Integration of renewables supply and demand; social acceptance of crucial smarts grid elements.

Scale Conflicts about Distributed Generation

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Renewable Energy:
"Distributed generation"

- Micro/decentralized generation:
  * PV (PhotoVoltaics)
  * micro CHP (biofuels, preferably bio-waste),
  * onshore wind
  * geothermal (prudential) hydro (tidal etc)
- Small scale, spatially dispersed
- Spatial claims renewables: "huge"
  MacKay DJC 2008
- Variable sources
- Power grid applied as 'storage' capacity

Charles D 2009 Science 324: 172-175 "Renewables test IQ of the grid"

Distributed Generation

Ackermann, Andersson, Söder 2004

Combined cycle gas T.	35–400 MW
Internal combustion engines	5 kW–10 MW
Combustion turbine	1–250 MW
Micro-Turbines	35 kW–1 MW
Renewable	
Small hydro	1–100 MW
Micro hydro	25 kW–1 MW
Wind turbine	200 Watt–3 MW
Photovoltaic arrays	20 Watt–100 kW
Solar thermal, central receiver	1–10 MW
Solar thermal, Lutz system	10–80 MW
Biomass, e.g. gasification	100 kW–20 MW
Fuel cells, phosacid	200 kW–2 MW
Fuel cells, molten carbonate	250 kW–2 MW
Fuel cells, proton exchange	1 kW–250 kW
Fuel cells, solid oxide	250 kW–5 MW
Geothermal	5–100 MW
Ocean energy	100 kW–1 MW
Stirling engine	2–10 kW
Battery storage	500 kW–5 MW
V2G (electr vehicle batrteries)	10-100 kW

Definition

- **Distributed Generation**

  is an electric power source

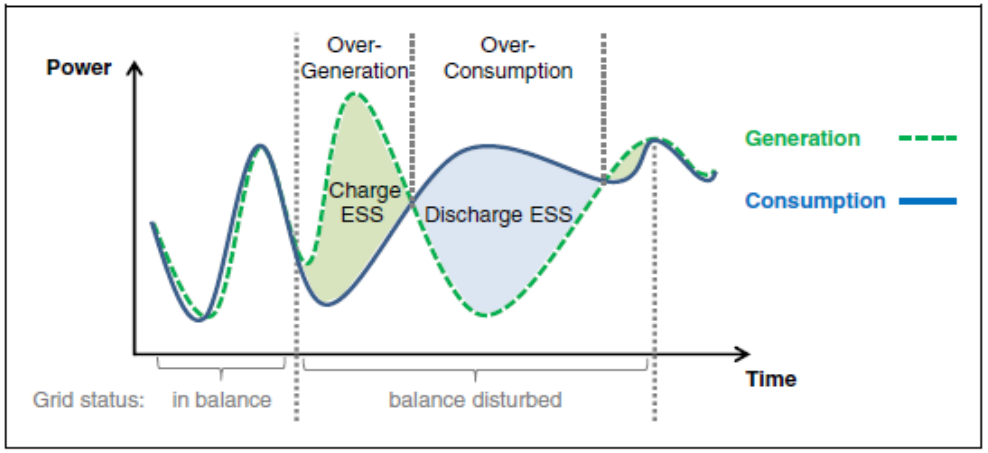
  - connected directly to the distribution network

  - or on the customer site of the meter.

Ackermann et al 2004

Feasibility RES requires integration of
- different supply patterns
- and (adapted) demand patterns

- Different patterns of variable supply
- Optimization supply and demand: needs (micro-)optimization



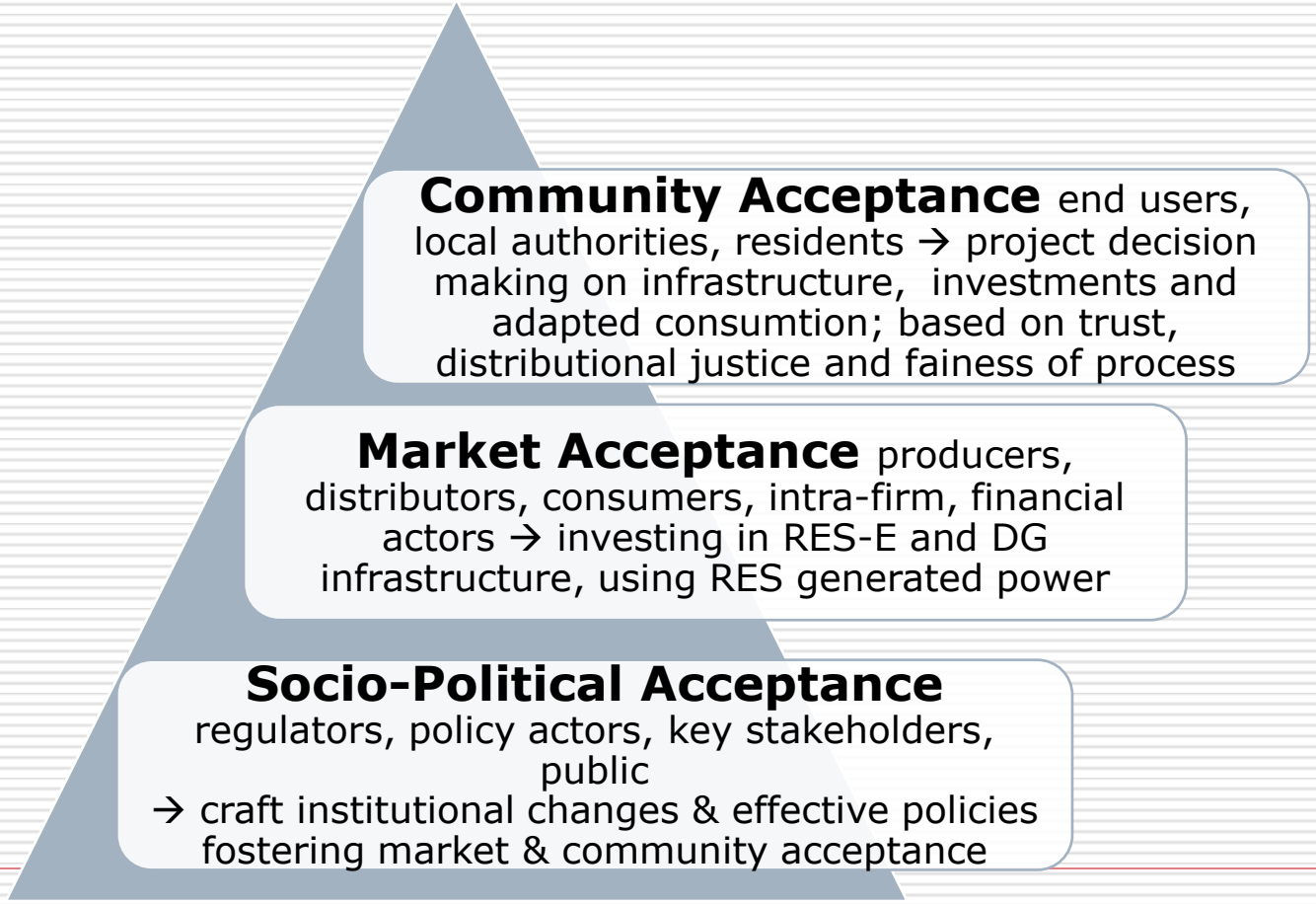
- Development of (local) micro-grids,
  - several 'prosumers' in a 'community'
  - load-control *(supporting DG, not central)*
  - including local storage (e.g. electr. vehicles)
- Smart meters, including smart regulation *(supporting 'prosumers' and 'micro-grid')*

Strong pressure on the power grid: towards a "Smart Grid"

- "Power grid consisting of a network of integrated micro-grids that can monitor and heal itself" *Marris E (2008) Upgrading the grid. Nature 454: 570-573*
- → Fundamental question:
  *Which **institutional changes** needed to establish smart micro-grids with renewable DG generation as much as possible?*
- Who will invest? Who has control about what? Does micro-generation get priority over large-scale unsustainable generating capacity?

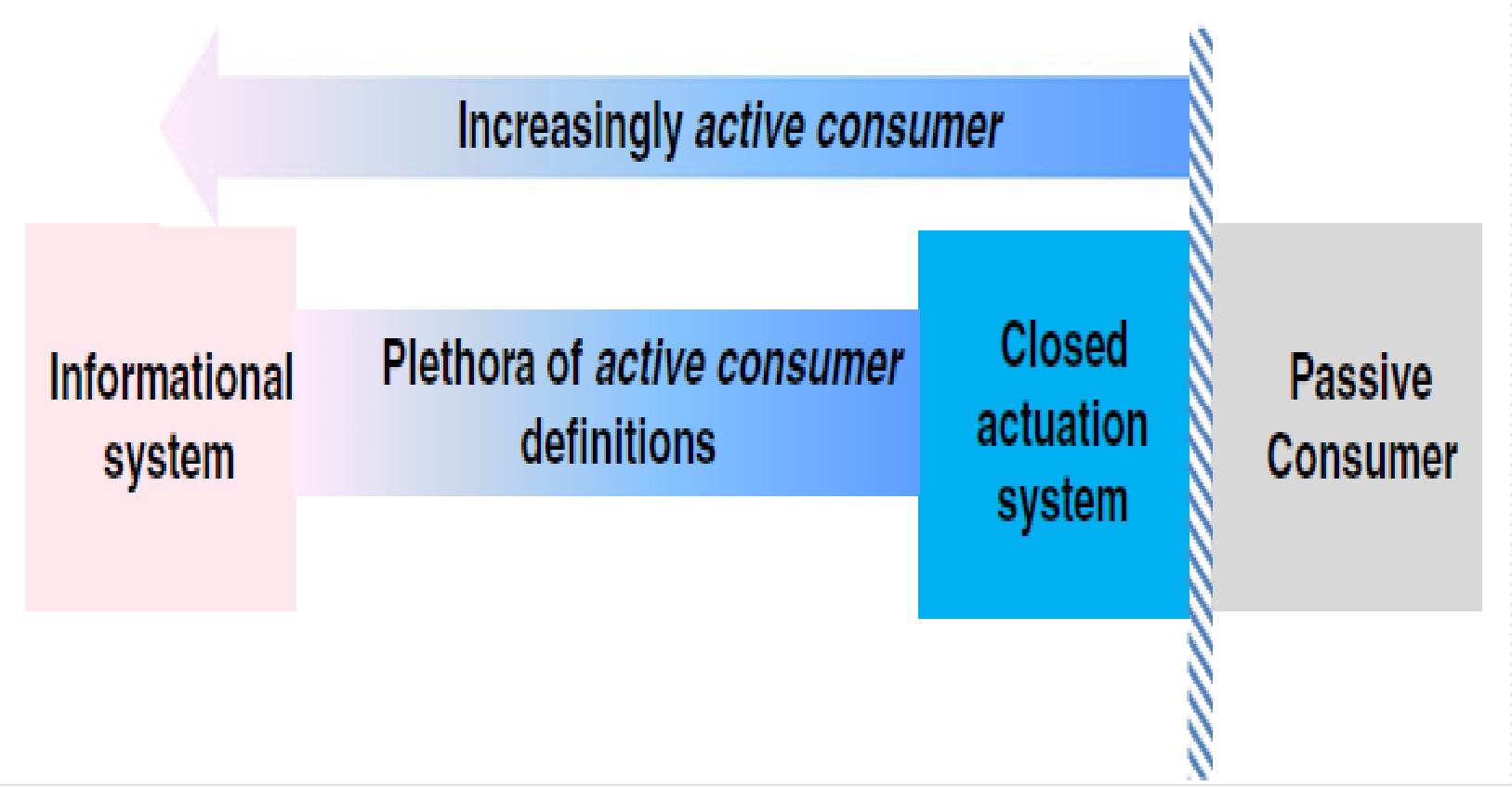
Social acceptance in innovation primarily issue with an institutional character

adapted from Wüstenhagen et al 2007. *Energy Policy* 35, 2386



Acceptance of what?

- key issue: *institutional scale conflict*
- socio-political and market acceptance of control of increasingly active consumers ('prosumers')



Peacock, Owens. Energy Efficiency 2014

Institutional lock-in: existing patterns of thinking and behaviour

"Alternatives representing radical technological change have to come from outside organisations representing the existing technologies, whereas the existing incumbents even make efforts to eliminate alternatives from decision-making processes."

Lund (2010) Energy 35: 4003-4009.

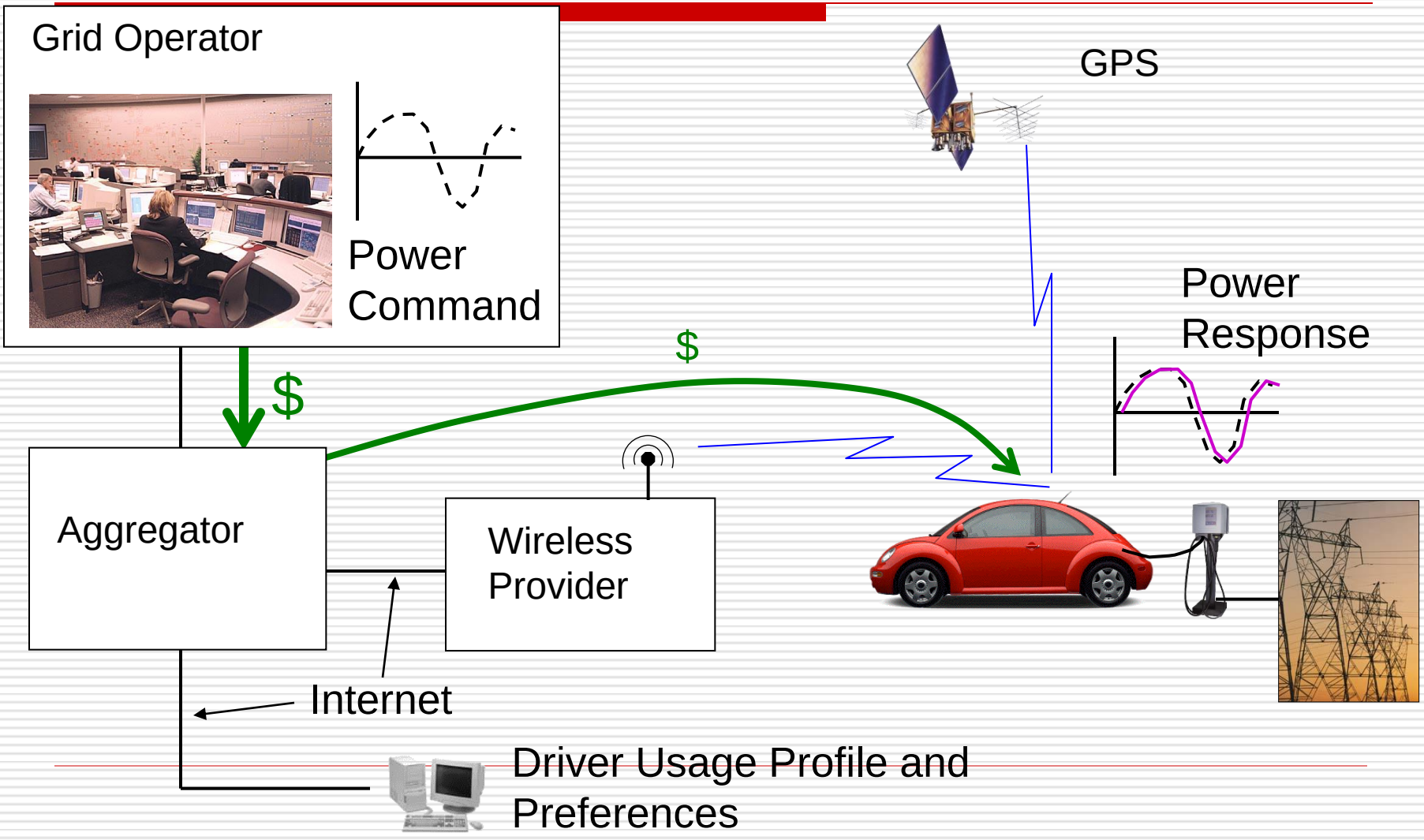
Comparison of 12 decision-making processes in RES projects in 1st country successful in RES implementation

Example V2G integration

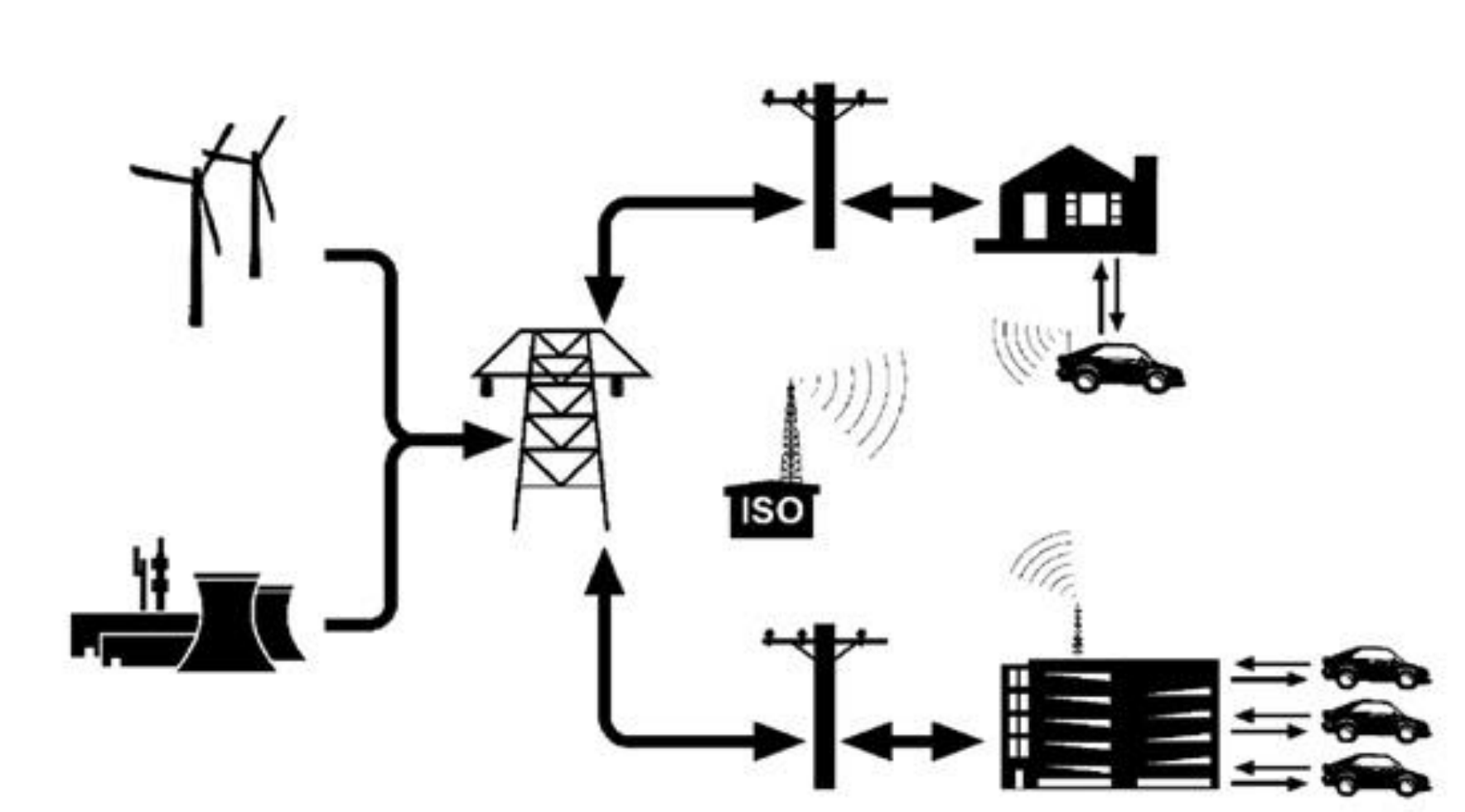
- controlled Electric Vehicles charging reduce required transmission capacity
- reduce electricity dispatch costs,
- curtailment of variability renewable energy sources (RES)
- curtailment storing energy by utilizing pumped hydro
- absorbs unserved load.

Verzijlbergh et al, 2014

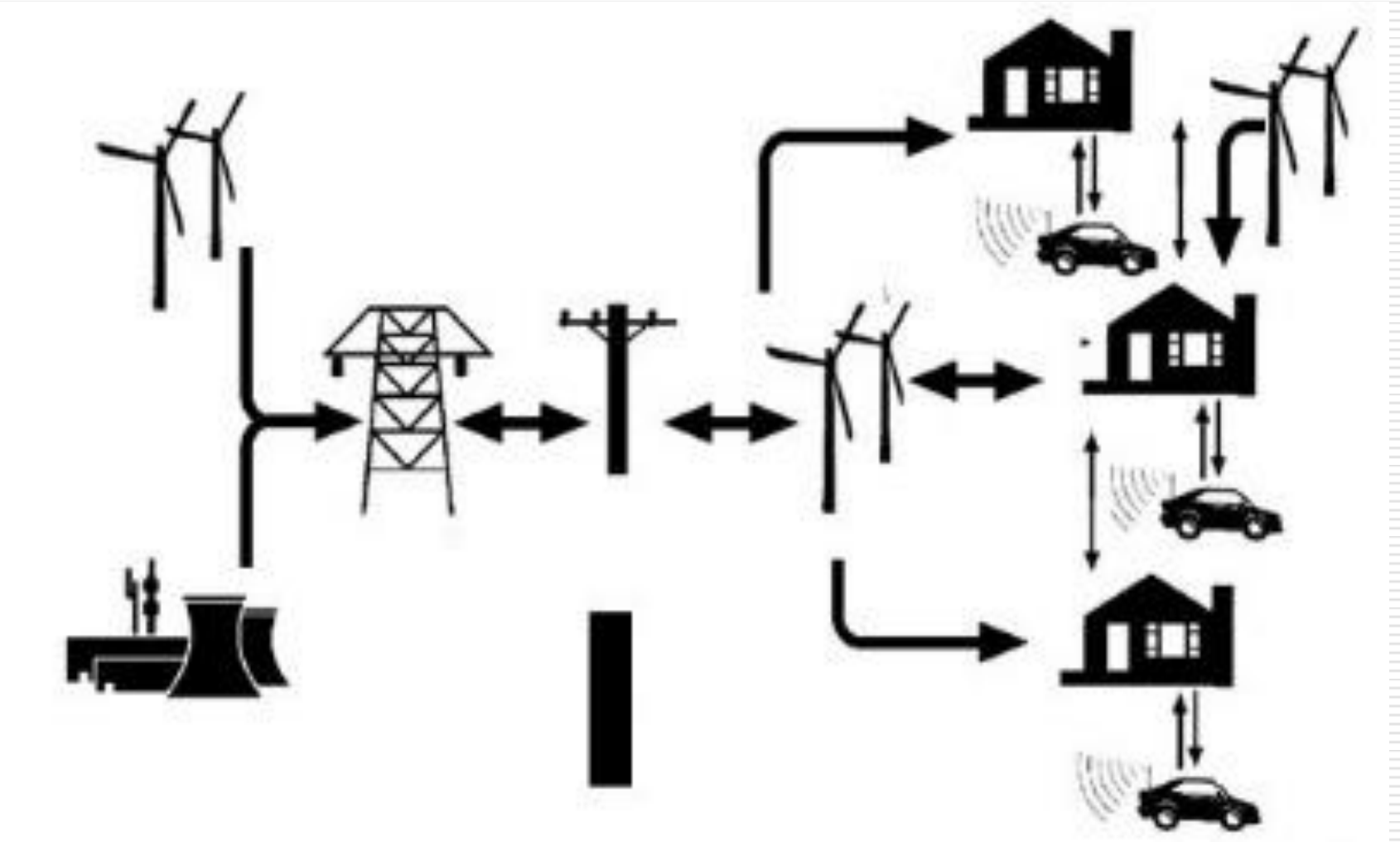
Grid Regulation with an EV Centralized vision



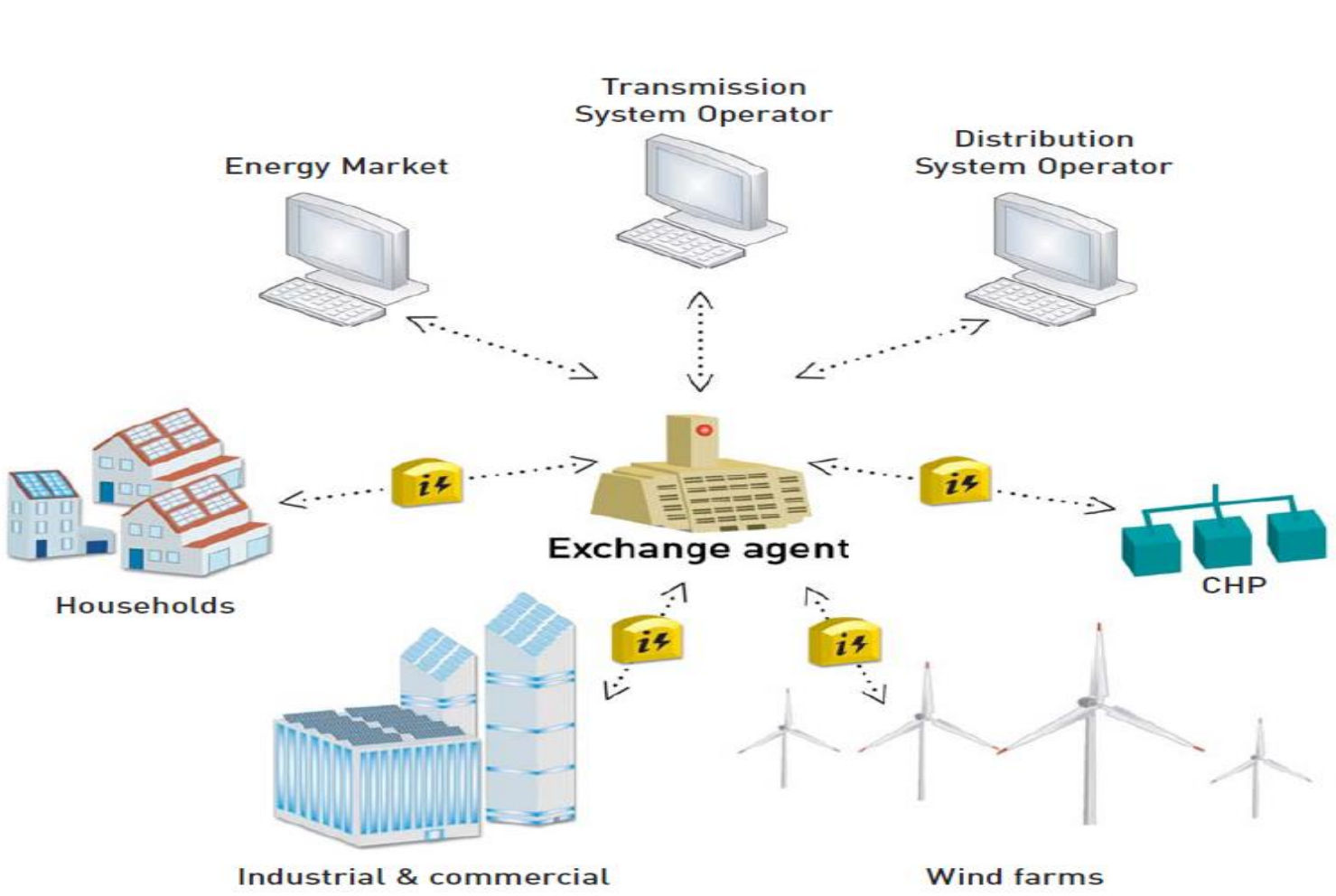
V2G Centralized vision



V2G: *Prosumer vision:* storage V2G helps RE integration in microgrid; enhancing acceptance and limiting transmission

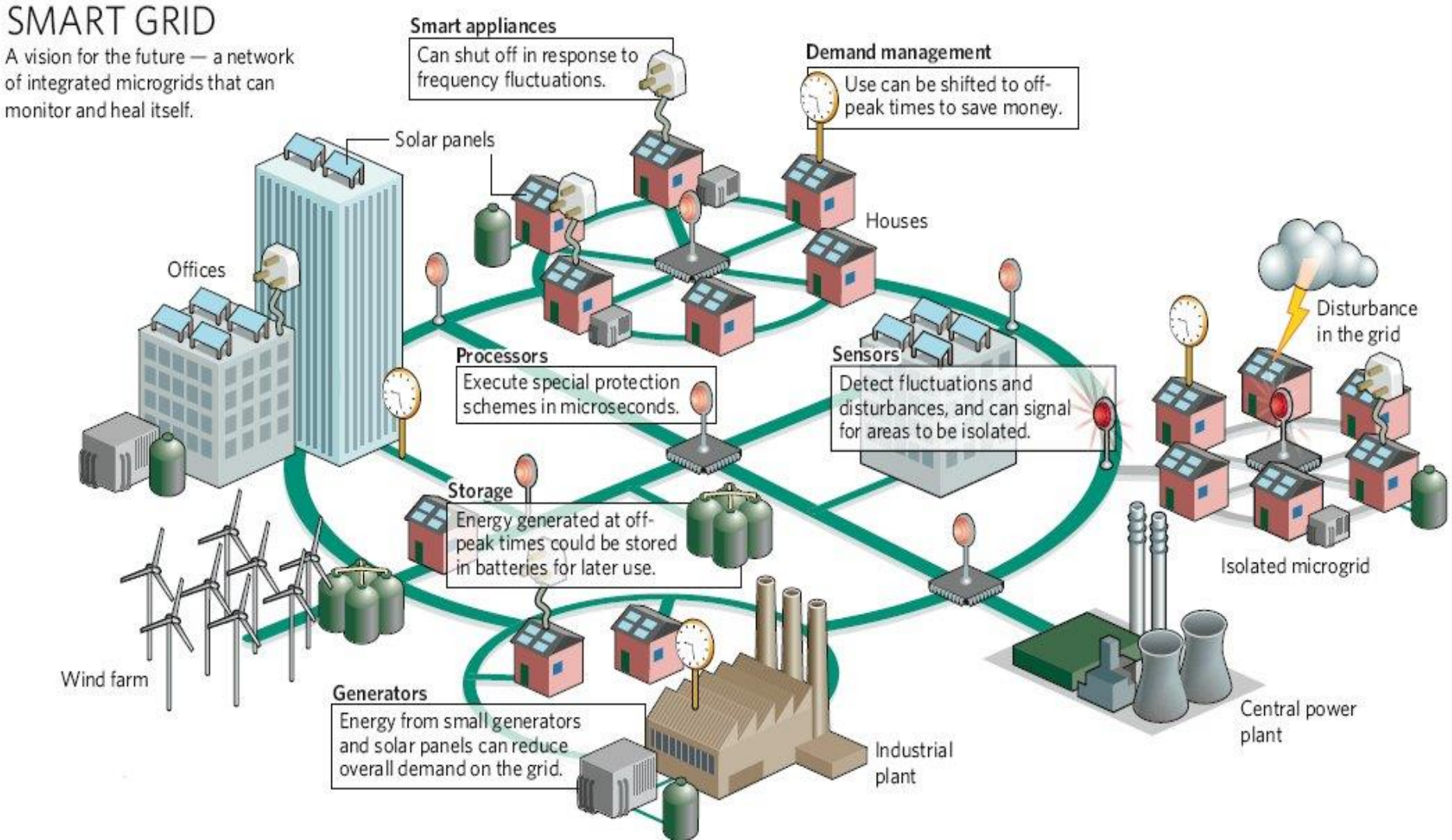


EU ‘vision’ on the ‘smart’ grid

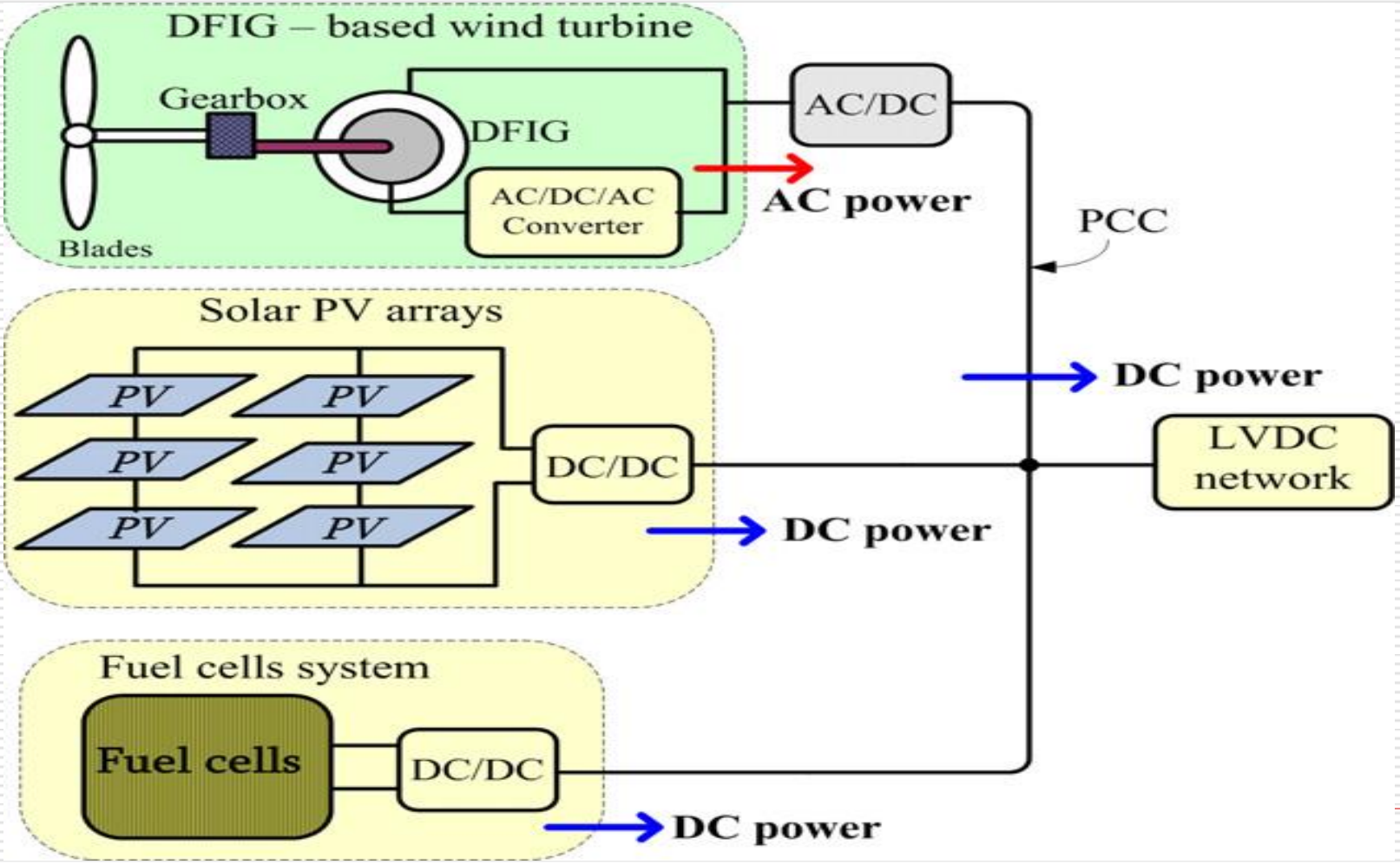

Transmission
System Operator
Energy Market
Distribution
System Operator
Exchange agent
Households
CHP
Industrial & commercial
Wind farms

‘Smart grid’: “…rescaling and distributed generation” … “integrated micro-grids that can monitor and heal itself”

Marris 2008, *Nature* 454, 570



Example: DG units with LowVoltage DC network [Justo et al. 2013, 390]



Institutional conflict: taxation

- Integrated production/demand
- Co-operating 'prosumers' (wind, solar, geothermal, storage etc.)
- Smart meters supporting co-operation and integration → no energy company control
- Where are the energy-flows taxed?
- Interest of the state (incumbent/vested interest) in current power supply system

DG with local storage in smart grid

- When the aim is to maximize IS [information system]-enhanced ESS [electricity storage system] … most promising to give private households absolute control rights over theses systems … to maximize personal security of supply"

  "… policy-makers could impose laws that give distribution system operators control rights over IS-enhanced ESS in private houses…."
- Römer et al, *Electr Markets* in press 2014, p.11

Thank you

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