capacity development – experiences from the Nordic electricity markets
- Sergey Voronin, 11/2013. Price spike forecasting in a competitive day-ahead energy market

In review process:

- Jussi Tuunanen, Modelling of changes in electricity end-use and their impacts on electricity distribution
- Petri Valtonen, DER as part of an electricity retailer's short-term profit optimization

Conclusions

- Electrification of the energy system and carbon neutral electricity generation are needed to stop the accumulation of the CO_2 into the atmosphere. As a result, the flexibility of the energy system has to be increased.
- Flexibility can be increased by demand response, storages, increased transmission capacity and controllable generation.
- From electricity markets viewpoint, this will call for harmonized incentives and common market rules within the market area and customer engagement
- Energy only markets may not provide enough incentives for adequate generation capacity. Capacity remunerative mechanisms (CRM) may be needed, but they have to be coordinated, to avoid negative cross-border effects.

www.greencampus.fi

Thank you!

D.Sc. Samuli Honkapuro
LUT Energy
Lappeenranta University of Technology
Lappeenranta, Finland
Samuli.Honkapuro@lut.fi