Neighbourhood Microgrids with Distributed Energy Systems

Coproduction of Renewables as a Polycentric Governed Natural Resource

19 November 2021
Strassbourg

Seminar
Cities and Energies in Europe

Maarten Wolsink

DebWo
Independent Research

University of Amsterdam
Department of Geography

Renewable Energy: *"Distributed Generation"* ~ focus on electricity, geography is key

- Micro/decentralized generation:
  * PV (PhotoVoltaics)
  * micro CHP (prudential: biofuels, bio-waste)
  * onshore wind
  * geothermal, hydro (prudential), tidal etc.
  * links to (low-heat) networks
- Small scale, spatially dispersed
- Spatial claims renewables: "huge"
  MacKay DJC 2008; Smil
- Variable sources, highly affected by geography
- Multiple scales → geographical / governance / polycentric (not simply 'decentral')

Definition DES - Distributed Energy Systems

Distributed Generation is

- an *electric power source*
- connected directly to *the distribution network*
- or on *the customer side of the meter*

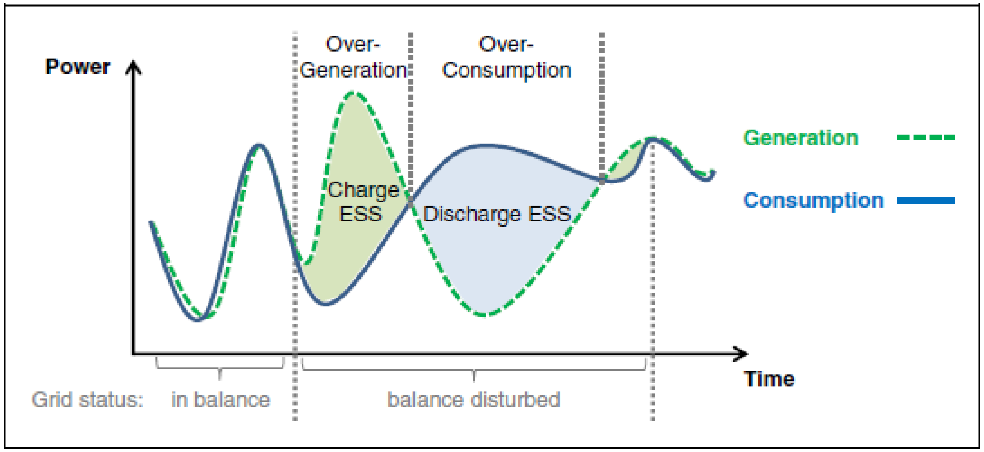
Ackermann et al 2001

Same applies to

- Power *Storage* systems
- *Management systems* of Flows and Capacities
- *Accounting* systems

RES-based Power Supply requires acceptance of
- integration of different variable supply patterns
- integration and adaptation demand patterns

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



- Development of (local) micro-grids,
  - several ‘prosumers’ in a 'community'
  - load-control *(DR supporting DG, not central)*
  - including local storage (e.g. EV’s)
- Smart meters (beyond current ‘Linky’ type) *(supporting ‘prosumers’ and ‘micro-grid’, **not** central power capacity)*

"Smart Grid‟: Buzz-word "Smart" is highjacked: heavy policy frame

- "Power grid consisting of a network of integrated micro-grids that can monitor and heal itself"
  Marris (2008) Upgrading the grid. Nature 454: 570-573
- Fundamental question Social Acceptance process: *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 less sustainable generating capacity?

Social-Technical Systems

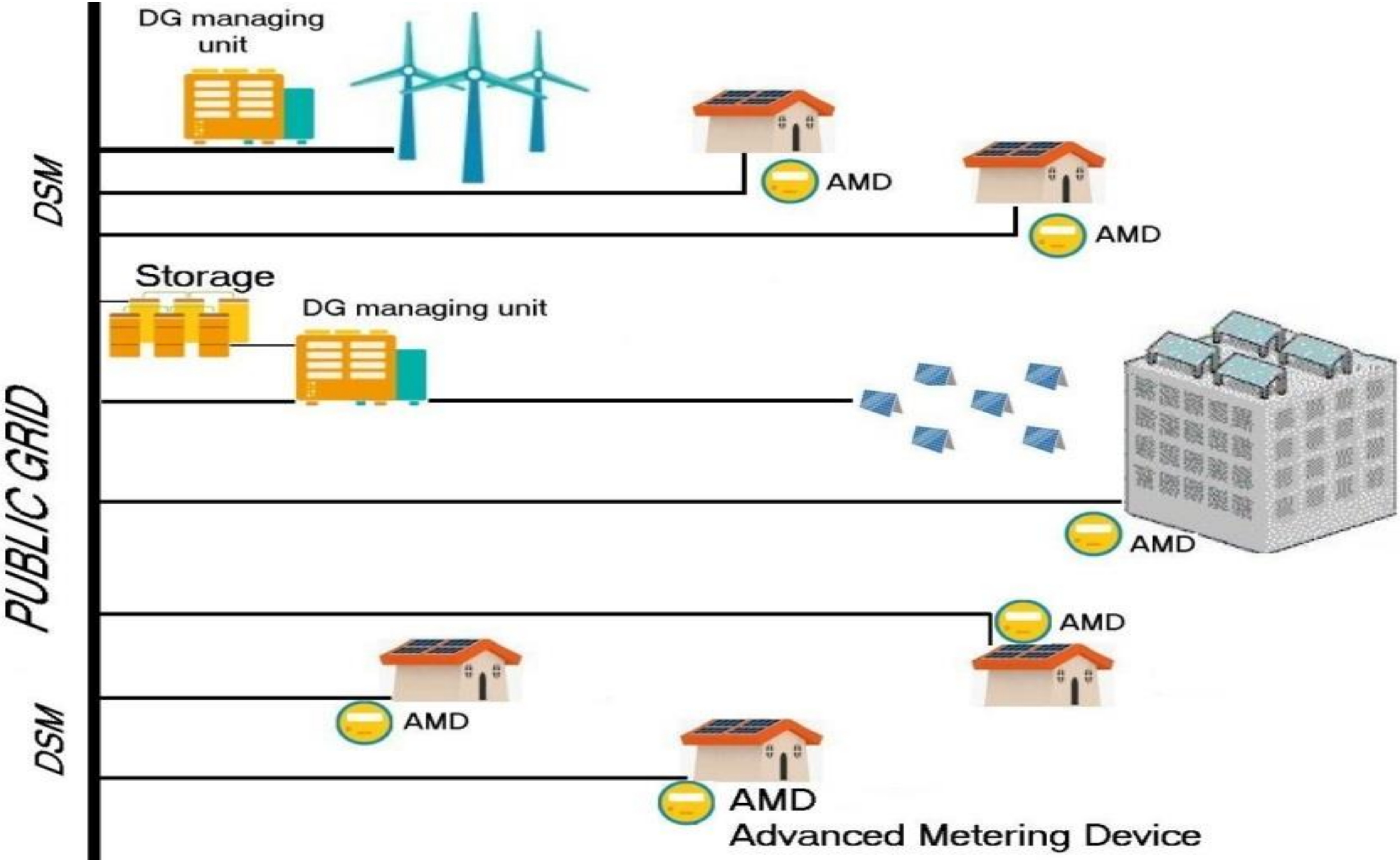
- Power supply system(s) is an STS
  def. *A system be made up of scientific and technological, as well as socio-economic and organizational components.*

- Transforming this STS into renewables based, zero-carbon is *innovation*….
  and hence, this includes social acceptance of
  ……… *creative destruction*
  ……….and *social innovation* Cajaiba-Santana 2014

- Key institutional innovation is:

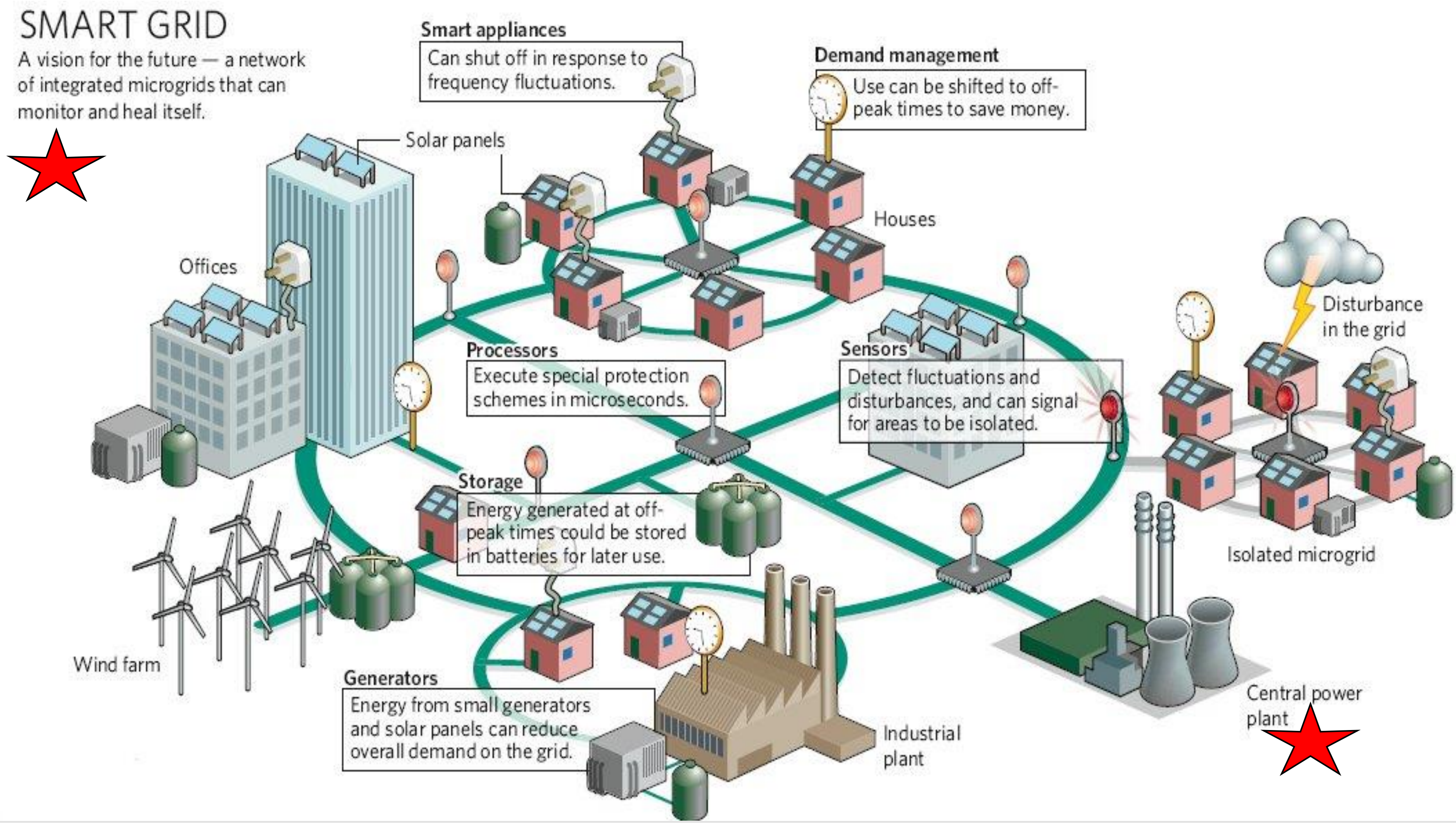
  Move the STS away from centralized design & hierarchical and centralized management

Centralized Grid connecting RES, storage, DSM
Current model / Dominant discourse (in policy and e-sector)



Proces of Social Acceptance concerns all decisions about all elements – social design (pol., cult., econ.), techno design, space for infrastructures, design and control of ICT

Marris 2008, Wolsink 2012



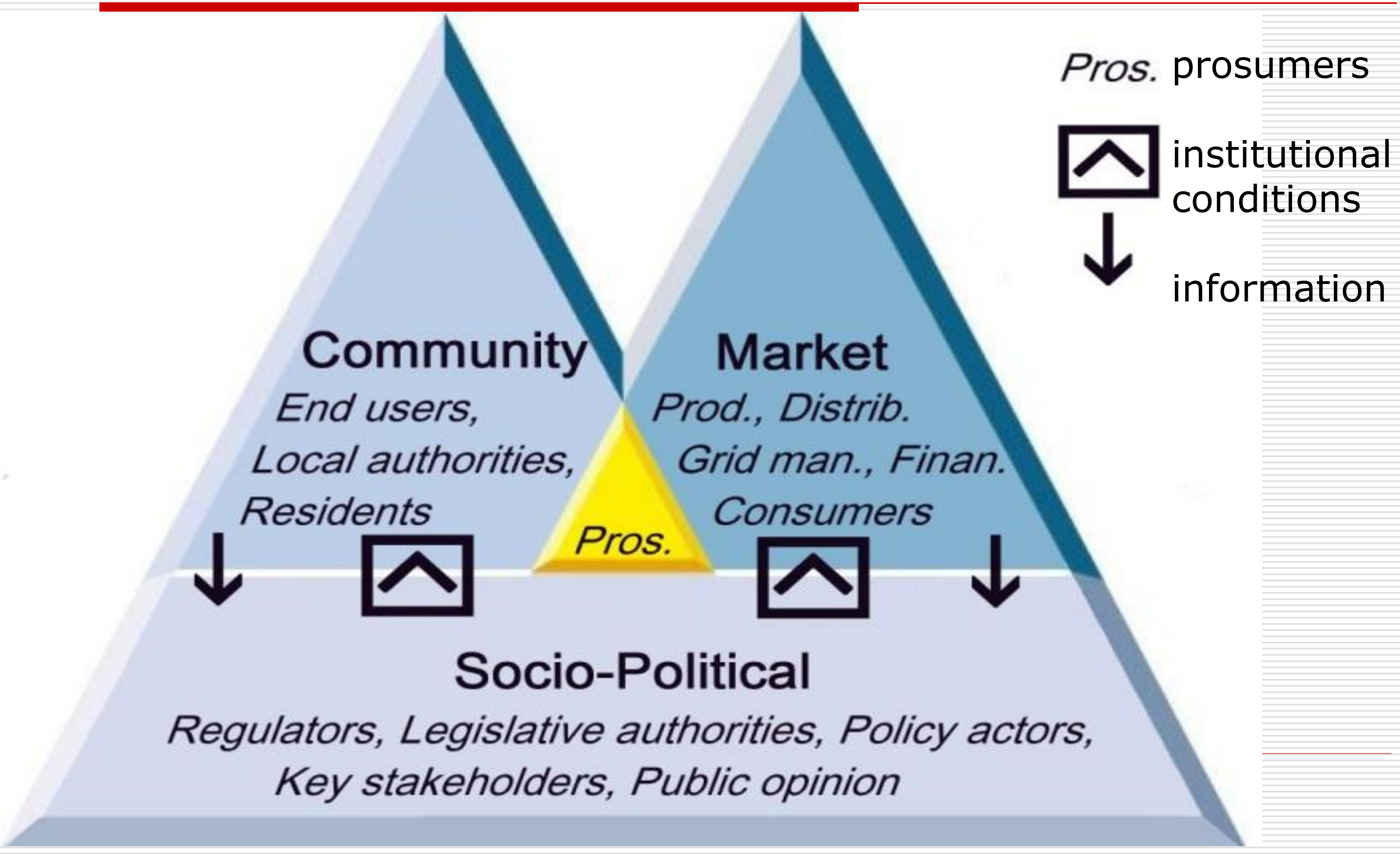
As geographical conditions are key, what about urban environments?

- How to achieve acceptance of DES in cities… and for cities?
- Energy use : +/- 67% world energy demand
- Greenhouse gas emissions: cities responsible for >70% world CO_2 emissions
- Land use of cities +/- 2% land surface

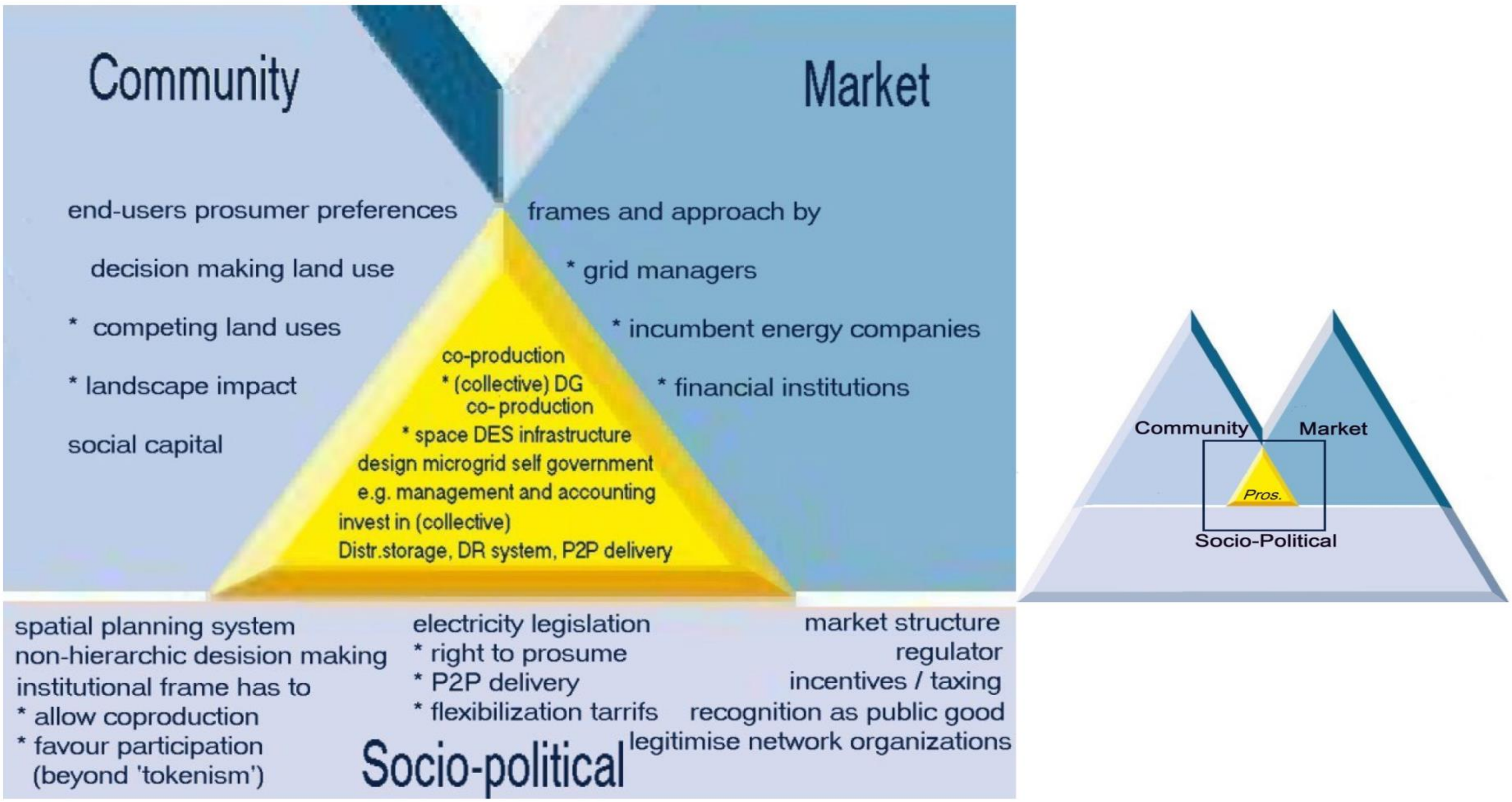
For RE 'space' is the prime scarcity factor
→ the geography of Distributed Energy Systems is crucial
→ high tension for urban areas

Social Acceptance of RE innovation

Wüstenhagen et al. 2007; Wolsink, 2018



Zooming in Distributed Energy Systems & prosumers



Wolsink, 2019

Figure 2. Social Acceptance of Distributed Energy Systems with 'prosumers' (Left); featured framework from base scheme (right) of the multi-layered SA conceptualization by Wolsink [4, p.291]


Community
Market
end-users prosumer preferences
decision making land use
* competing land uses
* landscape impact
social capital
frames and approach by
* grid managers
* incumbent energy companies
* financial institutions
co-production
* (collective) DG
co-production
* space DES infrastructure
design microgrid self government
e.g. management and accounting
invest in (collective)
Distr.storage, DR system, P2P delivery
spatial planning system
non-hierarchic desision making
institutional frame has to
* allow coproduction
* favour participation
(beyond 'tokenism')
electricity legislation
* right to prosume
* P2P delivery
* flexibilization tarrifs
market structure
regulator
incentives / taxing
recognition as public good
legitimise network organizations
Socio-political

For DES: Social Acceptance becomes issue of governance of *Common Pool Resources*

Social acceptance of renewables' innovation is the process of organizing 'co-production'
Ostrom, 1996; Wolsink 2018a

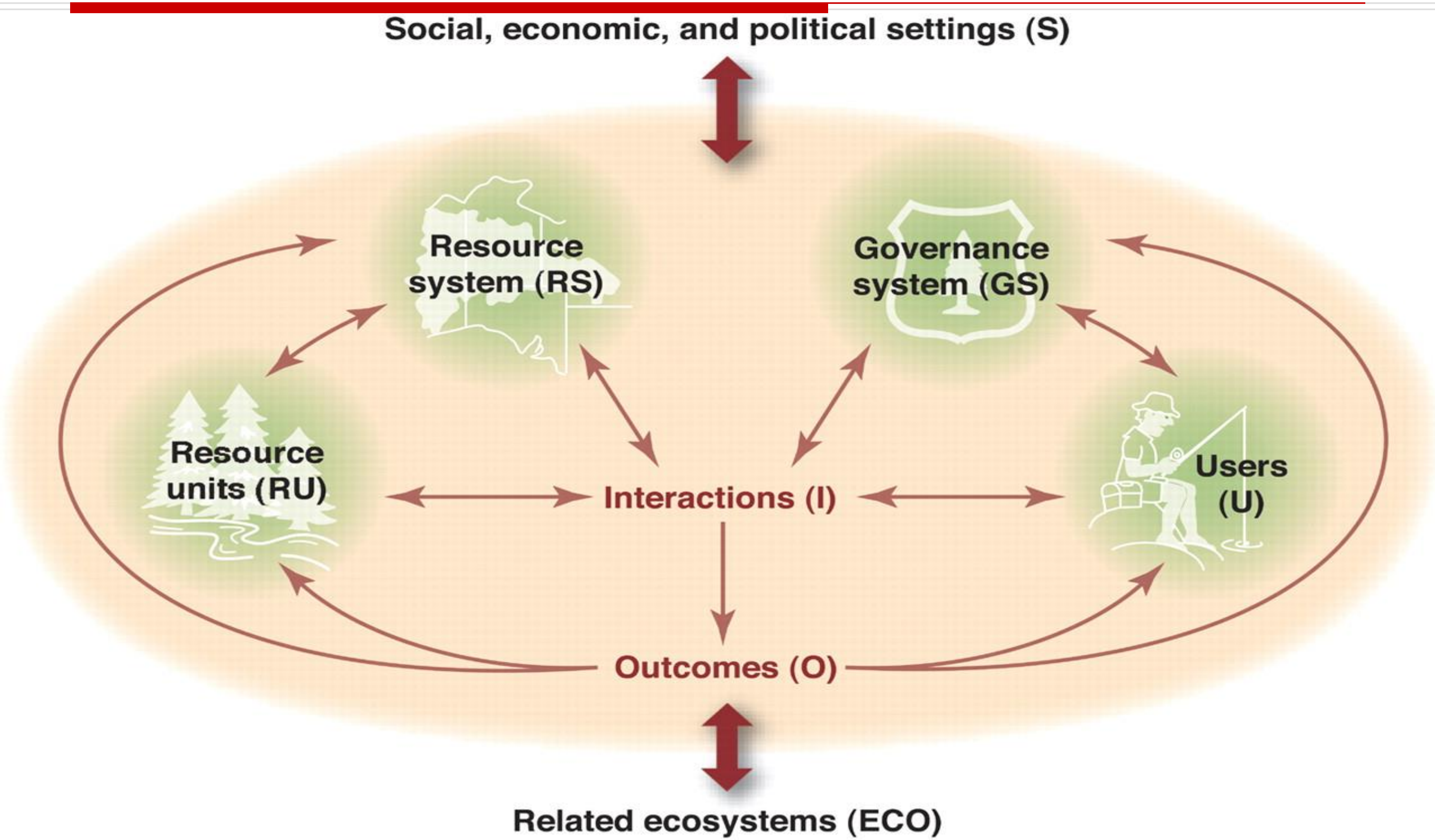
How to organize cooperation in varying SES (Social Ecological Systems ←→ STS's)

- among multi-level actors (community, market, policy making)
- to establish, maintain, operate
- STSs of shared power supply and shared use
- Fed with natural resources of renewables

Co-production in DG and DES

- \- in establishing shared infrastructure: investing, collectively or individually
- \- in cooperation to make required space available / land use for infrastructure / different kinds of property Schlager & Ostrom, 1992
- \- co-production, distribution and adaptation of consumption (DR) of electricity
- \- within urban space:
  * huge demand with high variation
  * limited and contested space
  * little competion with agicultural land use

General framework
Social Ecological Systems, 4 subsystems Ostrom, 2009



Ostrom’s SES framework, application for STS of DES microgrids Wolsink 2020

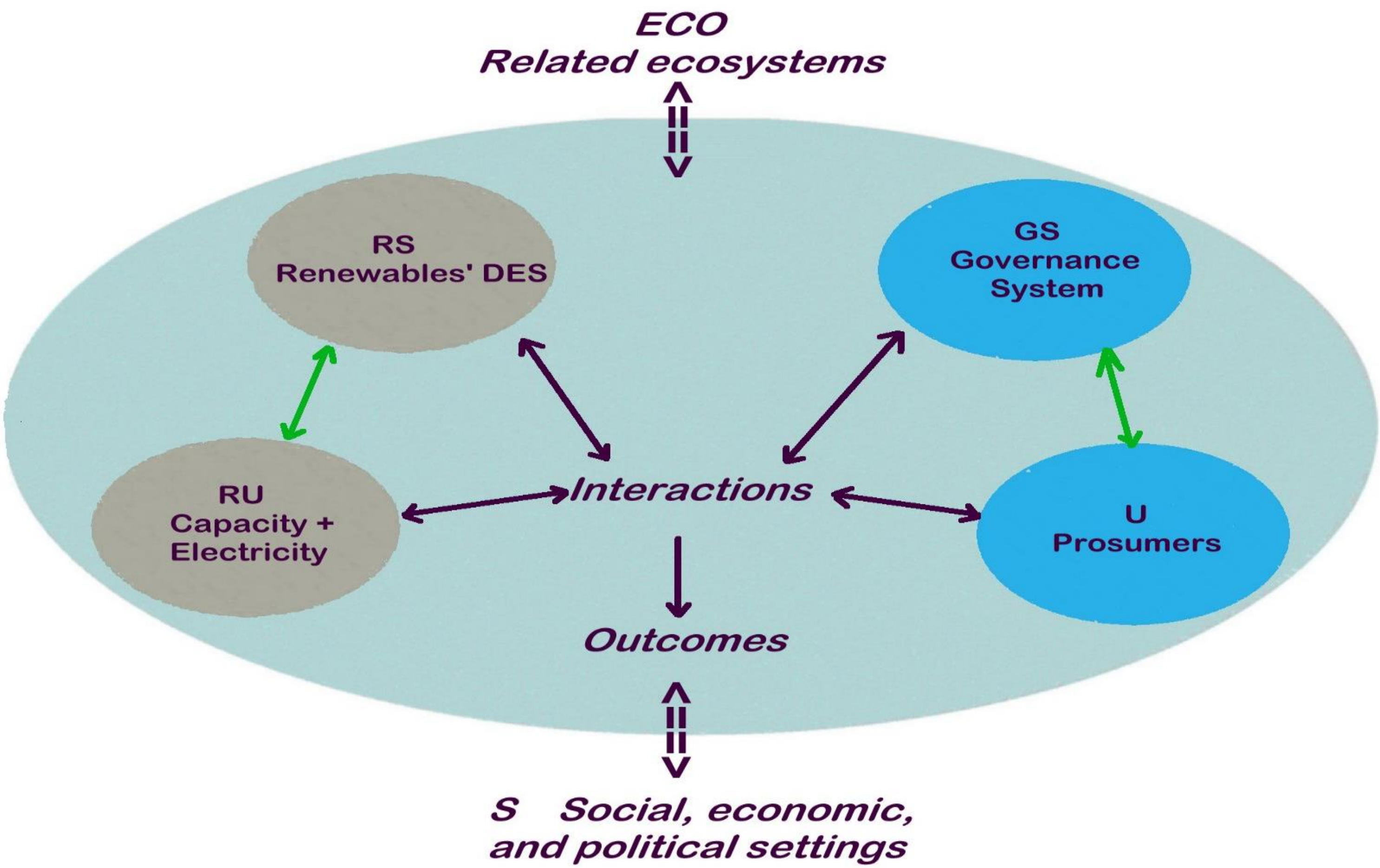


Table 1. Second-tier variables in framework for analyzing an SES

Social, Economic, and Political Settings (S)

S1- Economic development. S2- Demographic trends. S3- Political stability.
S4- Government settlement policies. S5- Market incentives. S6- Media organization.

Resource System (RS)

RS1- Sector (e.g., water, forests, pasture, fish)
RS2- Clarity of system boundaries
RS3- Size of resource system
RS4- Human-constructed facilities
RS5- Productivity of system
RS6- Equilibrium properties
RS7- Predictability of system dynamics
RS8- Storage characteristics
RS9- Location

Governance System (GS)

GS1- Government organizations
GS2- Non-government organizations
GS3- Network structure
GS4- Property-rights systems
GS5- Operational rules
GS6- Collective-choice rules
GS7- Constitutional rules
GS8- Monitoring & sanctioning processes

Resource Units (RU)

RU1- Resource unit mobility
RU2- Growth or replacement rate
RU3- Interaction among resource units
RU4- Economic value
RU5- Size
RU6- Distinctive markings
RU7- Spatial & temporal distribution

Users (U)

U1- Number of users
U2- Socioeconomic attributes of users
U3- History of use
U4- Location
U5- Leadership/entrepreneurship
U6- Norms/social capital
U7- Knowledge of SES/mental models
U8- Dependence on resource
U9- Technology used

Interactions (I) → Outcomes (O)

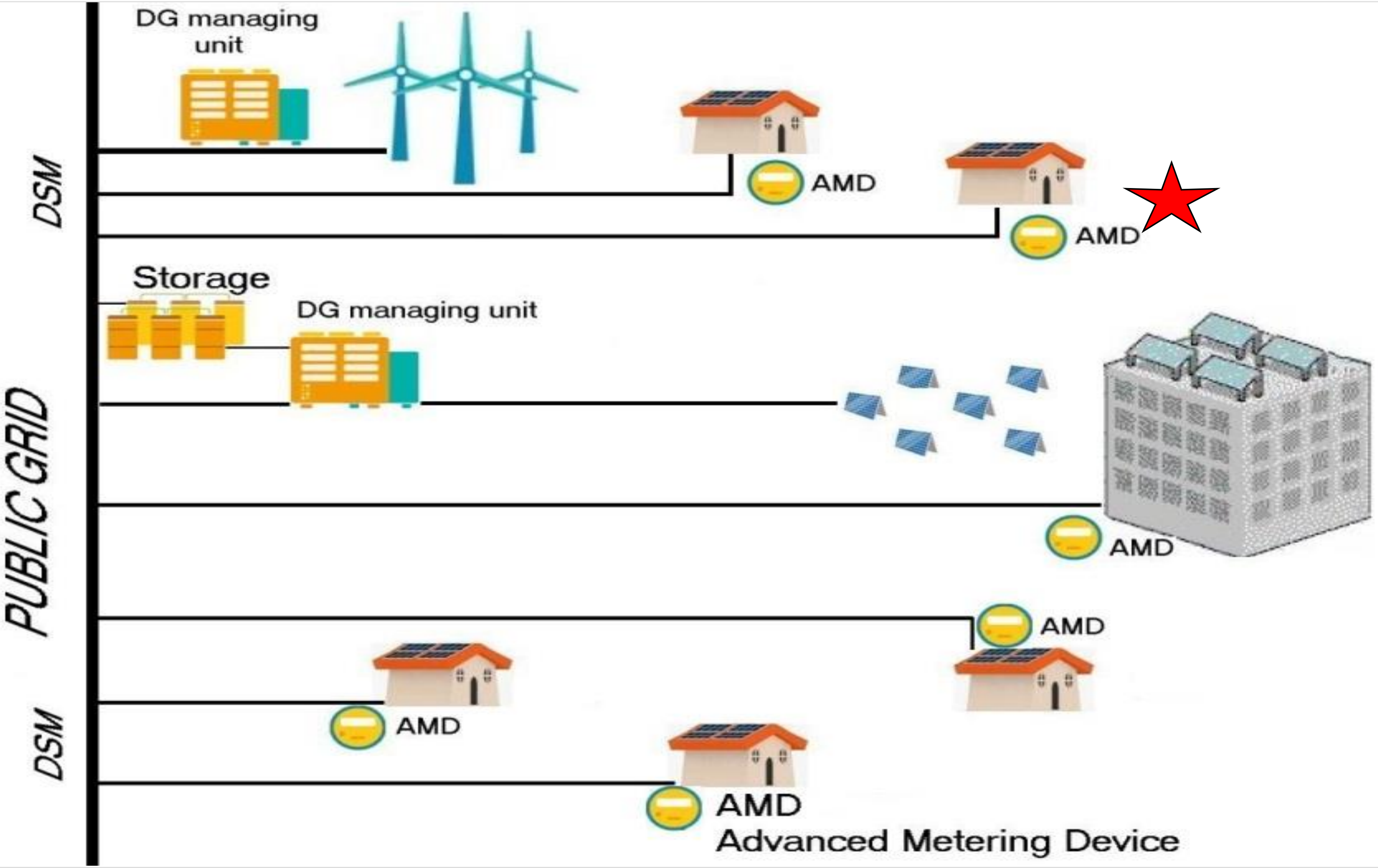
I1- Harvesting levels of diverse users
I2- Information sharing among users
I3- Deliberation processes
I4- Conflicts among users
I5- Investment activities
I6- Lobbying activities

O1- Social performance measures
(e.g., efficiency, equity, accountability)
O2- Ecological performance measures
(e.g., overharvested, resilience, diversity)
O3- Externalities to other SESs

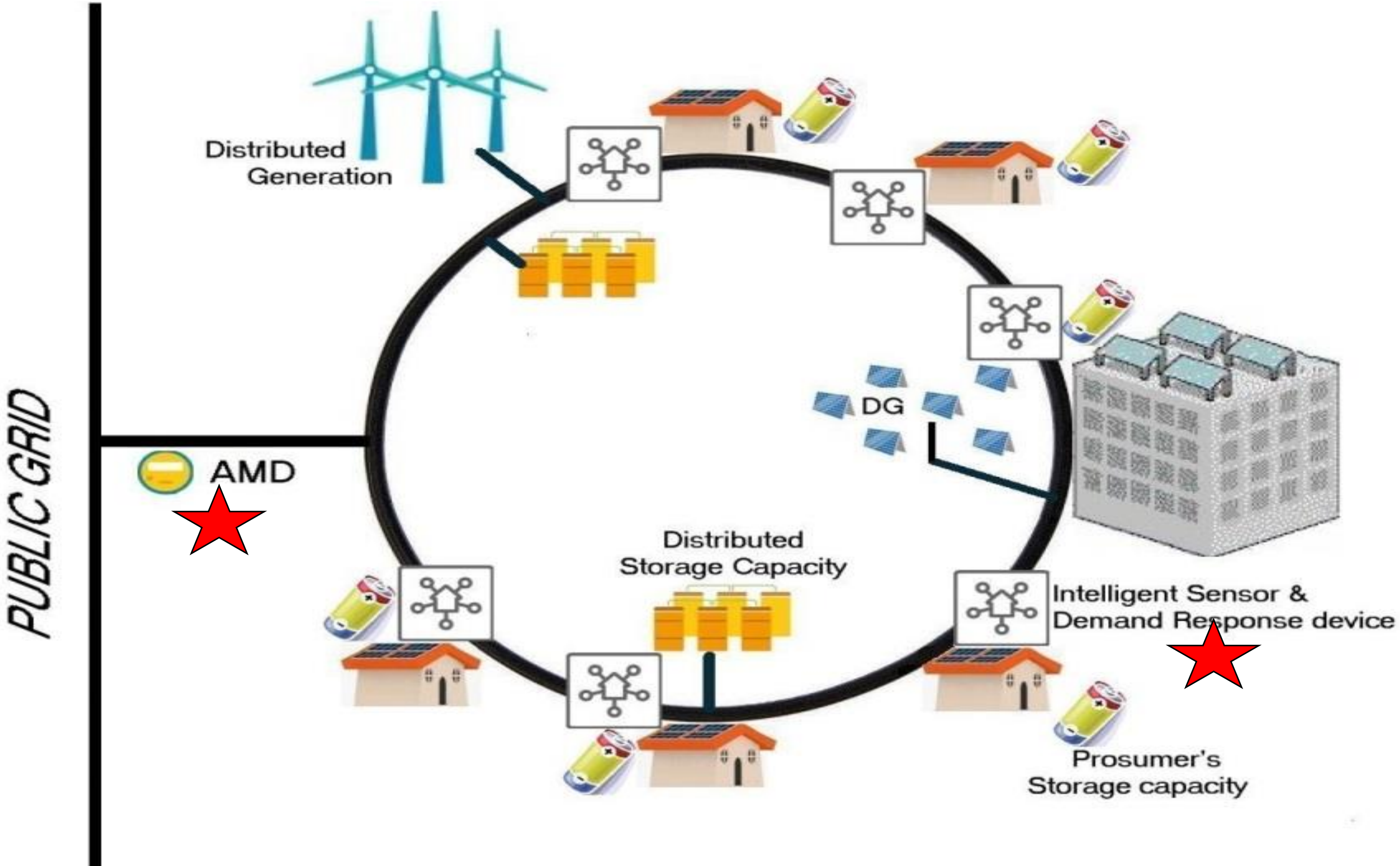
Fundamental features SES / STS

- Social-Ecological Systems exist with **huge variety**
(→ essentially geographical variety)
- Complex, almost never simple;
natural variety *and* social variety (pluralism, polycentrism)
- **Internal variety is good** (supports resilience)
- These notions run counter to common sense views,
…… widely held in policy, governments,
and among technocratics more broadly

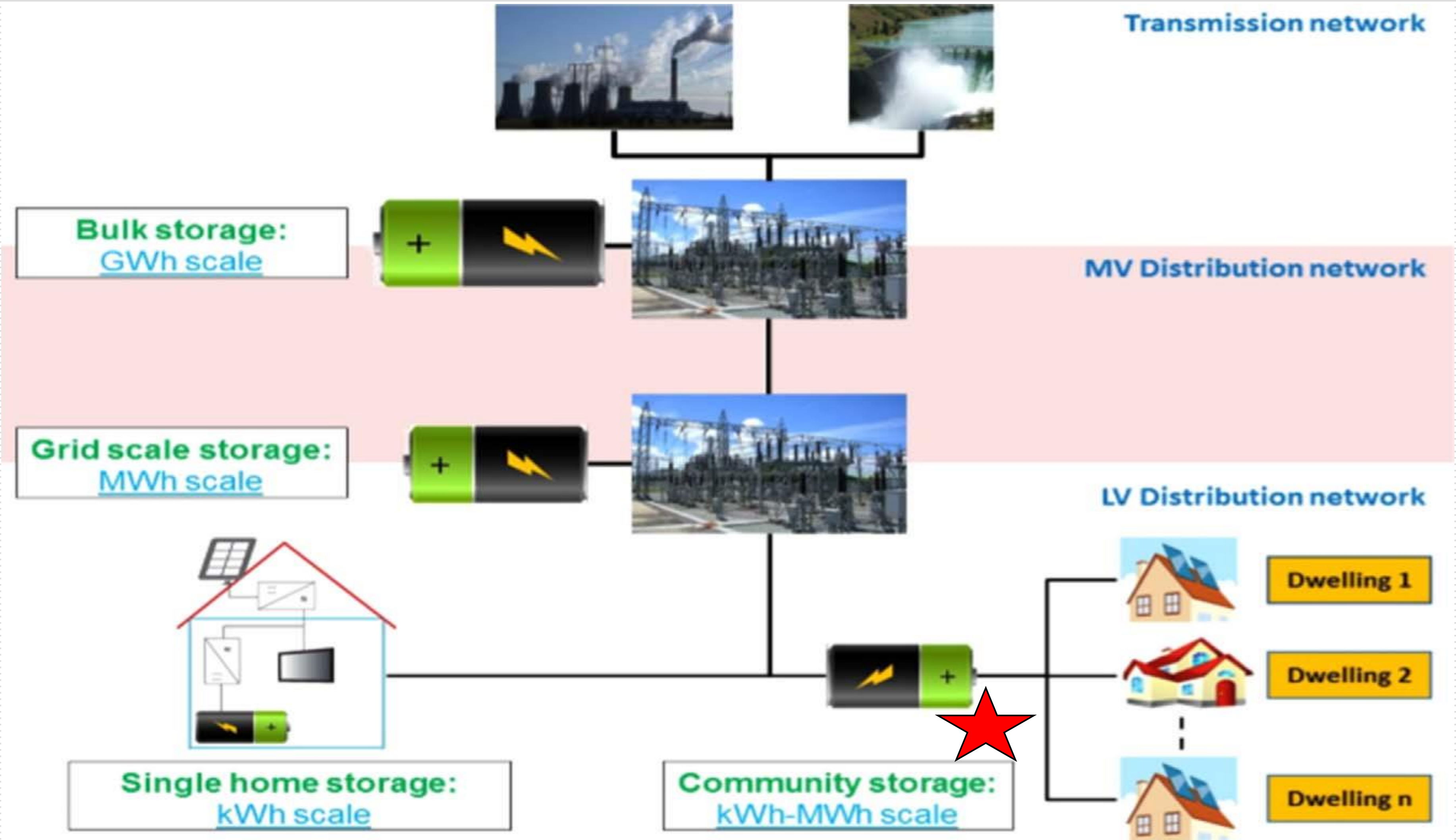
How to imagine co-production for this community ?



Intelligent Microgrid-community
DG, *co-production*, storage, internal DR

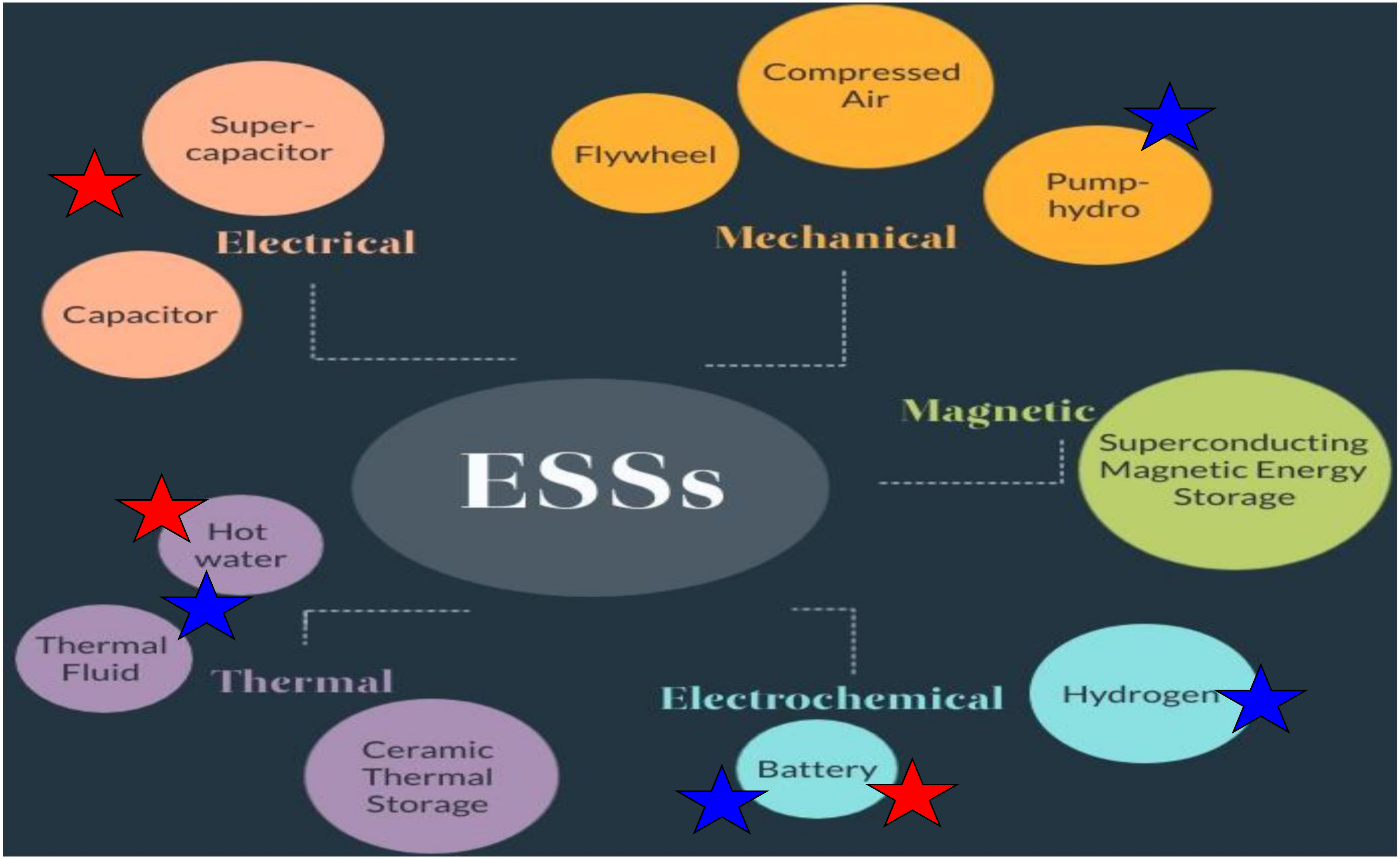


Example storage options in urban microgrids single building (home, offices etc.)and community

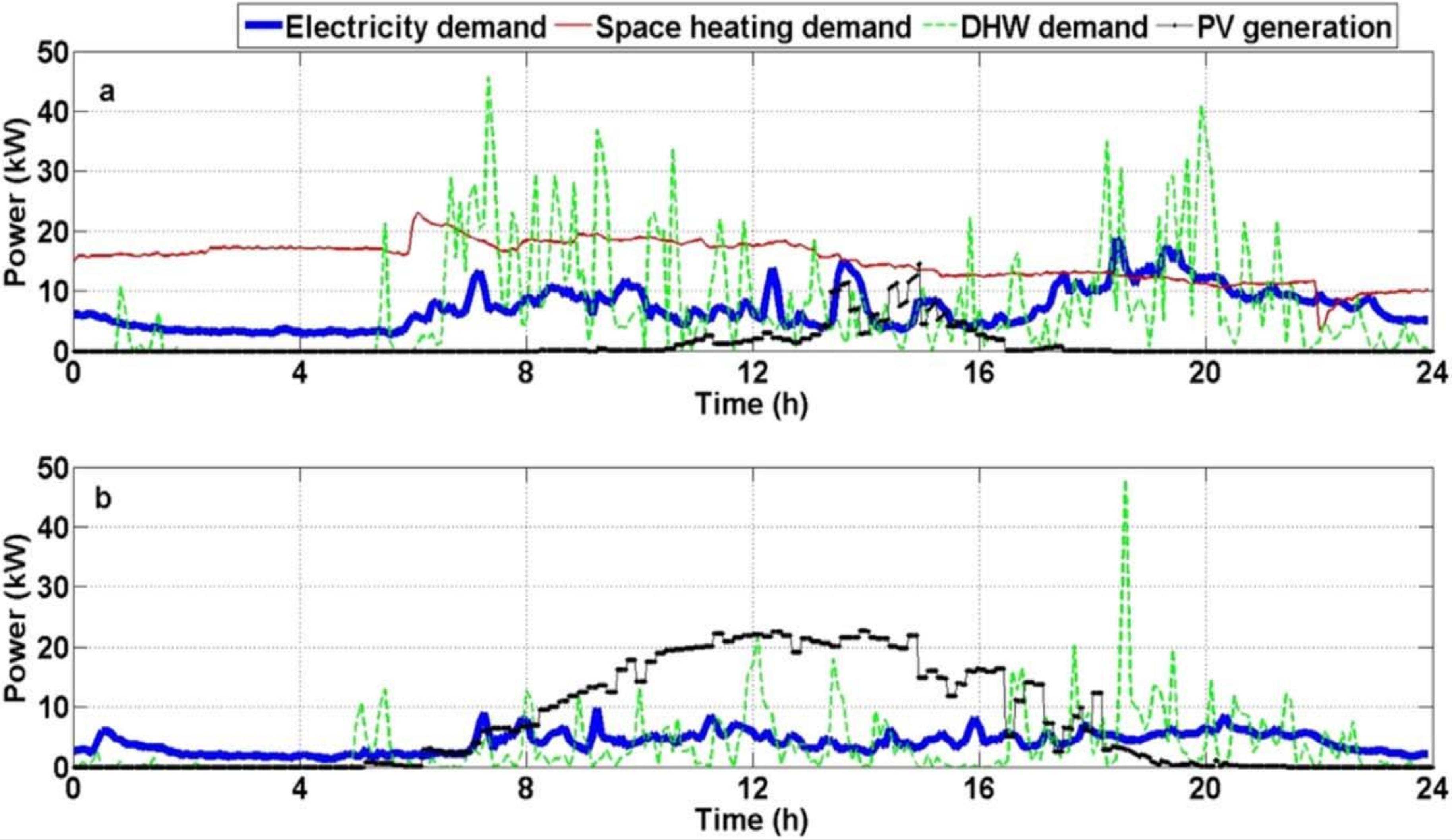


Options for storage - examples urban settings

single building collective / district

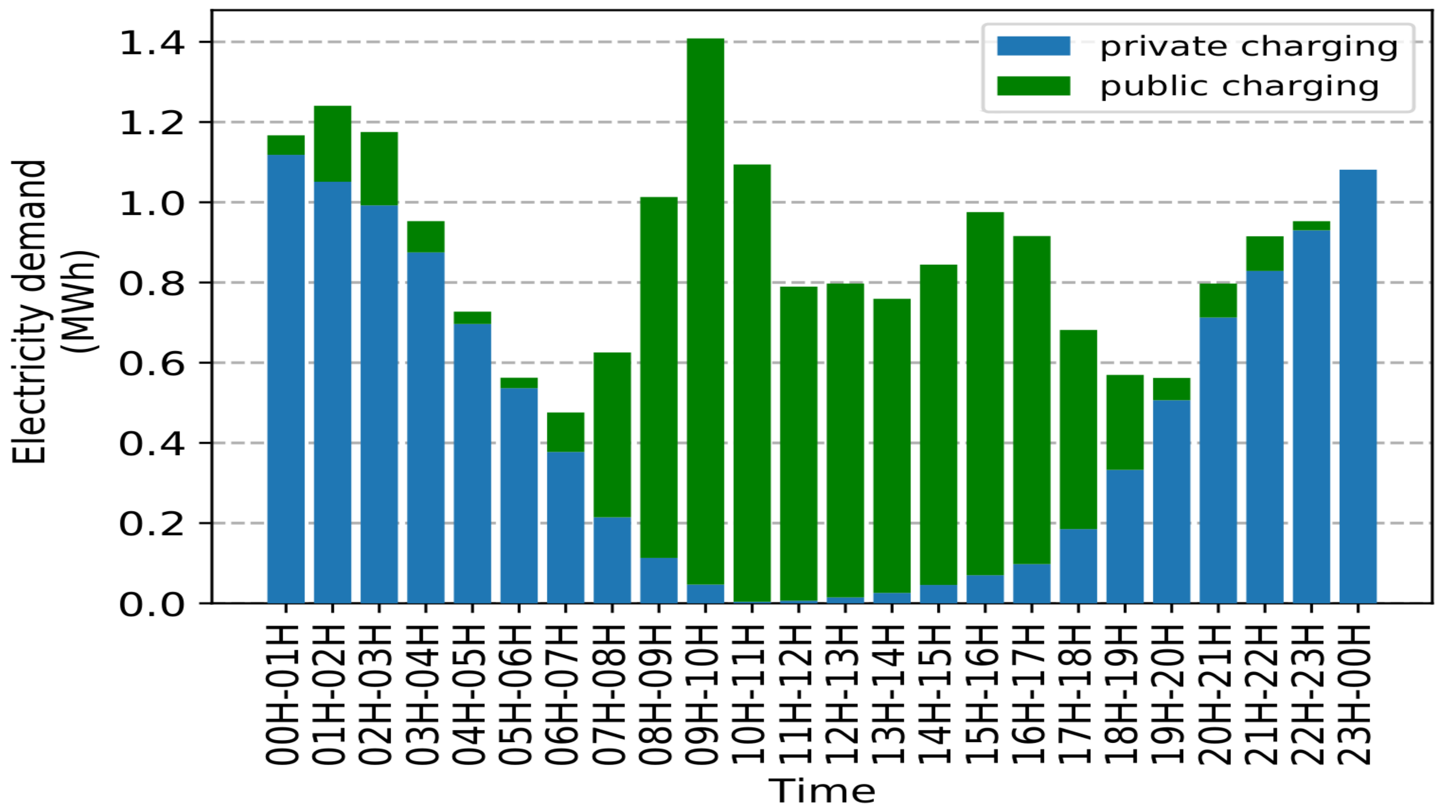


Flexibility: storage and DR needed patterns solar and demand Parra et al 2017; ex.Geneva

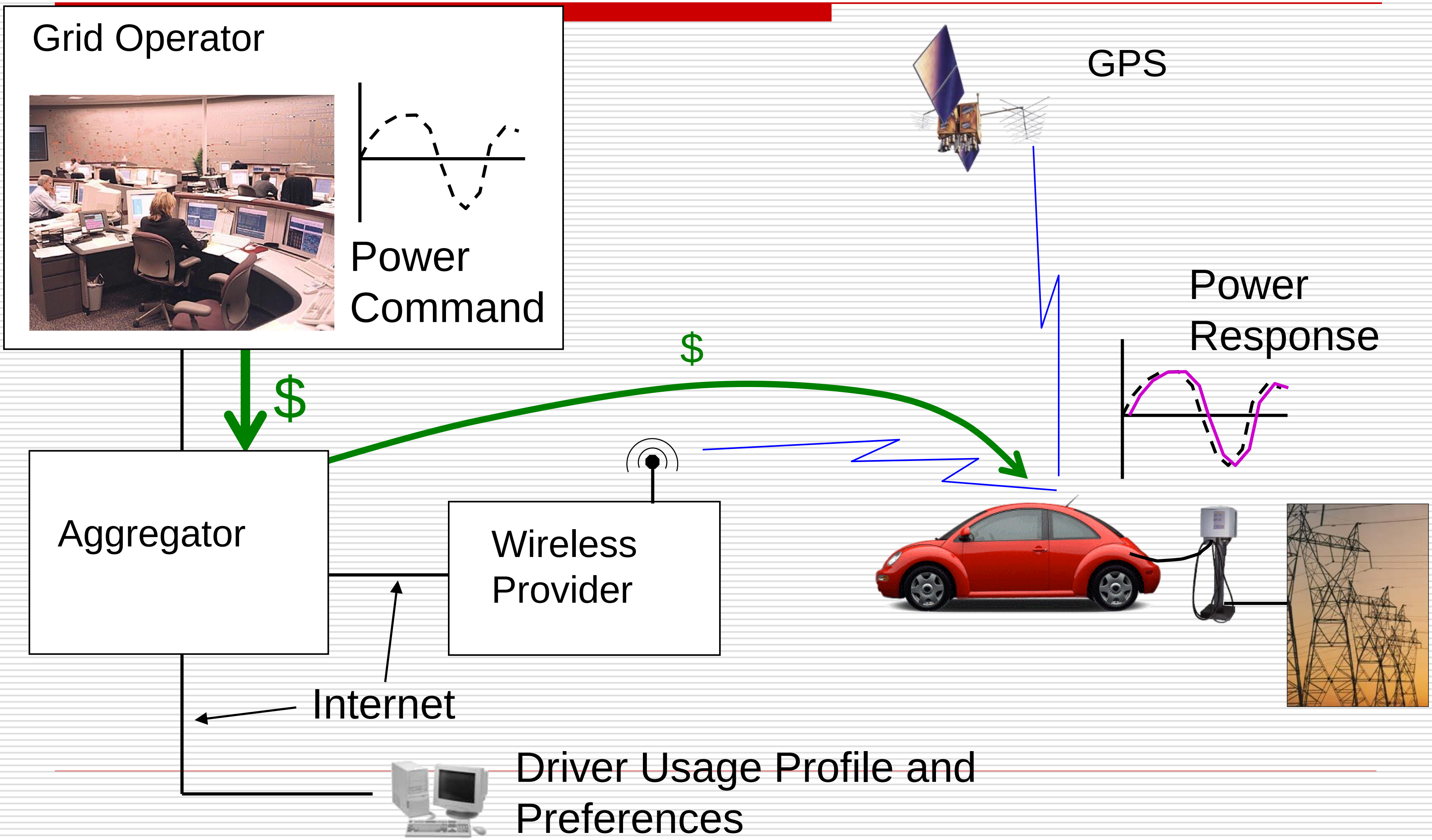


Load patterns of charging EVs

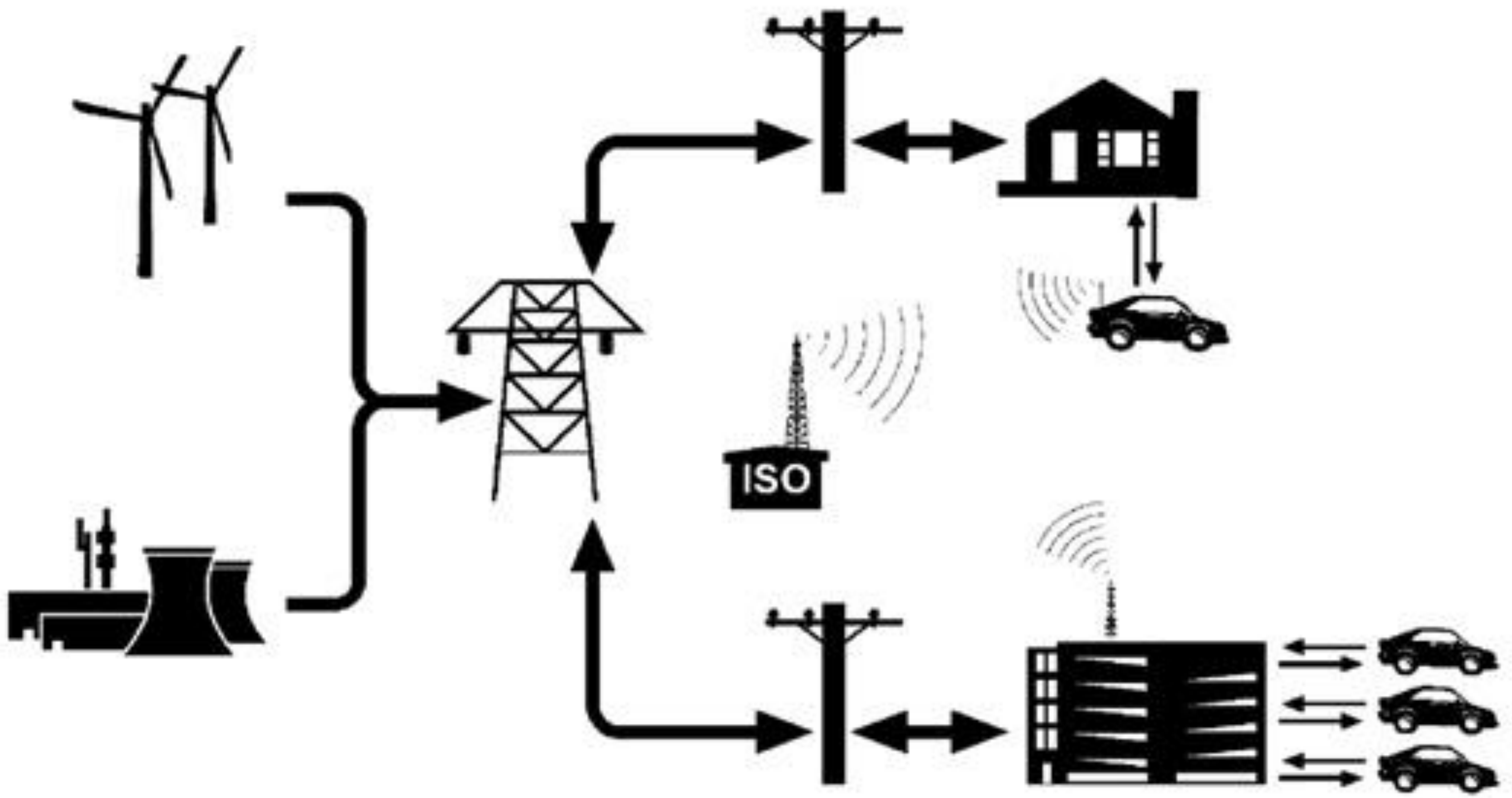
Model study Torino Lazzeroni 2021



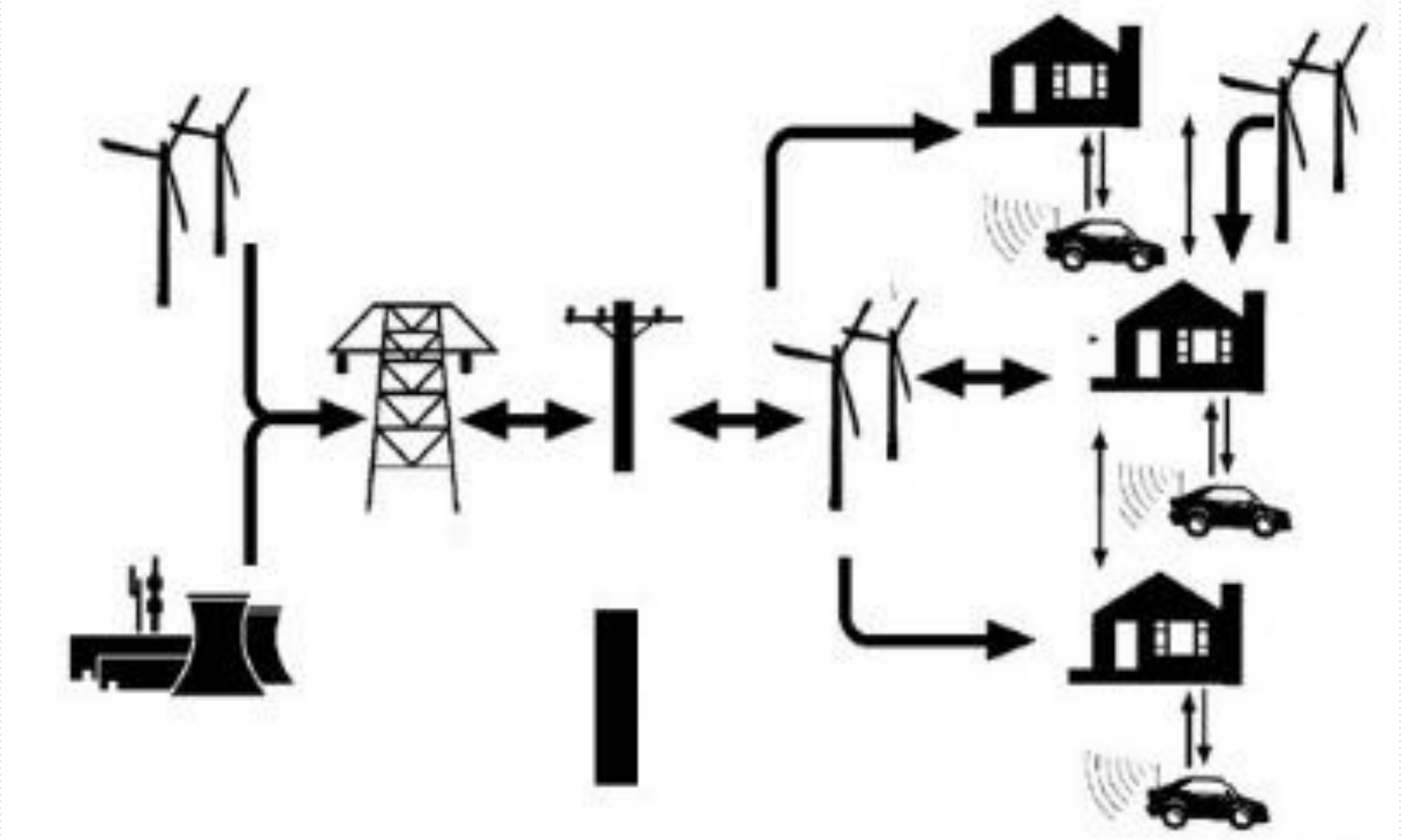
Grid Regulation with an EV Centralized Vision

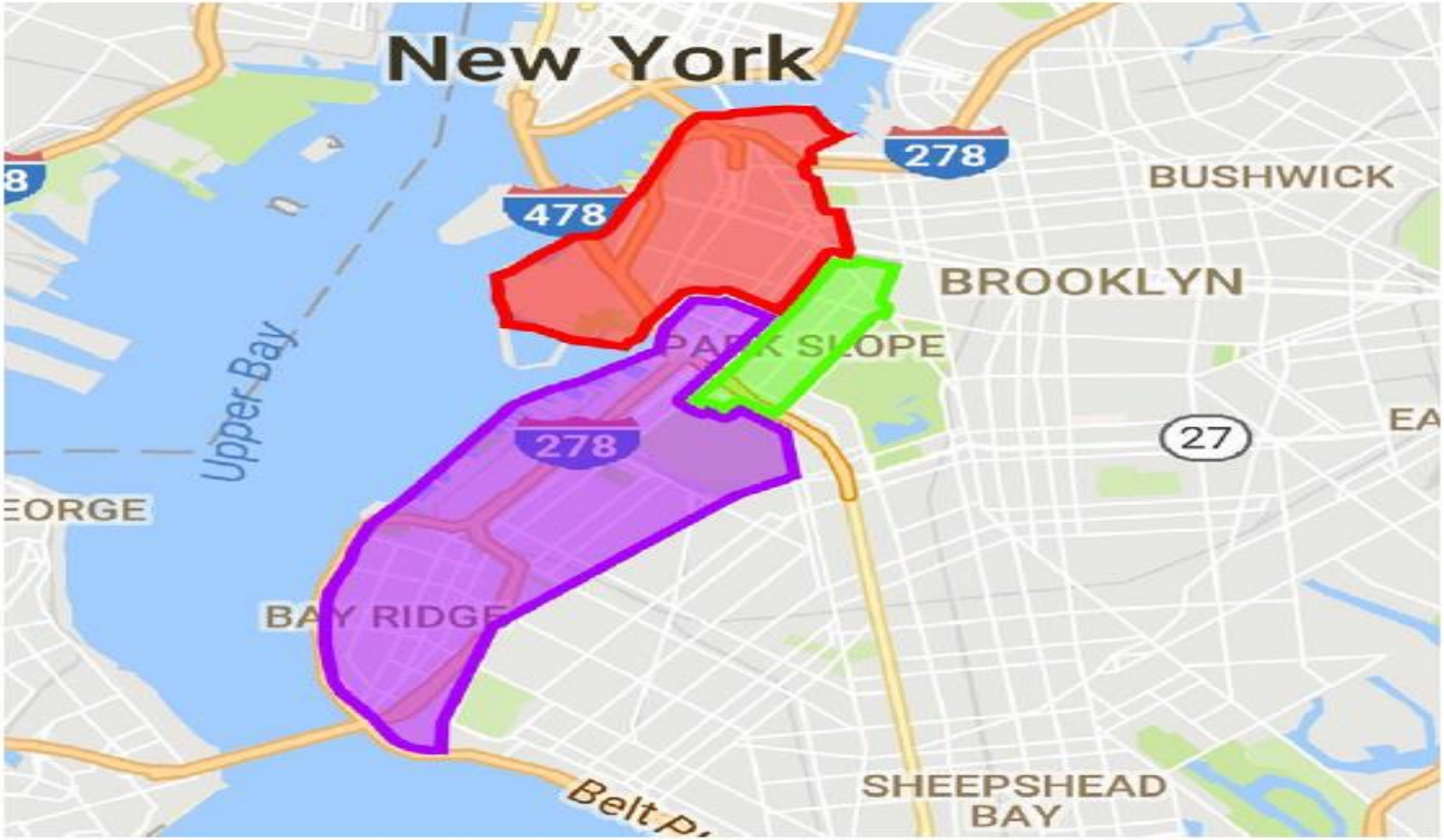


V2G Centralized vision



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



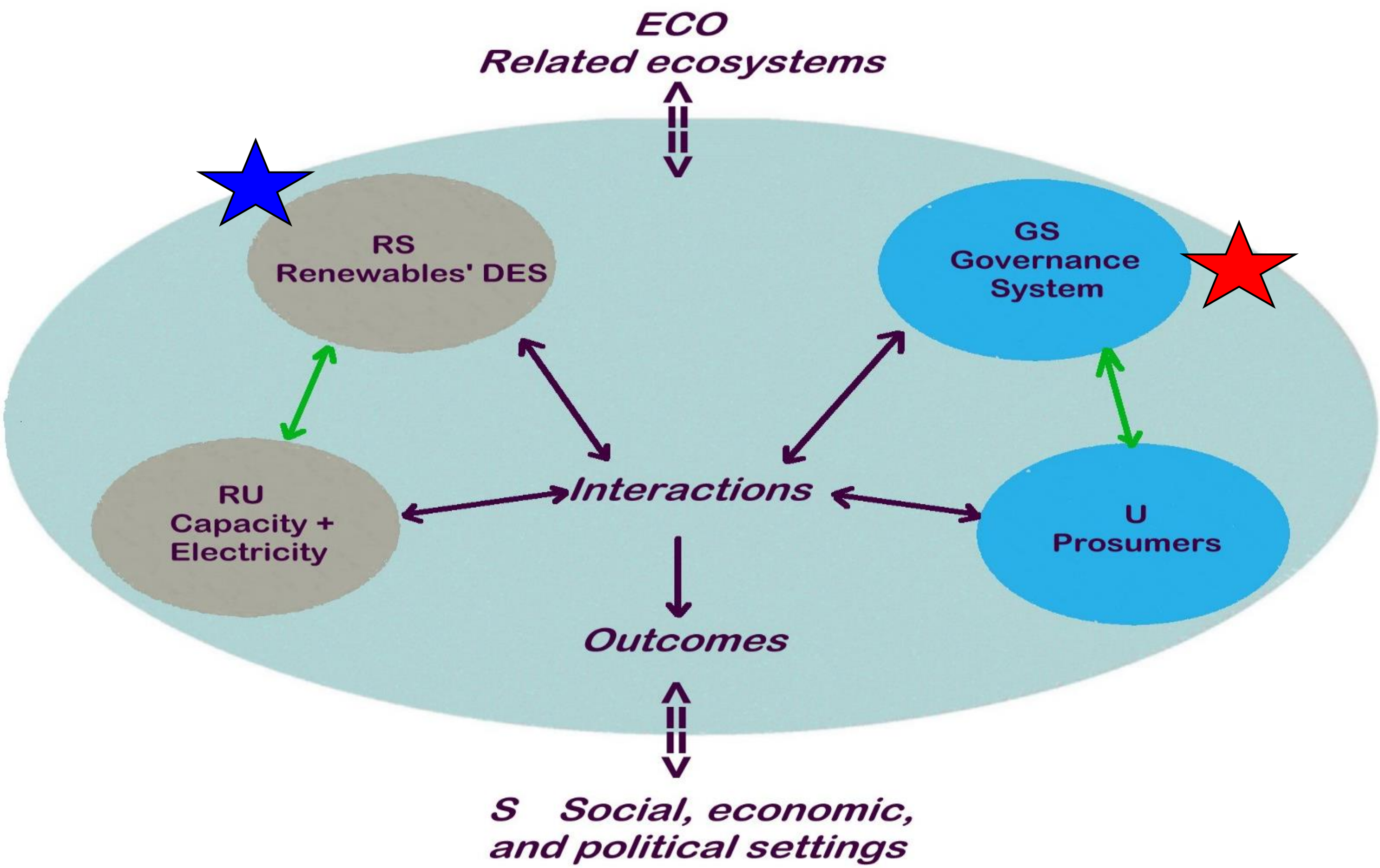


(a) The BMG connects participants from three distribution grids: the Borough Hall (red), the Park Slope (green), and the Bay Ridge (purple) network.

First DES microgrid Brooklyn, NY sept, 2017

- DG with peer-to-peer connections
- Cooperating prosumers
- Operation based on ICT system
- Mutual accounting based on internally collected and owned data (→ distributed ledgers)
- 'Trust' institutionalized by blockchain technology

Ostrom's SES framework, application for STS of DES microgrids Wolsink 2020



RE in urban district (resource system)

- Generation mainly Solar (PV, thermal)
- Depending on geography optional: wind, geothermal, (small) hydro, tidal/wave (coastal, islands), hydrogen (RE produced)
- Interconnected system (small distances, limiting required capacities) of sources, storage and ttansmission
- ICT infrastructure, adapted devices energy use
- Introduction of variety of storage (type and time-scale)
- Strong role for Electric Vehicles and thermal systems (heating, cooling, low temperature DH)

Governance system polycentric:
- community level

- Peer-to-peer delivery, distributed accounting
- Building trust (reciprocity, internal control)
- Self-governance communities
  - agency over use of space (rooftops, walls, in-home, public space within community
  - control over assets (generation, storage, sensors/meters)
  - over the data (energy flows, available capacities, transactions)
  - management system (use of capacities, generation, consumption [DR], accounting
- ICT may help, mainly when controlled by STS

Socio-political level: solve institutional barriers: taxation, hierarchical spatial planning, remove central control power supply system

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

Thank you

References

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

Acosta, C., Ortega, M., Bunsen, T., Koirala, B. P., Ghorbani, A. (2018). Facilitating energy transition through energy commons: An application of socio-ecological systems framework for integrated community energy systems. *Sustainability*, 10(2), 366

Cajaiba-Santana, G. (2014). Social innovation: Moving the field forward. A conceptual framework. *Technological Forecasting and Social Change,* 82, 42-51.

Gui, E. M., Diesendorf, M, MacGill, I. (2017). Distributed energy infrastructure paradigm: Community microgrids in a new institutional economics context. *Renewable and Sustainable Energy Reviews*, *72*, 1355-1365.

Lazzeroni P, Brunella Caroleo , Maurizio Arnone and Cristiana Botta (2021) A Simplified Approach to Estimate EV Charging Demand in Urban Area: An Italian Case Study. *Energies* 14, 6697.

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

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

Mengelkamp, E., Notheisen, B., Beer, C., Dauer, D., Weinhardt, C. (2018) A blockchain-based smart grid: towards sustainable local energy markets. *Computer Science - Research and Development,* 33, (1-2), 207-214.

Ostrom, E. (2009) A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, 325, 419-422.

Parag, Y., Sovacool, B. K. (2016). Electricity market design for the prosumer era. *Nature Energy*, *1*(4), 16032.

Parra, D., Swierczynski, M., Stroe, D. I., Norman, S. A., Abdon, A., Worlitschek, J., ... & Patel, M. K. (2017). An interdisciplinary review of energy storage for communities: Challenges and perspectives. *Renew Sust Energy Reviews*, *79*, 730-749.
Schlager, E., Ostrom, E. (1992). Property-rights regimes and natural resources: a conceptual analysis. *Land Economics, 68,* 249-262.
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.
Wolsink, M. (2018a). Co-production in distributed generation: renewable energy and creating space for fitting infrastructure within landscapes. *Landscape Research,* 43(4), 542-561.
Wolsink, M. (2018b). Social acceptance revisited: gaps, questionable trends, and an auspicious perspective. *Energy Research & Social Science,* 46, 287-295.
Wolsink, M. (2019) Social acceptance, lost objects, and obsession with the 'public'—The pressing need for enhanced conceptual and methodological rigor. *Energy Research & Social Science,* 48, 269-276
Wüstenhagen R, Wolsink M, Bürer MJ (2007) Social acceptance of renewable energy innovation. *Energy Policy* 35, 2683-2889