Institutional Conditions for Microgrids: *Social Acceptance of Integrating Distributed Generation and Land Use Required for the Infrastructure*

Maarten Wolsink

2015 26th August

'Sharing Futures' Summer School: Interdisciplinarity and intergenerationality in planning sustainable urban environments

24-26th August 2015

University of Birmingham
UK

https://scholar.google.nl/maarten wolsink

University of Amsterdam

Department of Geography, Planning & International Development Studies

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"

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 (favourable, but ≠ 'sustainable')*	
❖ Biomass, e.g. gasification	100 kW–20 MW
❖ 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
❖ 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

DG, continued

❖ Geothermal	5–100 MW
❖ Ocean energy (Waves, Tidal, Saline/Fresh pressure)	100 kW–1 MW
❖ Stirling engine (micro CHP)	2–10 kW
❖ *Distributed* *Storage and Transmission (of Renewable generated energy)*	
❖ Heat storage (electric boilers)	1-10 kW
❖ Heat storage in buildings (solar, electr. eat piumps)	10-500 kW
❖ 'Cold' storage (colling sustems)	1-100 kW
❖ Battery storage	500 kW–5 MW
❖ Electric vehicles (batteries)	10-100 kW
❖ V2G (Vehicle-to-grid; uploadiing)	10-100 kW
❖ MicroGrid (balancing supply-demand within)	1kW-100MW
❖ SuperCondicting Transmission lines	100-1000 kV
❖ *Storage in 'non-heat' consumption (of Renewable generated energy)*	
❖ Water Supply systems	10kW-1000 kW CWSS *(example Vllanova Balestieri, this course)*
❖ Desalinization systems	10kW-400 kW

❖ And many more emerging……

Definition

- **Distributed Generation**

  is an electric power source

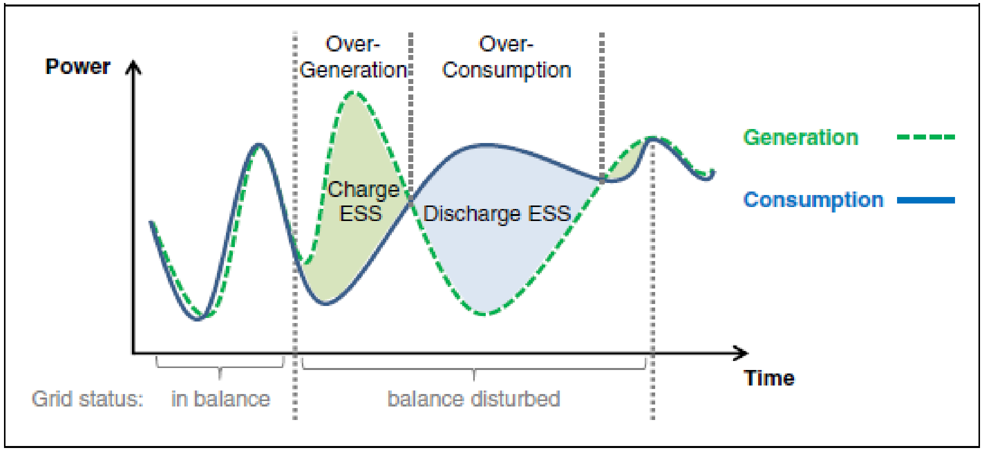
  - connected directly to the distribution network

  - or on the customer side of the meter.

Ackermann et al 2004

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

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



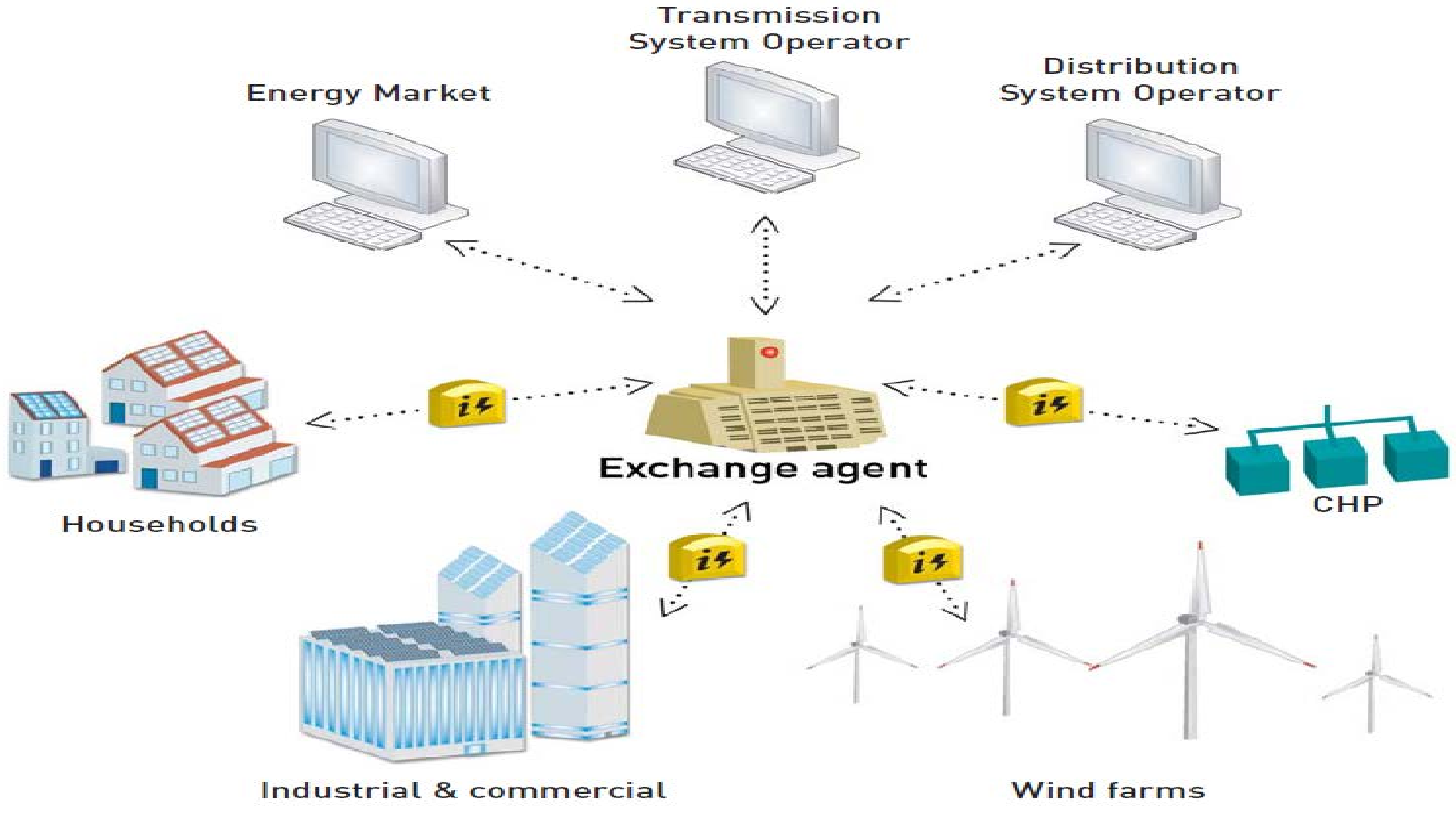
- Development of (local) micro-grids,
  - several ‘prosumers’ in a 'community'
  - load-control *(supporting DG, **not** central capacity)*
  - including local storage (e.g. electric vehicles)
- Smart meters, including smart regulation *(supporting ‘prosumers’ and ‘micro-grid’, instead of central power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

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?
  Where and how to site is all the infrastucture?

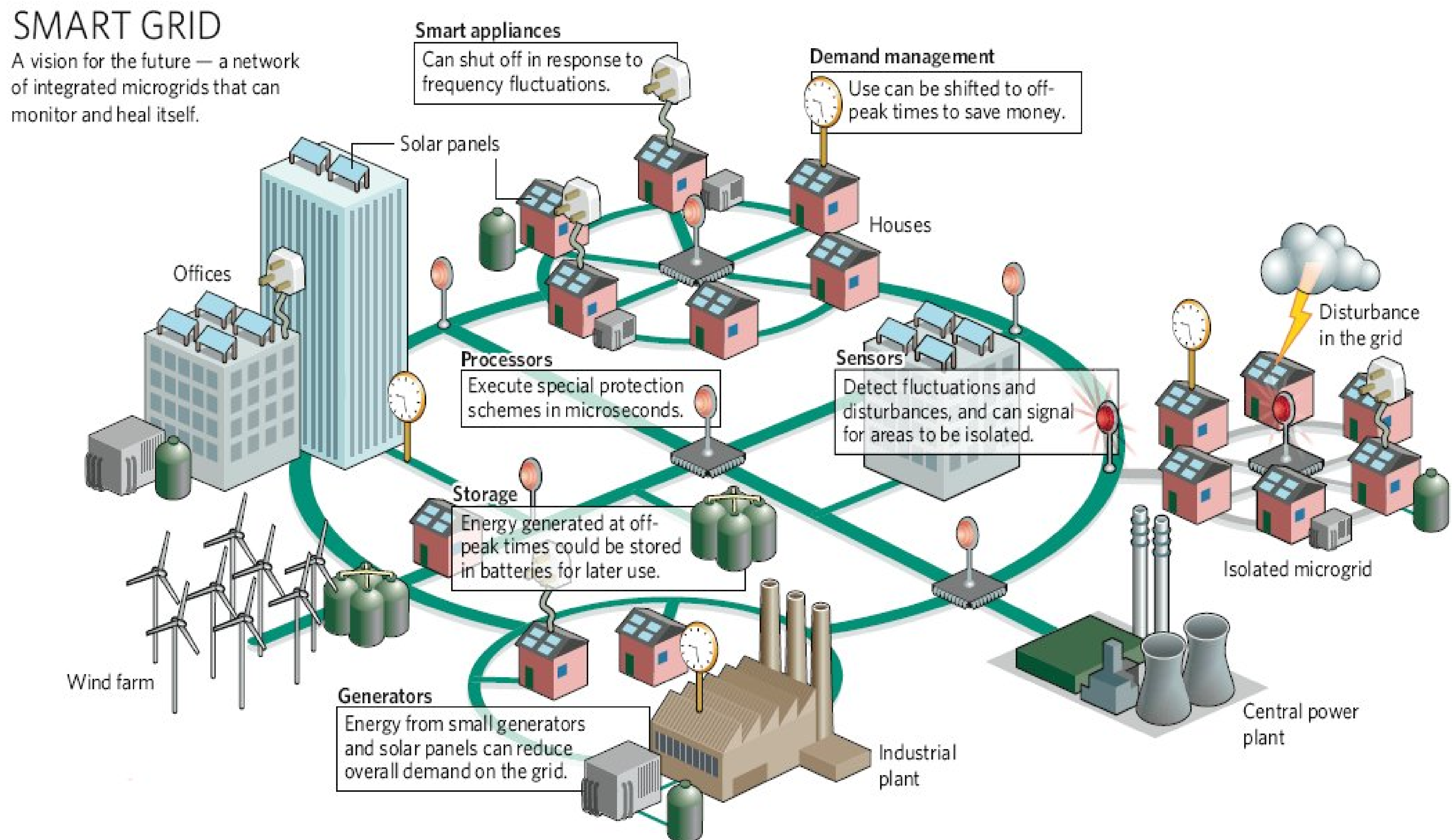
EU 'vision' on the 'smart' grid

EU vision still 'locked-in' in centralized thinking whereas DG is by definition not centralized

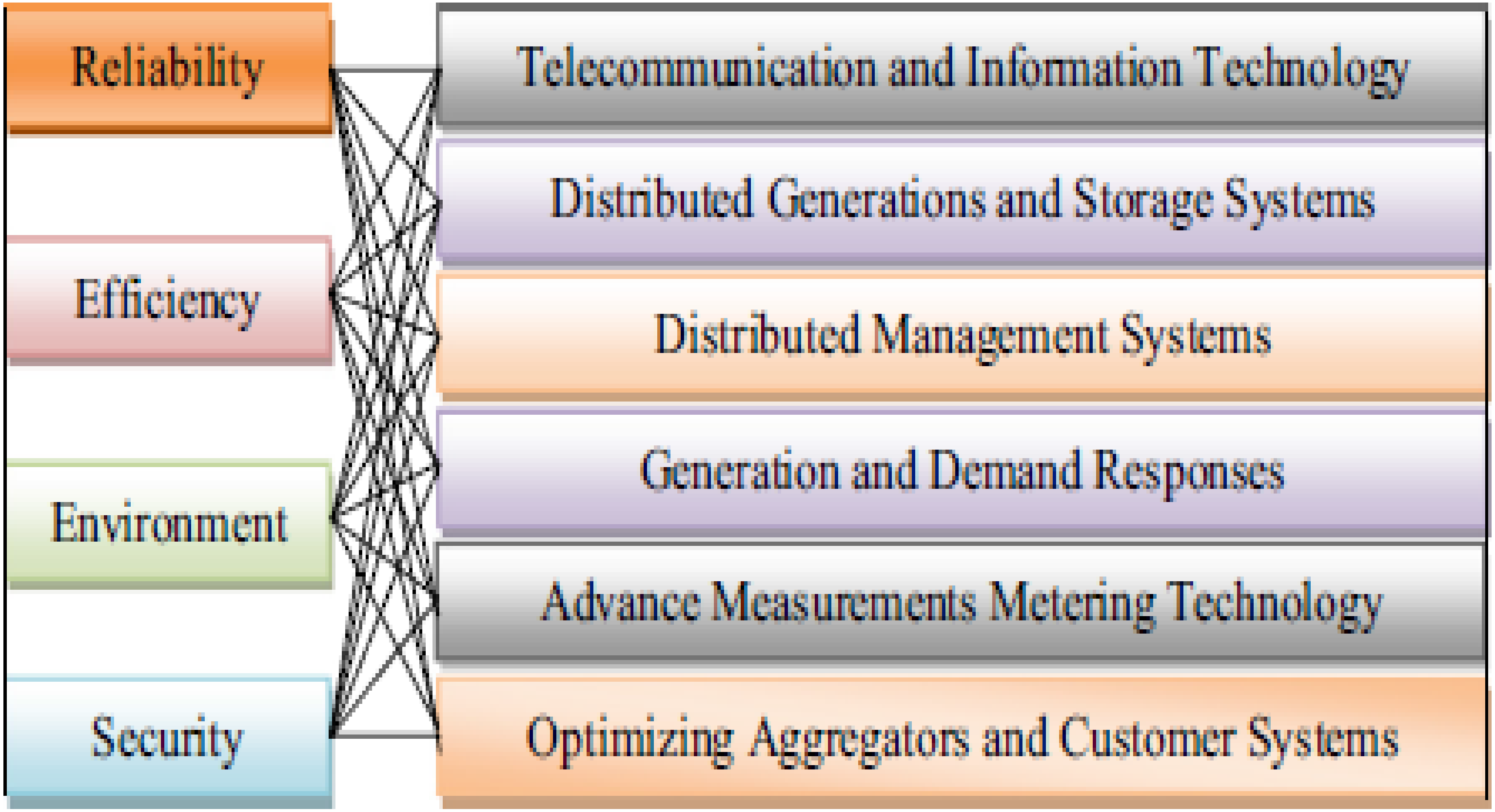


‘Smart grid’: “…rescaling and distributed generation” … “integrated micro-grids that can monitor and heal itself”

Marris 2008, *Nature* 454, 570

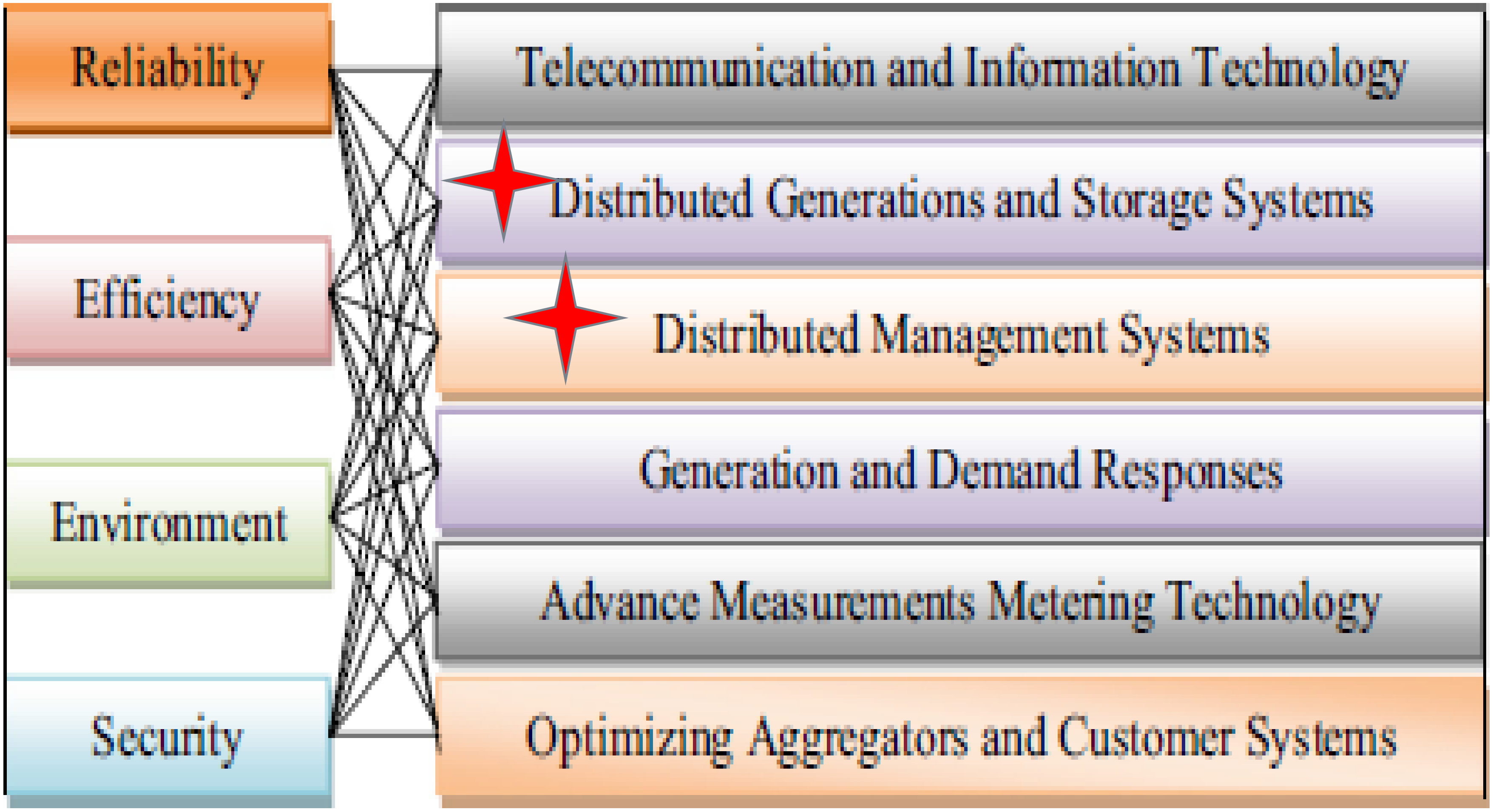


4 kinds of 'merit' (not guaranteed, depending upon institutional frame !!) related to 6 smart microgrid elements



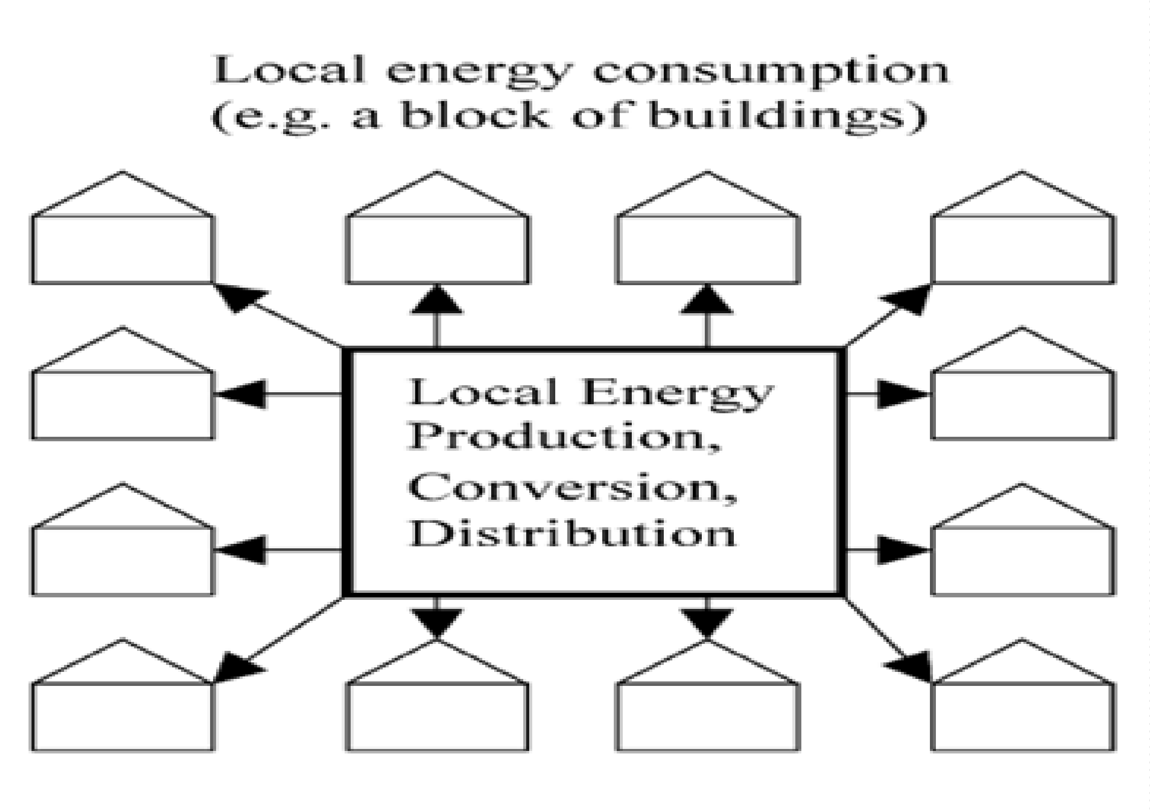
Haidar et al Ren Sust En Rev 2015

4 kinds of 'merit' (not guaranteed, depending upon institutional frame !!) related to 6 smart microgrid elements



Haidar et al Ren Sust En Rev 2015

Micro Grid (example of only houses)
All units connected to public grid
or All together connected as 1 system



Co-operating prosumers in microgrid form a **community** harvesting, applying and **governing a natural resource**

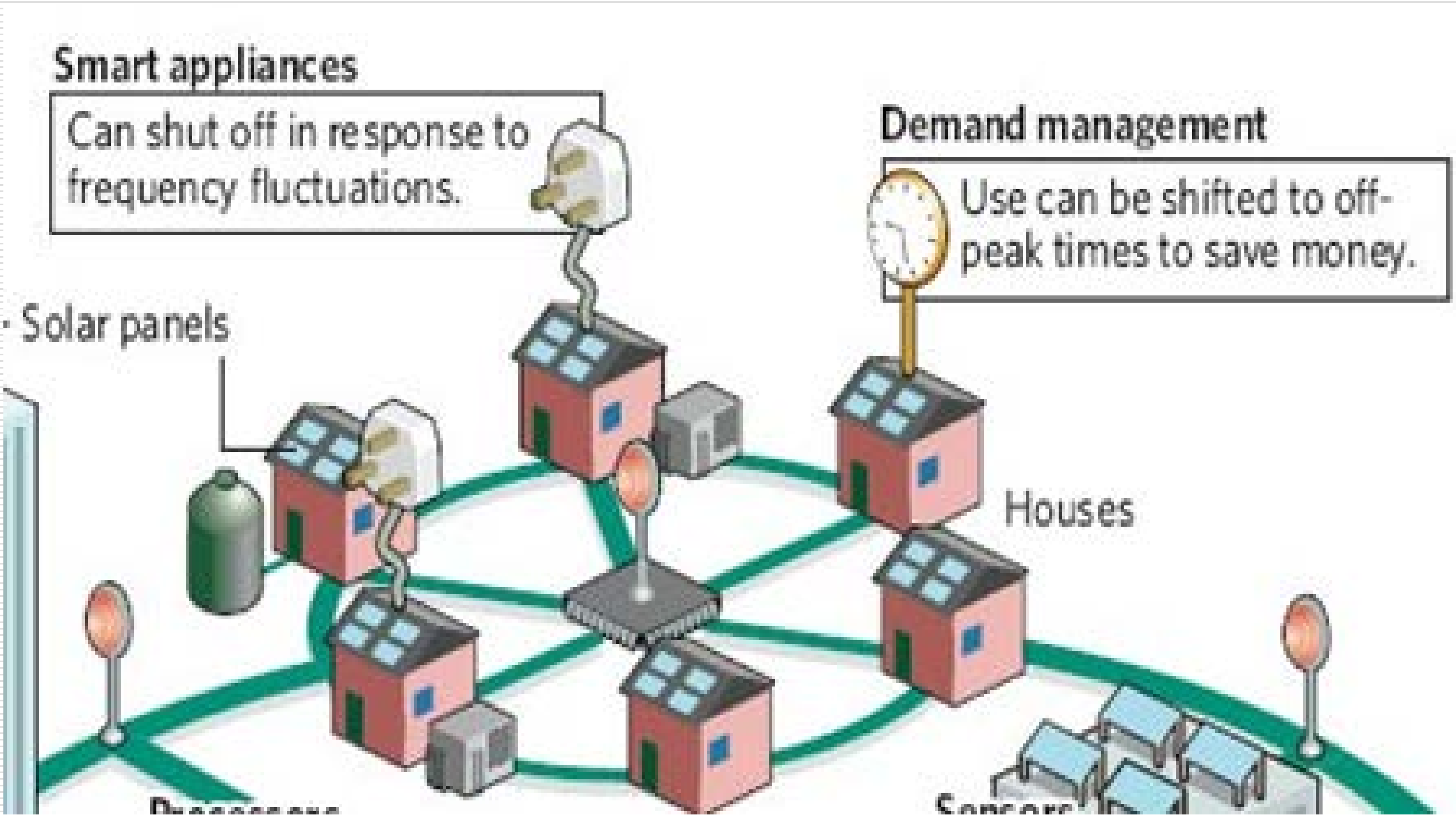
→ Lin Ostrom's institutional analysis of Common Pool Resources governance applies

"Contemporary policy analysis of the governance of common-pool resources is based on three core assumptions:
(*a*) resource users are norm-free maximizers of immediate gains, ...
(*b*) designing rules to change incentives of participants is a relatively simple analytical task
(*c*) organization itself requires central direction"

"……… all three assumptions are a poor foundation for policy analysis."

Ostrom E, 1999. Coping with tragedies of the commons. *Annual Review Political Science* 2, 493

Micro Grid (example of only houses)
internal integration of generation and demand (minimizing exchange with public grid)



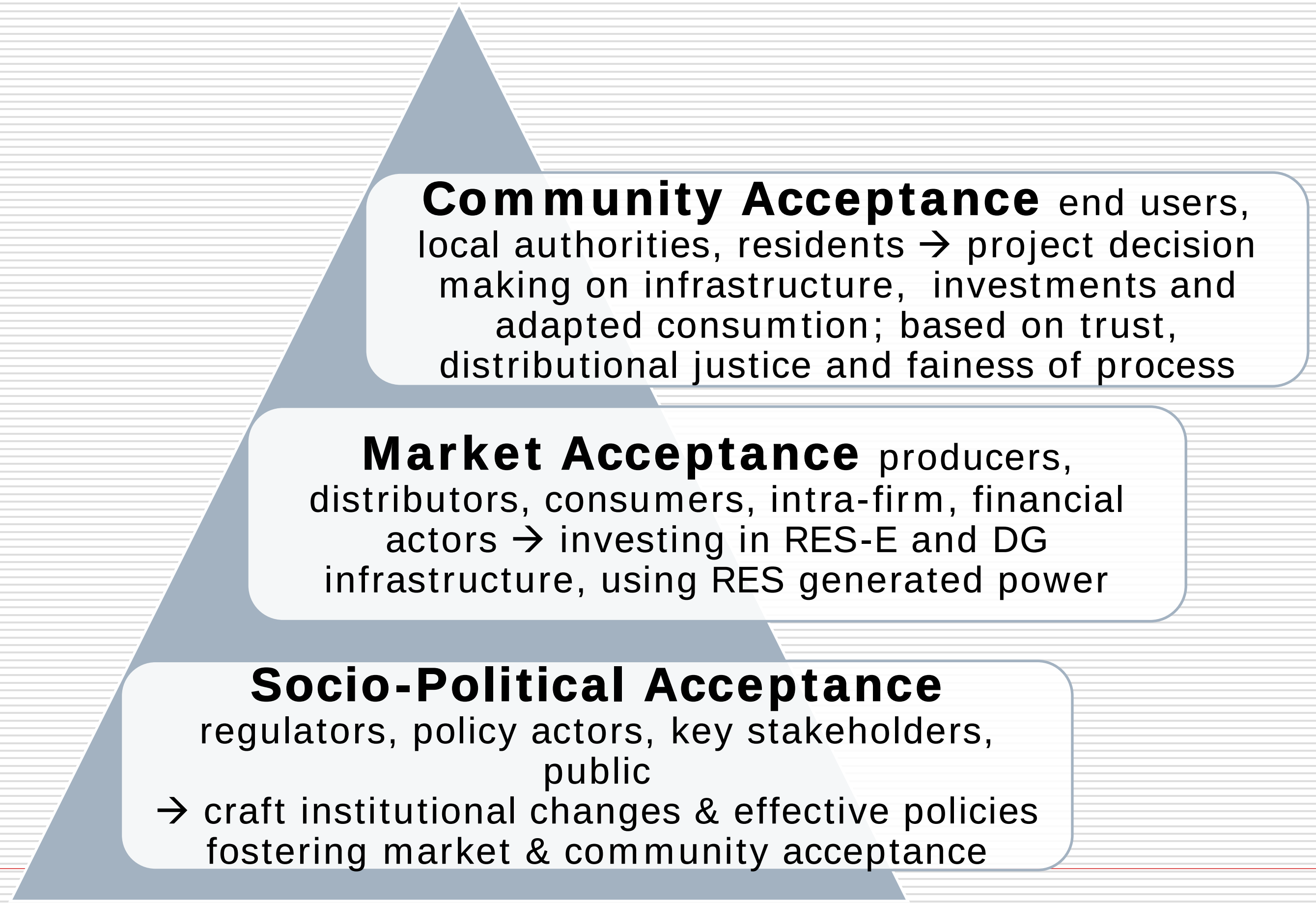
Distributed Generation and Storage systems

- Power Supply system is NOT technical, but a
- STS; Socio-Technical System Geels, 2004.
- Hence, essential social components, attached to:
  - Producers (increasingly 'prosumers')
  - Consumers (demand patterns, but also civilians)
  - Anyone involved in governance of the STS, as well as land use for infrastructure
  - **Acceptability of all SmartGrid elements**
- Introduction of a new STS is about changing **institutions,** escaping **institutional lock-in**

Unruh, 2000; Lund H, 2010; Lehmann et al 2012; Wolsink 2012

Social acceptance in innovation primarily issue with an institutional character

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

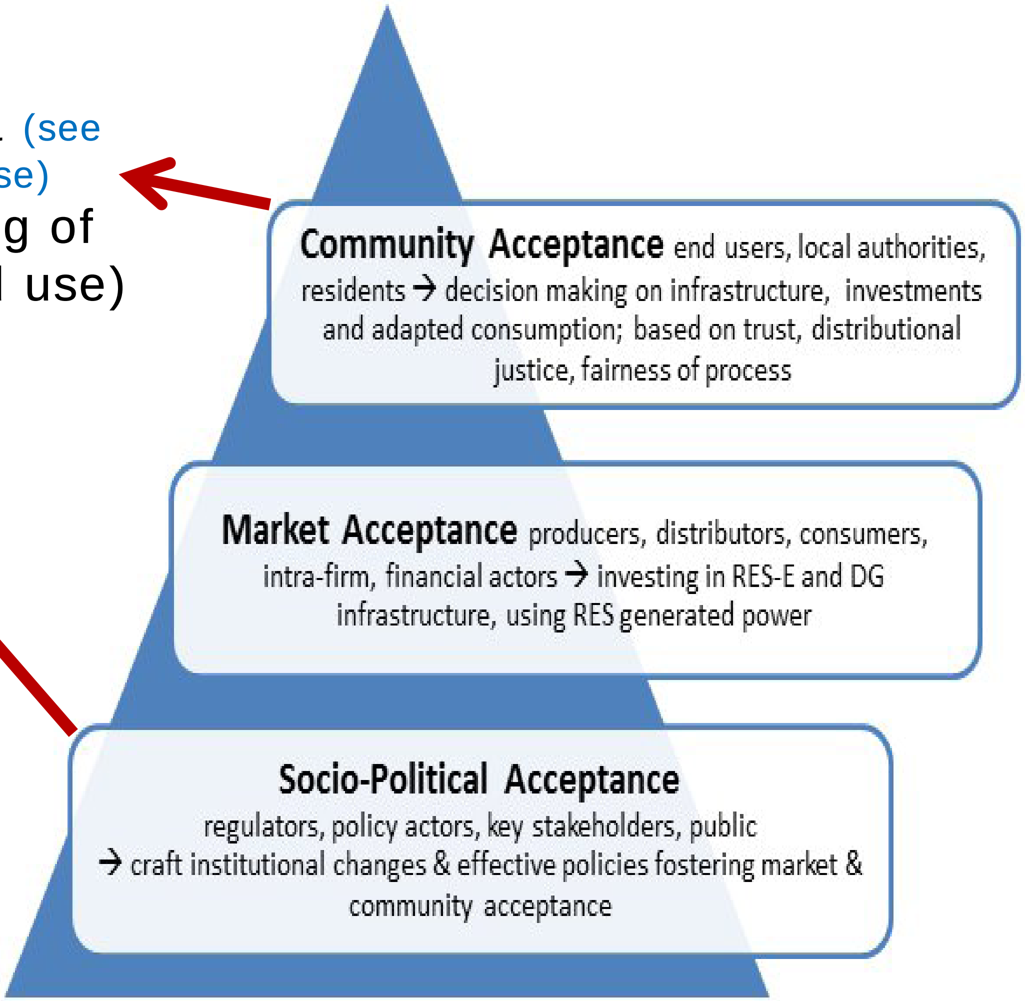


Social acceptance in innovation examples (among many others)

Elements such as

- ‘sustainable community agenda (see Hadfield-Hill, Local Environment, this course)
- anything about design and siting of infrastructure (communities’ land use)

(Wolsink 2012 *Encycopedia)*

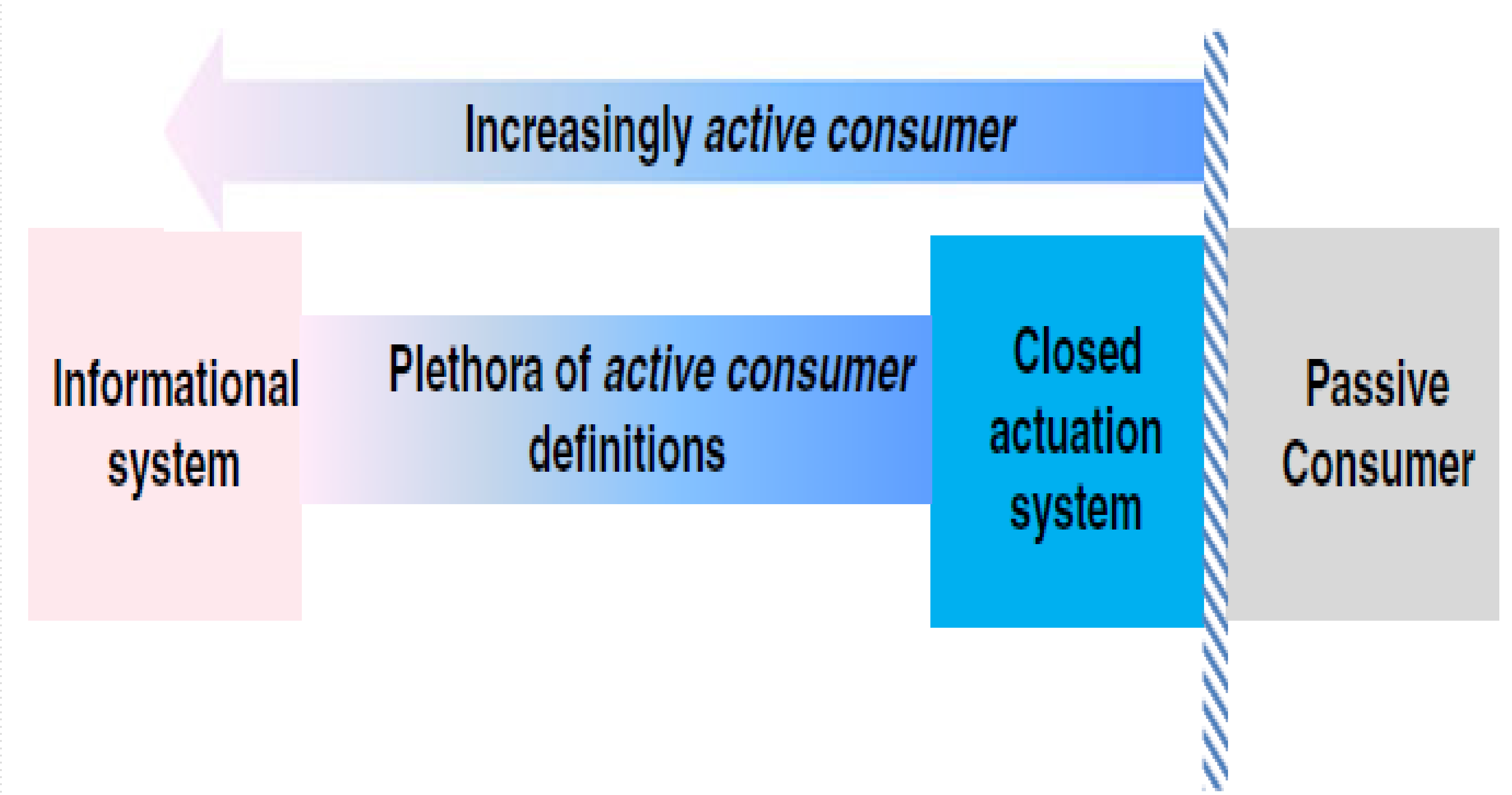


Elements such as

- fully restructured power supply system (STS)
- intitutional change in planning systems (redefining decision making on land use) opening acceptable options for RES and DG/microgrid infrastructure

(Wolsink 2012 *Encycopedia)*

Acceptance of what? Acceptance by whom?
- 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

Social integration and acceptance of renewable energy innovations: Power Supply system is an entirely new Socio-Techinical System

- Among policy makers, developers, power companies etc. huge misunderstanding of
  - what social acceptance really is
  - the essential necessity of engagement of the communities involved
- High potential acceptance of RE can only be realized within institutional frame of **self-governance** and **polycentric governance**
- **Institutitions** (def) behavioural patterns as determined by societal rules; "the rules of the game in society"

North D, 1991. *Institutions, Inst Change and Econ Perform.* Cambridge University Press.

Centralized, large scale; high infrastructure cost; continued of dependance (example Desertec)

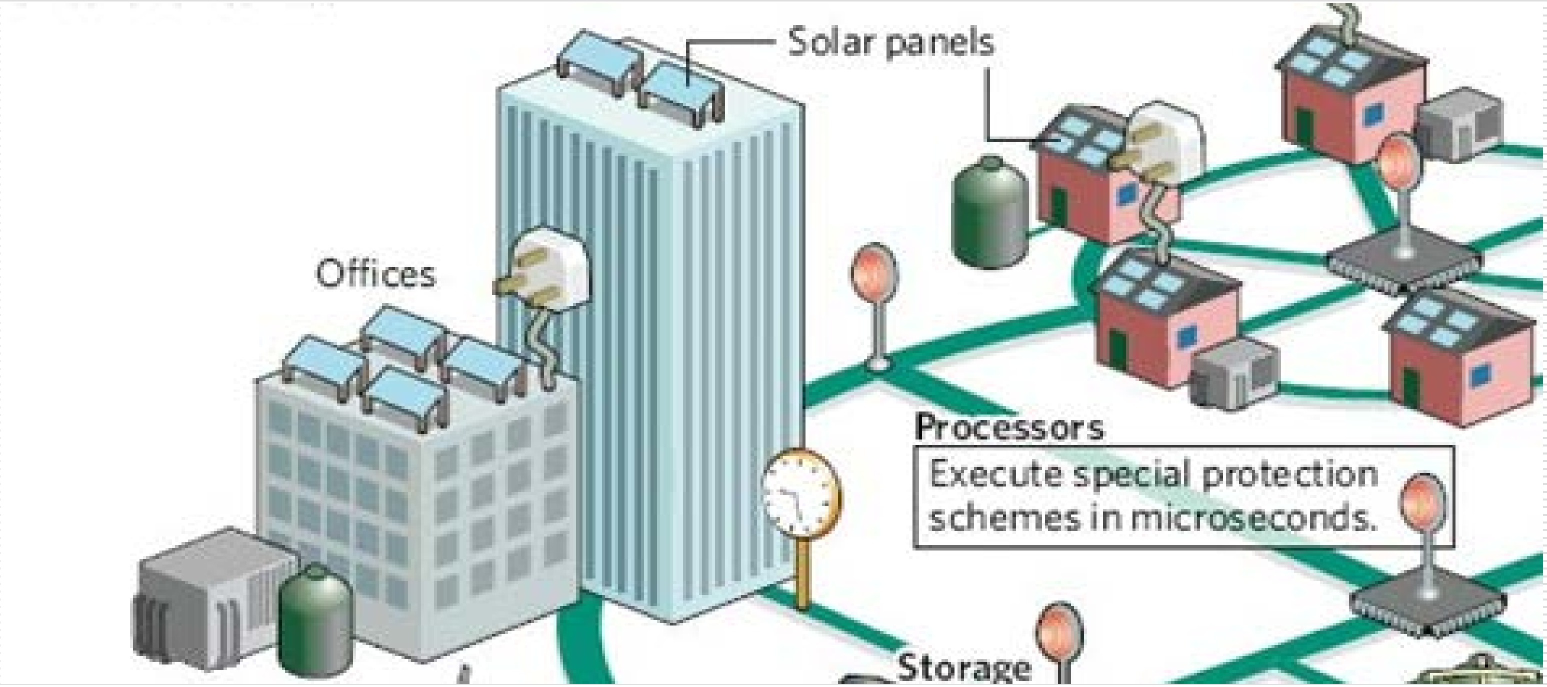
→ Self/polycentric governance (Ostrom) for all land use issue related to DG
example: landscape values & perceptions

- Resource is NOT scarce, scarcity is space needed for generation and distribution (McKay 2008)
- Number of required infrastructure units are greater in number, affecting more people and more landscapes (Nadaï & van der Horst, 2010; Wolsink, 2012)
- Energy infrastructure developments may threaten citizens' existing subjective connections to the landscape (Bell et al 2013; Devine-Wright, 2009; Wolsink, 2007).
- Landscape implications of community outsider's energy infra results in social opposition continuing to arise (Pasqualetti, 2011; Walker, et al, 2014)
- Energy landscape represent innovation, sustainability and positive environmental health; symbolism may drive cultural acceptability (McLachlan, 2010)

Acceptance of RES (wind power, solar, ocean, geothermal)
Fit to *local identity in the eyes of the community*

- Landscape AND social identity (cognitive/cultural)
- Fit to the landscape, determined mainly by the choice of the site
- Identity as experienced by local community
- ‘Objective landscape characteristics’ are affecting identity only after a process of PERCEPTION
- Embedding wind development in local economy
- Socio-economic benefits for community
- Fair decision making (environmental justice); exclusion causes trouble !!
- Local options for investments, from ownership or shareholdership to symbolic ‘sense of ownership’
- → current spatial planning institutional barrier

land use issues related to DG
2nd example: in CPR management crucial: resource rights



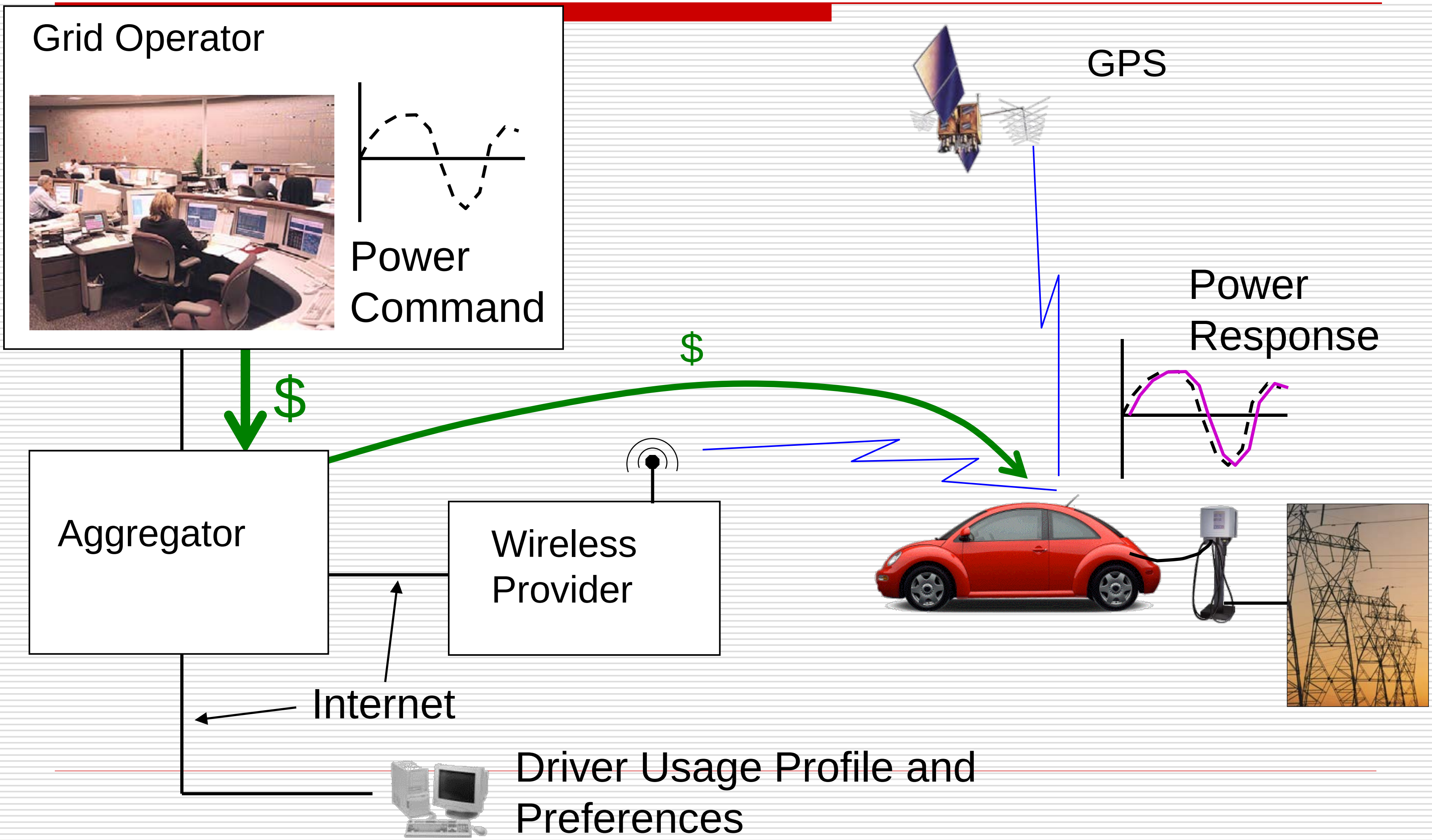
Meaning of 'space' and ownership of land changes.
- Integratating land use with generating power
- fully depending on local ecology, culture, and social-technical system (Schlager & Ostrom, 1992).

Governance of Energy supply: idea of DG counter to centralized planning and supply *Example* V2G integration

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

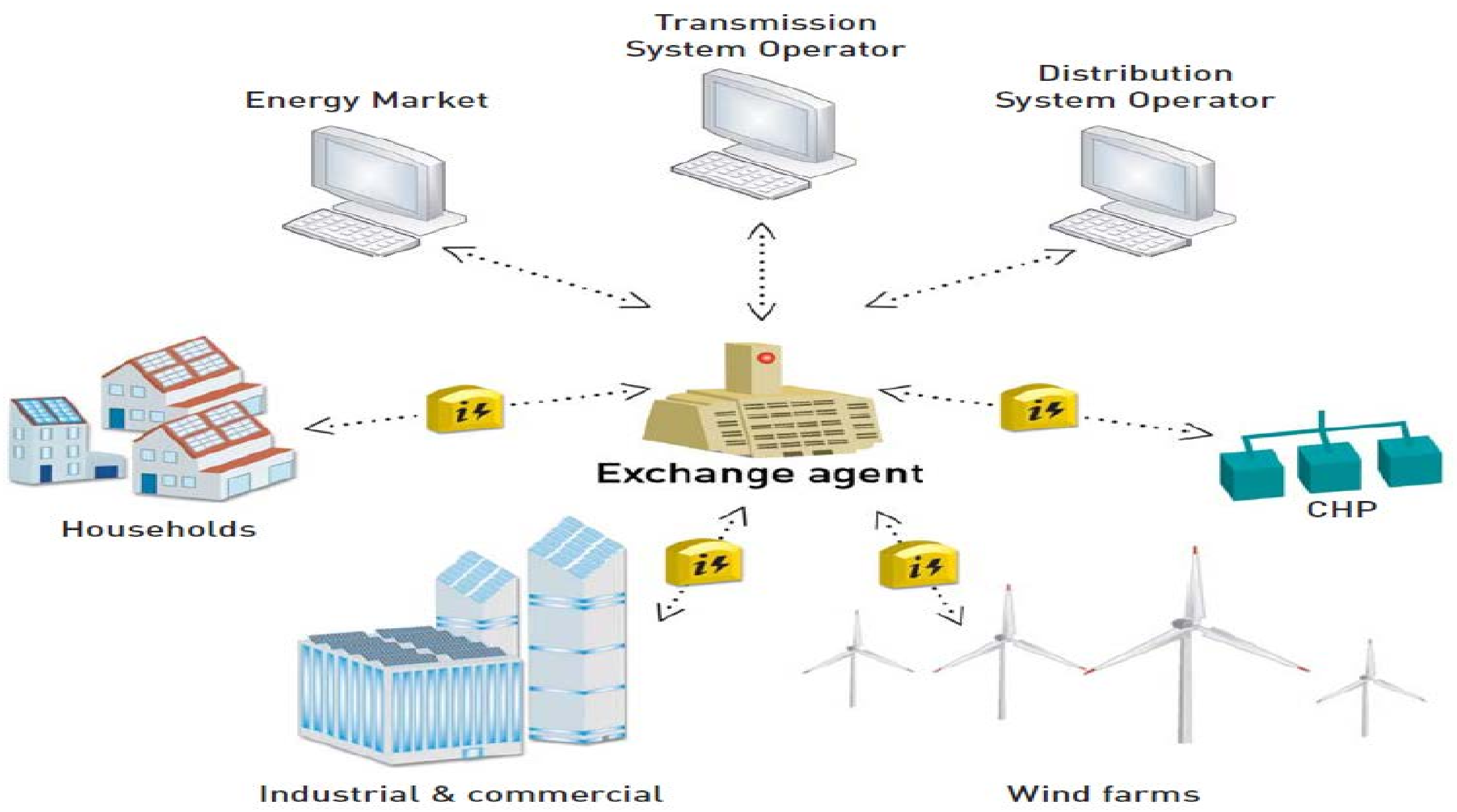
Verzijlbergh et al, 2014

Grid Regulation with an EV
Centralized vision

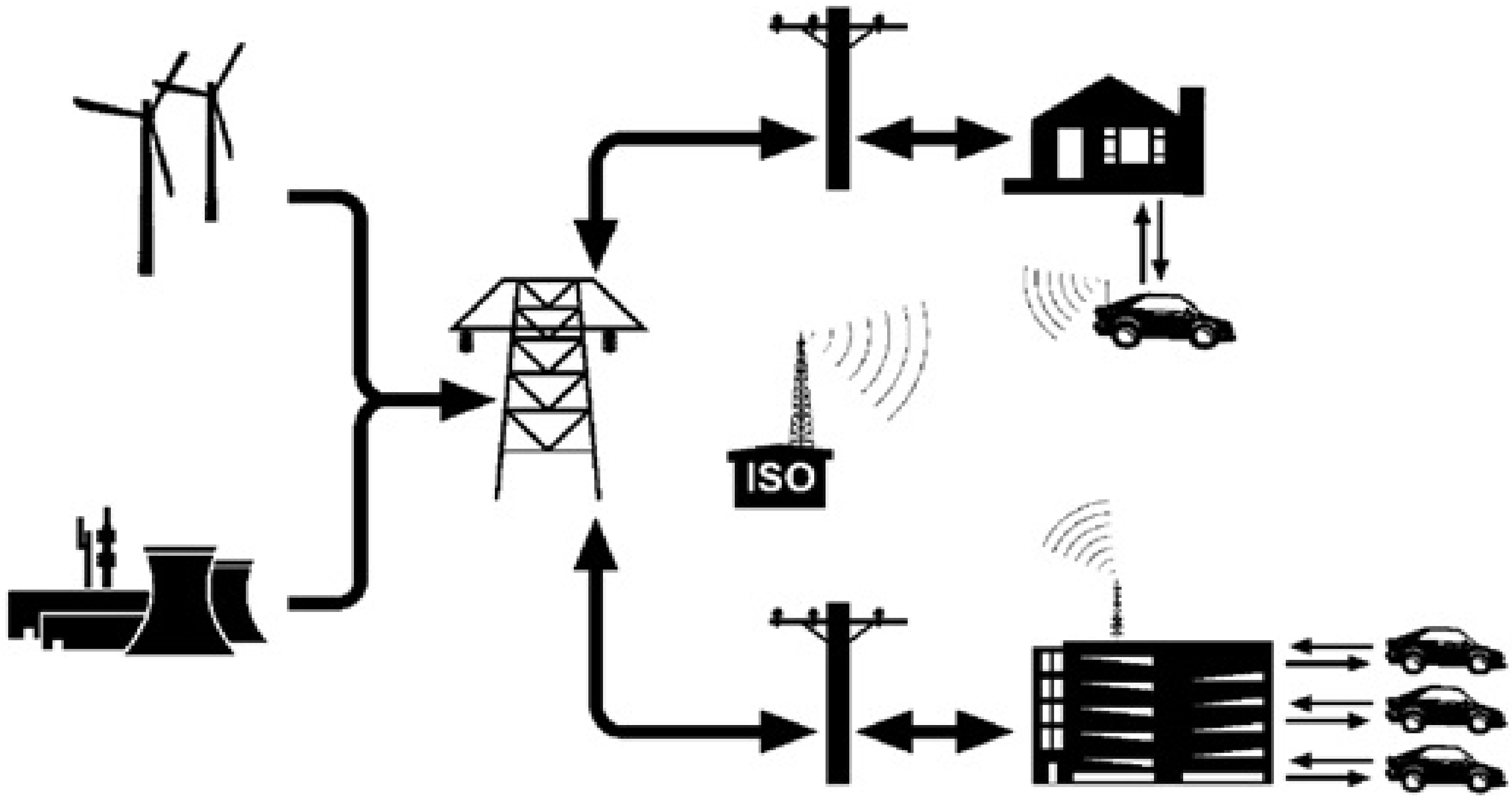


Remember previous slide on the EU vision still 'locked-in' in centralized thinking

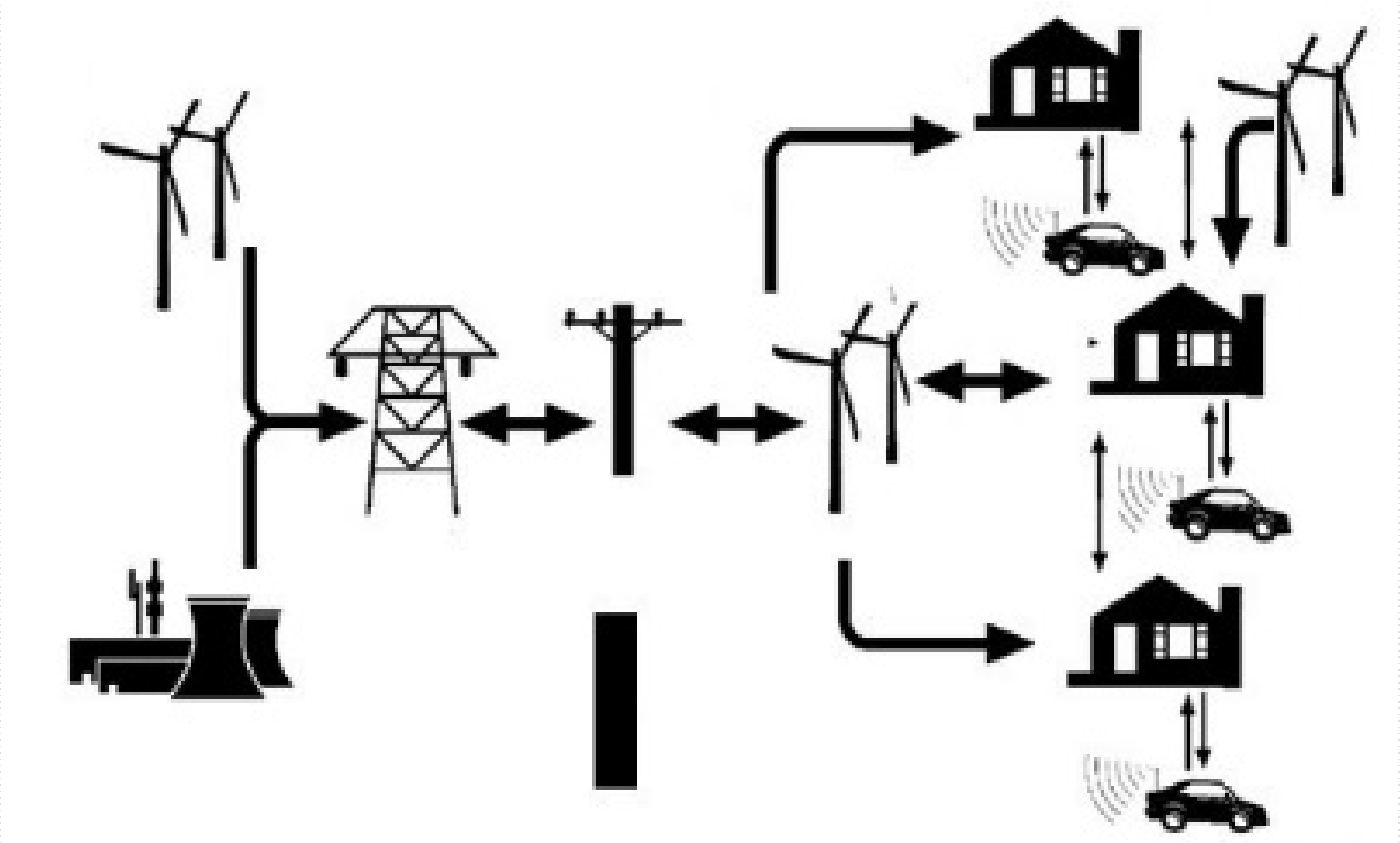
whereas DG is by definition not centralized



V2G Centralized vision

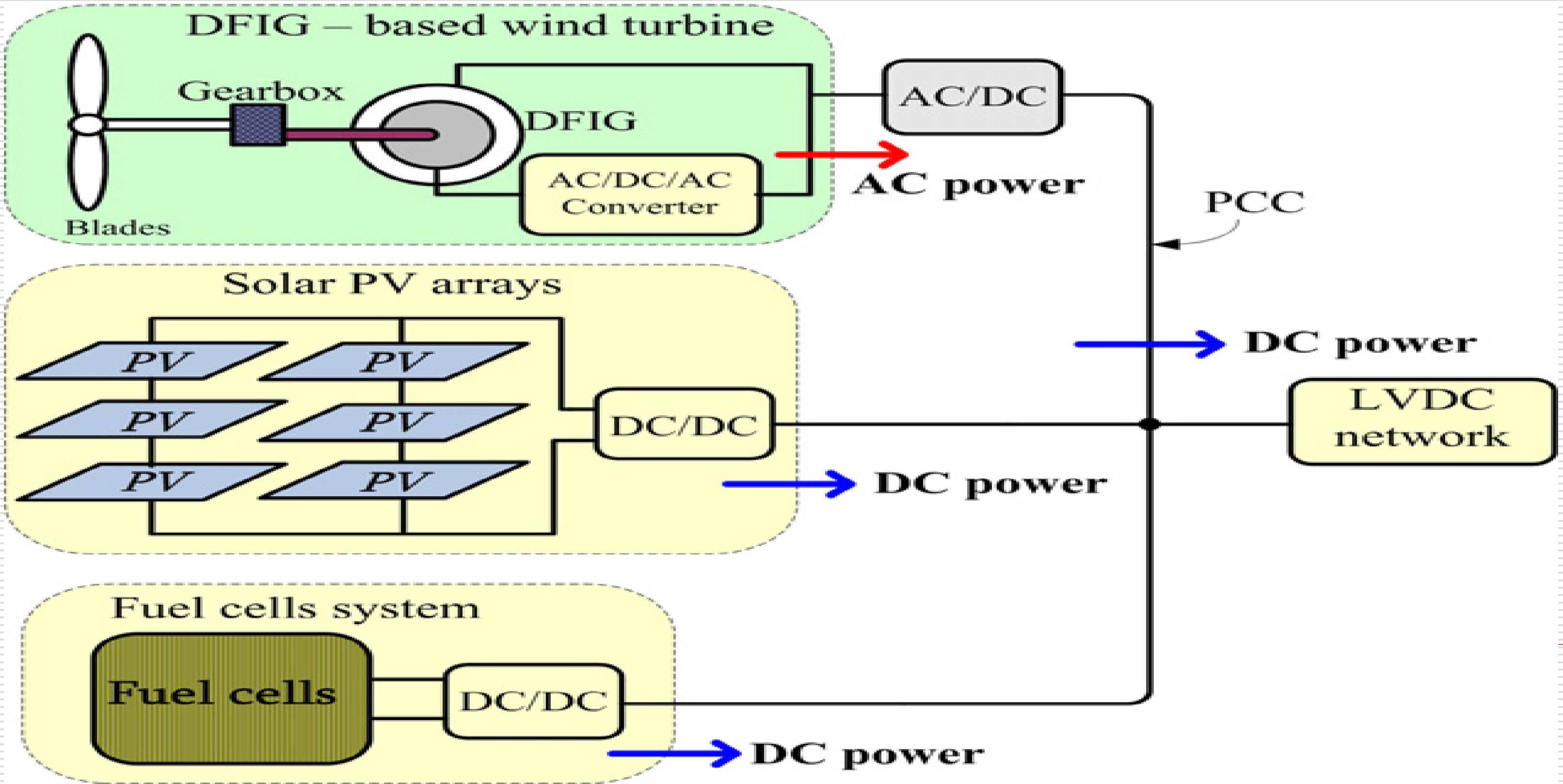


V2G: *Prosumer vision:* storage V2G helps RE integration in microgrid; enhancing acceptance and limiting transmission



intermezzo: (not in presented in lecture, but illustrating an answer on a question raised in class: example of intitutionalized, hierarchical standardization in power supply. DG units with LowVoltage DC network [Justo et al. 2013, 390]

Supply system based on AC 220V is not 'best technical, most efficient' but a decision based on a battle about market power (see Unruh, 2000) In microgrid it may become more rational to use DC generated power not first to invert to 220 V 50 Hz AC, and then for applications back to low voltage DC (e.g. 20V of 6V), increasingly needed for our appliences.



conclusions

- RES options: more socially acceptable → DG
- Central as backup *only*
- Huge variety among, and within systems
- Socio-Technical Systems (STS)
- Microgrid relates to a (co-operating) community
- Like SES → variety and complexity
  Accept Complexity as merit (also see Geldof this course)
- More resilient → Better adaptive capacity
  No hierarchy (creaes complications, destroys trust)
- Furthering co-production → co-operation
- Self governance in systems
- Polycentric governance; Adaptive governance

Thank you

References

Ackermann et al. (2001) Distributed generation: a definition. *Electric Power Systems Research* 57, 195–204

Bell, D., Gray, T., Haggett, C., & Swaffield, J. (2013). Re-visiting the “social gap”: public opinion and relations of power in the local politics of wind energy. *Environmental Politics*, *22*(April 2015), 115–135.

Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology*, *19*(6), 426-441.

Justo JJ, Mwasilu F, Lee J, Jin-Woo Jung J-W (2013) AC-microgrids versus DC-microgrids with distributed energy resources: A review. *Renew Sust Energ Reviews* 24, 387–405

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research policy*, *33*(6), 897-920

Haidar AMH, Muttaq K, Sutanto D (2015) Smart Grid and its future perspectives in Australia. Renewable and Sustainable Energy Reviews 51(2015)1375–1389

Justo, J. J., Mwasilu, F., Lee, J., & Jung, J. W. (2013). AC-microgrids versus DC-microgrids with distributed energy resources: A review. *Renewable and Sustainable Energy Reviews*, *24*, 387-405.

Lund H (2010) The implementation of renewable energy systems. Lessons learned from the Danish case. *Energy* 35, 4003-4009.

Lehmann, P., Creutzig, F., Ehlers, M. H., Friedrichsen, N., Heuson, C., Hirth, L., & Pietzcker, R. (2012). Carbon lock-out: advancing renewable energy policy in Europe. *Energies*, *5*(2), 323-354

MacKay DJC (2008) *Sustainable Energy – without the hot air.* UIT Cambridge.

McLachlan, C. (2009). Technologies in place: symbolic interpretations of renewable energy. *The Sociological Review*, *57*(s2), 181-199.

Mengolini, A., Vasiljevska, J. (2013). *The social dimensions of Smart Grids – Consumer, community, society.* JRC scientific and policy reports, European Commission.

Marris E (2008) Upgrading the grid. *Nature* 454: 570-573

Nadaï, A., van der Horst, D. (2010). Introduction: Landscapes of Energies. *Landscape Research*, *35*(2), 143–155.

Ostrom E (1999). Coping with tragedies of the commons. *Annual Review Political Science* 2, 493

Pasqualetti, M. J. (2011). Opposing Wind Energy Landscapes: A Search for Common Cause. *Annals of the Association of American Geographers*, *101*(4), 907–917.

Peacock AD, Owens, EH (2014). Assessing the potential of residential demand response systems to assist in the integration of local renewable energy generation. *Energy Efficiency* 7, 547-558.

Römer B, Reichhart P, Picot A (2014) Smart energy for Robinson Crusoe: an empirical analysis of the adoption of IS-enhanced electricity storage systems. *Electron Markets*, in press.

Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: a conceptual analysis. *Land economics*, 249-262.

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy policy*, *28*(12), 817-830.

Verzijlbergh R et al. (2014) Does controlled electric vehicle charging substitute cross-border transmission capacity? *Applied Energy* 120, 169-180

Walker, B. J., Wiersma, B., Bailey, E. (2014). Community benefits, framing and the social acceptance of offshore wind farms: an experimental study in England. *Energy Research & Social Science*, *3*, 46-54.

Wolsink, M. (2007). Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy policy*, *35*(5), 2692-2704.

Wolsink, M. (2012). Wind power: basic challenge concerning social acceptance. *Encyclopedia of sustainability science and technology.-Volume 17*, 12218-12254.

Wolsink, M. (2012) The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renew Sust Energ Reviews* 16, 822–835.

Wüstenhagen R, Wolsink M, Bürer MJ (2007) Social acceptance of renewable energy innovation. *Energy Policy* 35, 2683-2889