Renewables: common pool natural resources – distributed generation in intelligent grids
Wolsink, M.P.

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Renewables: common pool natural resources – distributed generation in intelligent grids

Maarten Wolsink *

"Breaking the Rules – Energy Transitions as Social Innovations"
conference June 14th-15th, 2018 at WZB Berlin Social Science Center.

Keynote for the conference

* University of Amsterdam
Department of Geography, Planning and International Development Studies

Abstract

The current trend in our power supply system is to shift power generation towards much smaller energy conversion units: DGRS – Distributed Generation using Renewable Sources. Traditional power plants are large centralised units, primarily fuelled by coal and oil, natural gas, nuclear fission and large hydro-power stations. These are deeply institutionalized socio-technical systems (STS), but the future perspective of this STS needs upgrading, as current systems are run by “big unwieldy corporate machines” whose change is “characterized by recalcitrance and torpor” (Bakke, 2016, p.xx). The adjacent consequences of the emergence of DGRS requires far reaching re-organization of the STS, that implies significant institutional changes moving away from centralized and hierarchical management (Wolsink, 2018).

DG is based on a network of multiple, smaller generating units and other infrastructure – storage, transmission – situated close to energy consumers, integrated in microgrids that together constitute an intelligent grid (Gui et al. 2018; Wolsink 2012; von Wirth et al., 2018). The essence of DG in microgrids also implies the recognition of the significance of cooperating actors – prosumers – to establish power generating capacity integrated in these microgrids. An essential building block of intelligent grids is adaptation of demand patterns by all sorts of demand response (Siano, 2014). Calculated technical potentials for demand response may be interesting, but eventually the rate of acceptance of such systems becomes the key issue for realization of adapted demand patterns. Centrally led Demand Side Management schemes are known to be unpopular among customers (Darby, McKenna, 2012), but demand response within cooperation
networks of prosumers aiming at enhancing the utilization of their own DG seem to be more promising.

The multi-disciplinary theory applicable to this new STS system, aimed at sustainable use of the natural resource of renewables’, is the institutional theory developed for the proper management of social-ecological systems, common pool resource theory (Ostrom, 2009). The concept of ‘coproduction’ means that citizens can play an active role in producing public goods and services of consequence to them (Ostrom, 1996). Recently, CPR theory has been recognized as a fruitful approach for studying social-technical systems for the provision of power with DG, which is literally co-production of electricity. It is also co-production on planning and decision-making on DG and other intelligent grid infrastructures, as within a microgrid the partner-prosumers have their input in terms of asset like generation capacity, space for infrastructure, and storage capacity, and this input may be individual as well as collective when these assets are installed by co-operation and collectively managed. A major institutional change needed for this, is that generated power or re-loaded power from storage facilities can be peer-to-peer consumed by others in the microgrid. These factors may be considered a manifestation of the ‘sharing economy’ (Martin, 2016). Peer-to-peer delivery is one of the elements fully running counter to the centralized design of the current power supply system. The producer-customer paradigm is institutionalized in legislation, in design of tariffs, and in hardware (location, design and ownership of meters), and as a result in dominant – even locked-in – ways of thinking. Besides the rapid emergence of DG technologies – PV reaching the level of ‘grid-parity’, electric vehicles, supercapacitors, batteries (Wolsink, 2018) – within the domain of ICT, there are also rapidly emerging technologies supporting the intelligent self-governance of the energy flows, generation, storage and transmission capacities – sensors, artificial intelligence, blockchain etc. As another major example the consequences of these developments for yet another institution that is part of the lock-in in our current power supply systems, taxing, will be discussed.
Renewables:
Common Pool Natural Resources –
* Distributed Generation in Intelligent Grids *

"Breaking the Rules – Energy Transitions as Social Innovations"
keynote 14 June 2018
to the conference June 14th-15th, 2018
at WZB Berlin Social Science Center, Berlin (D)

Maarten Wolsink
Dep. of Geography, Planning and International Development Studies
University of Amsterdam

Starting points

• Conference slogan tells us: transforming energy systems: ‘Social Innovations’
• ‘Breaking the Rules’
• Indeed, this talk is about the proces of social acceptance of “institutional change”
• Institutions are (definition)
  ... *behavioural patterns* as determined by societal rules...
  "the rules of the game in society"
• Renewables are natural resources. Common Pool Resources theory on sustainable resources use (Ostrom) is also an institution
Starting points

• Power supply system(s) is an STS
  *Social-Technical System*
  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**…. including ‘creative destruction’

• Innovation – definition –
  A change of *ideas*, that becomes manifest in *products, processes, or organizations*, that are applied successfully in practice.

• Key innovation is:
  move the STS away centralized design & hierarchical and centralized management

A ‘must read’ on the need to innovate power grid (book on North America)

- The electricity grid is
  • a machine
  • an infrastructure
  • a cultural artifact
  • a set of business practices
  • and an ‘ecology’………

- .....designed for the exact opposite of 21st-century needs
Innovation theory on current STS

Famous lock-in example: “Clio and the economics of qwerty”  David, AmEconRev, 1985

- Institutional “lock-in”  Unruh, 2000  EnergPol ‘carbon lock-in’
- Existing configuration energy sector emerged in history (“path dependency”)
- To serve certain objectives (rational, but also political)
- STS cross-linked with sectors like industry, land use, transportation, communication... (also: path dependency)
- Current system → does not serve new objectives → barriers; resisting vested interests → inertia
- New elements of STS are not accepted easily....... → social acceptance turns as the key to realize RE potentials, → particularly structural social elements of the STS: institutions

Moving away from Centralization and Hierarchy

- Current STS:
  ● generation in central power plants
  ● distribution via centralized infrastructure
  ● hierarchical and uniform regulation and management
  ● centralized accounting: metering and tariffs
- Move away: towards increasing DGRS
  ● Distributed Generation, rapid emergence of prosumers
  ● rapid increase of variety (infrastructure, and organization)
  ● Polycentricity in governance and management
  ● distributed accounting:
    - distributed (intelligent) metering; peer-to-peer delivery; variable and dynamic tariffs; variable and distributed ledgers
Definition

Ackermann et al 2001

- **Distributed Generation**
  (more broadly: Distributed Energy Resources)

  *is an electric power source* (or other electric resources)
  - connected directly to the distribution network
  - or on the customer site of the meter.

- Geographically dispersed
- Numerous locations
- Huge variety

Variety: huge diversity in Distributed Generation:
with implications for co-production and spatial requirements

sample Ackermann et al 2001; table Wolink Landshces 2018
Distributed Energy Resources: also storage and transmission options

<table>
<thead>
<tr>
<th>Type of infrastructure</th>
<th>Size (kW)</th>
<th>Relevance for co-production and participation</th>
<th>Spatial claim (assumed / type)</th>
<th>Landscapes reference / type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat storage (residential)</td>
<td>1-5 kW</td>
<td>Single owner</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Heat storage (commercial buildings; solar, electric, heat pumps)</td>
<td>10-50 kW</td>
<td>Single owner / co-operative</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>Heat storage (geothermal)</td>
<td>100 kW</td>
<td>Single owner</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Battery storage</td>
<td>500 kW</td>
<td>Single owner / co-operative</td>
<td>Indoor</td>
<td>Low</td>
</tr>
<tr>
<td>Battery storage (Vehicle-to-grid)</td>
<td>10-100 kW</td>
<td>Single owner / private car, co-owned</td>
<td>Indoor or outdoor</td>
<td>None</td>
</tr>
<tr>
<td>Electric vehicle public transport, charging</td>
<td>10-100 kW</td>
<td>Public / private / co-operative</td>
<td>Outdoor or indoor</td>
<td>None</td>
</tr>
<tr>
<td>Storage Renewables</td>
<td>Energy in use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighboring WTE systems</td>
<td>1-5 MW</td>
<td>Co-operative / public / shareholder</td>
<td>Light energy / operations / public</td>
<td>Moderate</td>
</tr>
<tr>
<td>Pumped hydro (high altitude water basin)</td>
<td>10-100 MW</td>
<td>Centralized</td>
<td>Large</td>
<td>High</td>
</tr>
<tr>
<td>Desalination; renewables</td>
<td>750 kW</td>
<td>Co-operative / shareholder / public</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Environmental of RES-powered power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVAC Transmission</td>
<td>10-15 MW</td>
<td>Public / private / co-operative</td>
<td>Large</td>
<td>Slight</td>
</tr>
<tr>
<td>Intermediate frequency (IFC)</td>
<td>100-1000 kW</td>
<td>Centralized</td>
<td>Large</td>
<td>High</td>
</tr>
<tr>
<td>Low voltage grid (AC)</td>
<td>10-100 kW</td>
<td>Co-operative / household</td>
<td>Small</td>
<td>None</td>
</tr>
<tr>
<td>Low voltage grid (AC)</td>
<td>500-1000 kW</td>
<td>Public / co-operative</td>
<td>Small</td>
<td>None</td>
</tr>
</tbody>
</table>
### Renewable Energy is abundant

**Scarcity is required space**

Energy-density (energy/area) [Smil, 2010]

### Table: Distributed Storage

<table>
<thead>
<tr>
<th>Type of Infrastructure</th>
<th>Size (capacity)</th>
<th>Relevance for co-production and participation</th>
<th>Spatial claims (amount / type)</th>
<th>Landscape relevance / type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat storage (electric boilers)</td>
<td>1-4kW</td>
<td>Single owner</td>
<td>None indoor</td>
<td>None</td>
</tr>
<tr>
<td>Heat storage buildings (solar, electric heat pumps)</td>
<td>10-500kW</td>
<td>Single owner / co-operative</td>
<td>Low Resource rights / passive solar</td>
<td>Low Orientation sun, planning design</td>
</tr>
<tr>
<td>Cold storage (cooling systems)</td>
<td>1-100 kW</td>
<td>Single owner</td>
<td>None indoors</td>
<td>None</td>
</tr>
<tr>
<td>Battery storage</td>
<td>500 kW-5 MW</td>
<td>Single owner / co-operative</td>
<td>Small Indoor or spot</td>
<td>Low Visual Moderate waste</td>
</tr>
<tr>
<td>Electrolizers/ Fuel cell hydrogen storage</td>
<td>50-1kW</td>
<td>Single owner</td>
<td>Small Indoor or spot</td>
<td>None</td>
</tr>
<tr>
<td>Electric vehicles (Vehicle-to-grid)</td>
<td>10-100 kW</td>
<td>Single owner / private cars / co-owned</td>
<td>Very small Recharging points / possible indoor</td>
<td>None</td>
</tr>
<tr>
<td>Electric vehicles: public transport / freight</td>
<td>10-100 kW</td>
<td>Public / private / co-operative</td>
<td>Small Recharging points / possible indoors</td>
<td>None</td>
</tr>
</tbody>
</table>

### Figure: Power Density vs. Area

- Thermal power plants
- Coal fields
- Oil fields
- Central solar towers
- Geothermal
- Flat plate collectors
- Photovoltaics
- Tidal
- Ocean heat
- Wind
- Hydropower
- Phyтомass
- Hydro

Source: [Smil, 2010]
Decision about all elements – social design (economic, political, cultural), technological design, decisions about space for infrastructures taken in processes of Social Acceptance (Original concept: Wüstenhagen et al. 2007)

**Socio-political acceptance**
- of technologies
- of policies
- of institutional change
- by policy makers
- by key stakeholders
- by the public

**Community acceptance**
- place attachment
- landscape identity
- fairness of process
- by residents
- by local authorities
- trust

**Market acceptance**
- by consumers
- of green tariffs
- of new parties
- by investors
- intra firm
- by incumbents

Social Acceptance, advanced: multi-layered processes

Pros. prosumers

Pros.

institutional conditions

Information
Huge spatial requirements (need reduction distance prod.-cons.)
Varying in supply patterns (need adapted demand patterns)
Huge geographical variety STSs (abolishment uniformity)

- Different patterns of variable supply (ecology)
- Optimization supply and demand: needs (micro-) optimization
- Development of (local) micro-grids,
  - several ‘prosumers’ in a ‘community’
  - load-control (supporting DG)
  - including local storage
- Intelligent metering and regulation devices
  (supporting ‘prosumers’ and ‘micro-grid community’)

Dominant discourse:
Centralized Grid, RES replacing fossil, central storage,
Demand Side Management (‘smart’?)
Strong pressure on the power grid: towards an Intelligent Grid

- "Power grid consisting of a network of integrated micro-grids that can monitor and heal itself"
- Fundamental question: Which institutional changes needed to establish those micro-grids with renewable DG as much as possible?
- Who will invest?
  Who is in control?
  Over what?
  vonWirth et al. 2018; Gui et al. 2017; Wolsink 2012
- Ownership and control is about:
  - all assets of the infrastructure
  - decisions about space
  - collecting and use of data
Centralized Grid connecting RES, storage, Demand Side Management

Intelligent Microgrid-community
DG, co-production, storage
co-produced and individual
Distributed Storage capacity
Parra et al, 2017

- Batteries (Li-ion; NiCd; Ni-Metal hydrate ...)
  - including V2G (electric vehicles)
  - developing: NaS
- Thermal (devices, underground...)
- Developing: Supercapacitors - high (dis-)charge capacity
- Developing: fuelcells; hydrogen
- Possible options:
  - Flywheels (option for short term network stability)
  - Compressed air
  - Superconducting Magnetic Energy Storage (short term, micro SMES for internal microgrid network stability)

Another way to define social acceptance
– in terms of Common Pool Resources theory

Social acceptance of renewables’ innovation is the process of organizing ‘co-production’ Ostrom, 1996; Wolsink 2018
- in establishing infrastructure
  (investing, required space, sharing data)
- of electricity
  - The inclination to cooperate in varying STSs (as compared to SES’s, Social Ecological Systems)
  - among multi-level actors (community, market, policy making)
  - to establish, maintain, operate
  - socio-technical systems of power supply and and shared use
  - based on natural resources of renewables
Fundamental features

- 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)
- **Complexity is good**
- All efforts to simplify: “not a good idea”
  [https://www.youtube.com/watch?v=Qr5Q3Vvpl7w#t=0.115416](https://www.youtube.com/watch?v=Qr5Q3Vvpl7w#t=0.115416)
- These notions run counter to common sense views, ...... widely held among policy analysts, governments, and technocrats more broadly

---

Ostrom, 1999. “Coping with tragedies of the commons”
Am Polit Sci Review 2 493-535

“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.”
Institutional settings should foster, create, and maintain...

- **Trust**
  - crucial characteristics are:
  - *Self governance*: within framework let users organize themselves
  - *Adaptive governance*: system should be flexible, resilient to sudden, external changes
  - *Polycentric governance*: decisions not taken in one centre, but at many different places, different arenas [Ostrom, 2010, p551]
  - *Multi-level governance*: actors part of SES operate on different scale levels, also different governance levels *(scale ≠ hierarchy)*
Examples RS (Resource system) variables
RU (resource units) variables

RS2 System boundaries → boundaries of microgrid
RS4 Human constructed facilities → all infrastructure
RS8 Storage: also human constructed

RU4 Economic value → peer-to-peer deliverance
RU7 Spatial and temporal distribution → storage, demand response
Examples

Variables defined in the Governance System

**GS3 Network structure** (network organization *instead of company*)
**GS4 Property-rights systems**
**GS5 Operational rules** → DR system, distributed accounting

.....
**GS8 Monitoring and sanctioning processes** Advanced sensors and DR device (intelligent meter)

Variables defined in ’U’ (Users) and ‘I’ (Interactions)

**U2 Socioeconomic attributes of users**
**U6 Norms/social capital**
**U9 Technology used**

**I1 Harvesting levels diverse users**
**I2 Information sharing among users**
ict within the intelligent microgrid

**O1 Social performance measures** (efficiency, accountability, equity)
Scheme microgrid based on DG with peer-to-peer delivery
Mengelkamp et al Appl Energ 2018

- DG with peer-to-peer transactions
- Cooperating prosumers
- Operation based on sensors and processors
- Mutual accounting based on internally collected and owned data (distributed ledgers)
- ‘Trust’ institutionalized by blockchain technology; recent option, further research needed
Example of institutional conflict:
Incumbent/vested interest government/state (part of lock-in) in current STS

- Intelligent meters (sensor + demand response device)
  - counting blockchain ‘credit’ based on Artificial Intelligence
  - no energy company or public grid manager control

- Can energy-flows still be taxed?
- Not without impeding DG and DStorage
Thank you
references


