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Local self-sufficiency in terms of energy production

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Definitions

self-sufficient: *able to supply one's own or its own needs without external assistance (*Merriam-Webster)

(*de facto* synonyms: **autonomus, autarkic**)

Schmidt *et. al*. (2012) distinguish:

absolute energy self-sufficiency – off-grid system

relative energy self-sufficiency – grid-connected system (= **zero net energy**)

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Measuring self-sufficiency

energy self-sufficiency ratio:

total (endogenous) energy production / total energy consumption [%]

$$\text{self-sufficiency} = \frac{\uparrow \text{Endogenous renewable energy}}{\downarrow \text{Total energy consumption}}$$

(Barcelona Energy Agency, 2013)

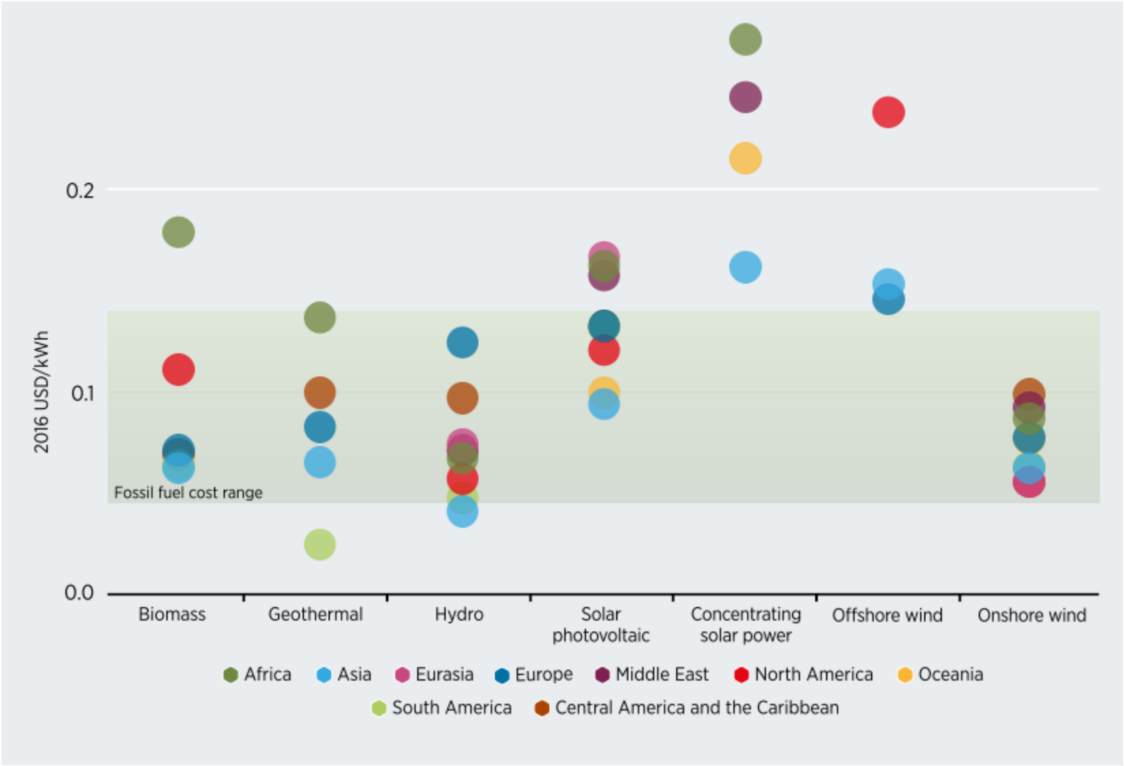
some methodological considerations:

- energy carriers: heat, electricity, fuels
- spatial boundaries of ’local’ production
- spatial boundaries of consumption (mobility)

Why self-sufficiency? – authorities' perspective

- **Energy security**
  - 'peak oil' – availability of fossil fuels
  - geopolitical situation – instability of supply & prices
  - grid reliance (climate change)
- **Costs reduction (or even financial surpluses)**
  - declining costs of production from RES vs. fossil fuels
  - grid construction & operation
  - selling electricity to grid
- **Transition to low-carbon economy**
  - *Energiewende*: opposition to nuclear energy
- **Local socio-economic development**
  - employment, skills development
  - R&D within the municipality
  - closed financial cycles
- **Attracting investors** (Polish energy clusters)
- **Increasing social awareness of the importance of sustainable development**

Figure 2.3 Regional weighted average levelised cost of electricity by renewable power generation technology, 2016 and 2017



Source: IRENA Renewable Cost Database.

(International Renewable Energy Agency, 2018)

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Why self-sufficiency? – prosumers' perspective

„Leenheer et al. (2011) identifies **environmental concerns, technology affinity and reputation of electricity companies** as the most important drivers for Dutch households generating their own power via microgeneration technologies (e.g. micro-CHP). **Financial factors and power outages did not have a significant effect**.

In contrast, for a German sample Korcaj et al. (2014) reveal that the **aspiration of financial gains, autarky benefits and social status** have a positive relationship to the attitude towards purchasing PV systems." (Engelken et al. 2016):

„[in the UK] the most important motivations are **earning money from installation**, **increasing household energy independence** and **protecting against future high energy costs"** (Balcombe et al., 2014, p. 403)

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Why self-sufficiency? – prosumers' perspective

Table 2
Summary of motivations and barriers associated with adopting microgeneration as found in literature.

	Motivation	Barrier
Financial	– Save or earn money from lower fuel bills and government incentives – Increase the value of my home	– Costs too much to buy/install – Cannot earn enough/save enough money – Lose money if I moved home – High maintenance costs
Environmental	– Help improve the environment	– Environmental benefits too small
Security of supply	– Protect against future higher energy costs – Make the household more self sufficient/less dependent on utility companies – Protect the household against power cuts	– Would not make me much more self sufficient/ independent
Uncertainty and trust	– Use an innovative/high-tech system	– Home/location not suitable – System performance or reliability not good enough – Energy not available when I need it – Hard to find trustworthy information/advice – Hard to find any information/advice – Hard to find trustworthy builders to install
Inconvenience	None identified	– Hassle of installation – Disruption or hassle of operation – Potential requirement for planning permission
Impact on residence	– Improve the feeling or atmosphere within my home – Show my environmental commitment to others	– Take up too much space – The installation might damage my home – Would not look good – Neighbour disapproval/annoyance

(Balcombe et al., 2013, p. 658)

Energy sources

'Distributed' energy production:

- P < 50-100 MWp
- bottom-up planned, locally controlled
- usually connected to grid (behind the meter)
- mostly renewable energy sources, but not necessarily

(Paska et al., 2010)

Energy sources

Technical solutions feasible at the local level:

- PV panels
- solar collectors
- wind turbines
- heat pumps
- biomass, biofuel and biogas
- hydrogen cells
- micro-hydropower plants

https://gazetawroclawska.pl/wroclaw-panele-sloneczne-na-dachu-wiezowcabedzie-ich-wiecej/ga/10050612/zd/18678048

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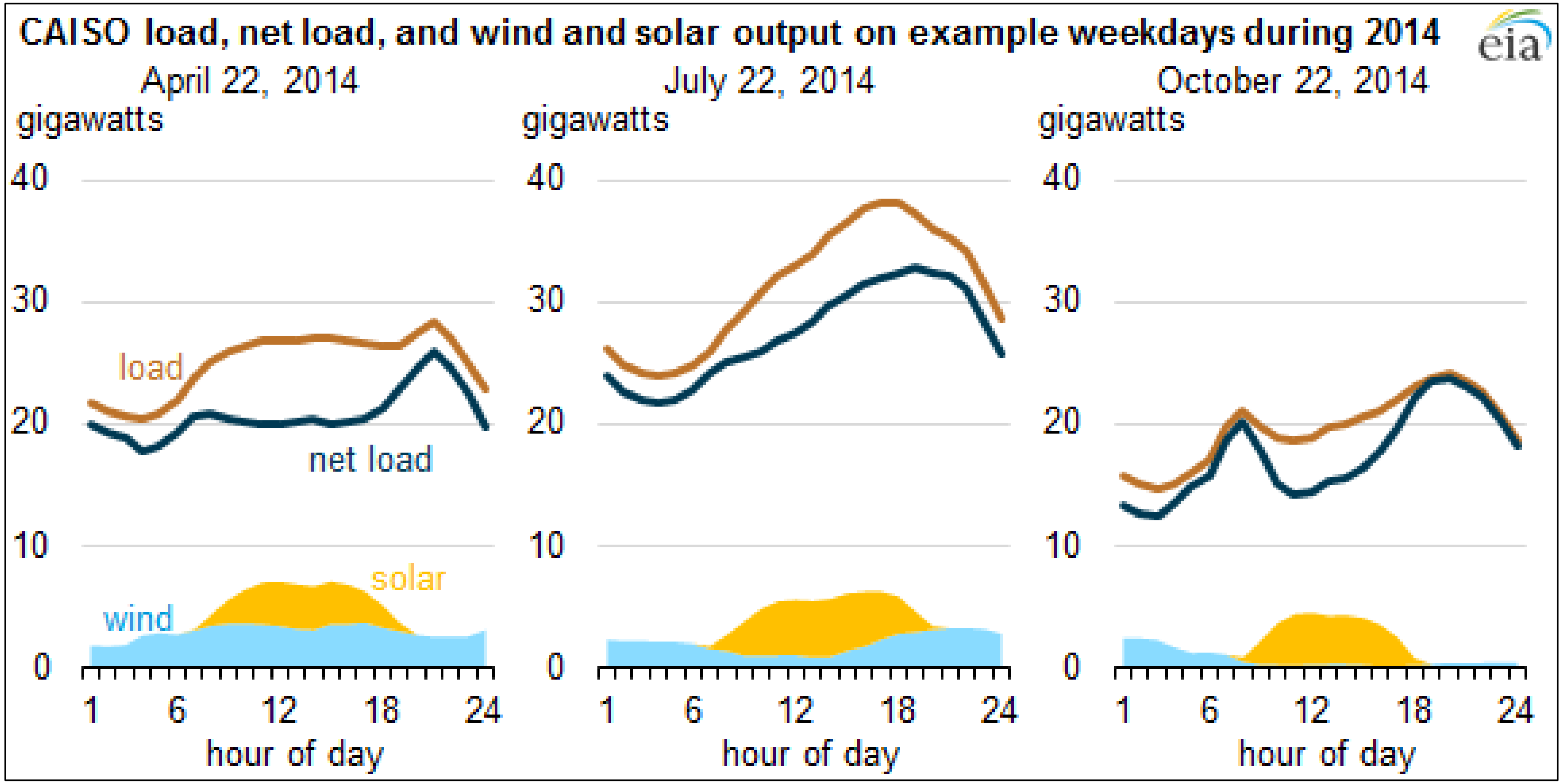
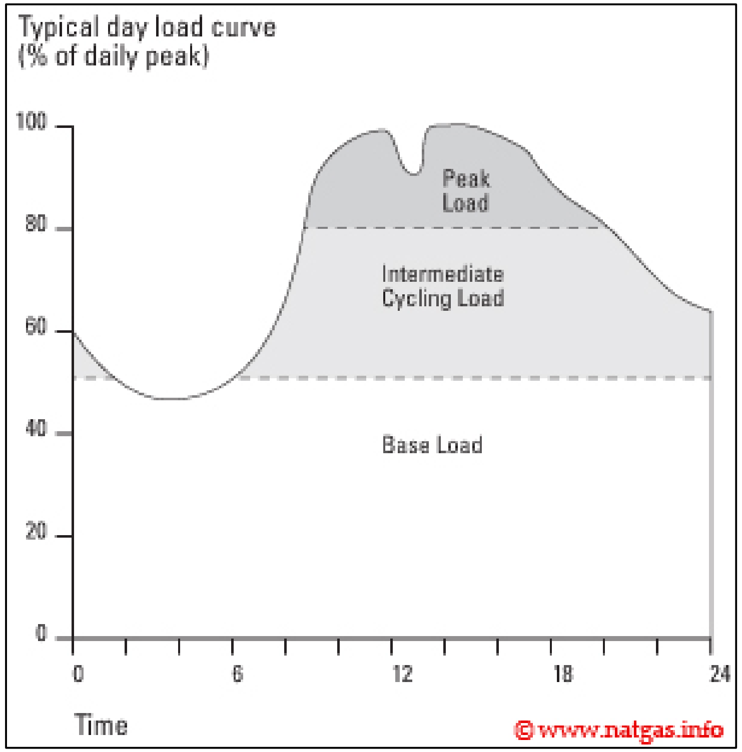
Daily demand vs. supply (electric energy)



(source: https://www.eia.gov/todayinenergy/detail.php?id=19111)

Baseload & Peak Load



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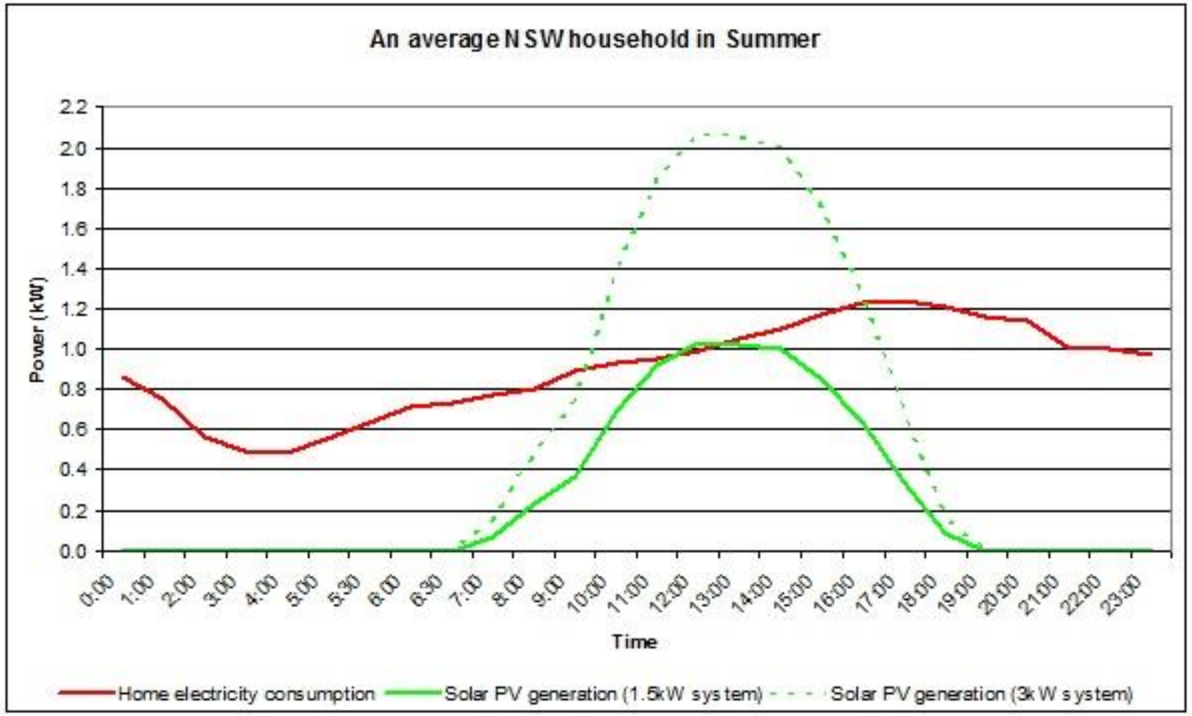
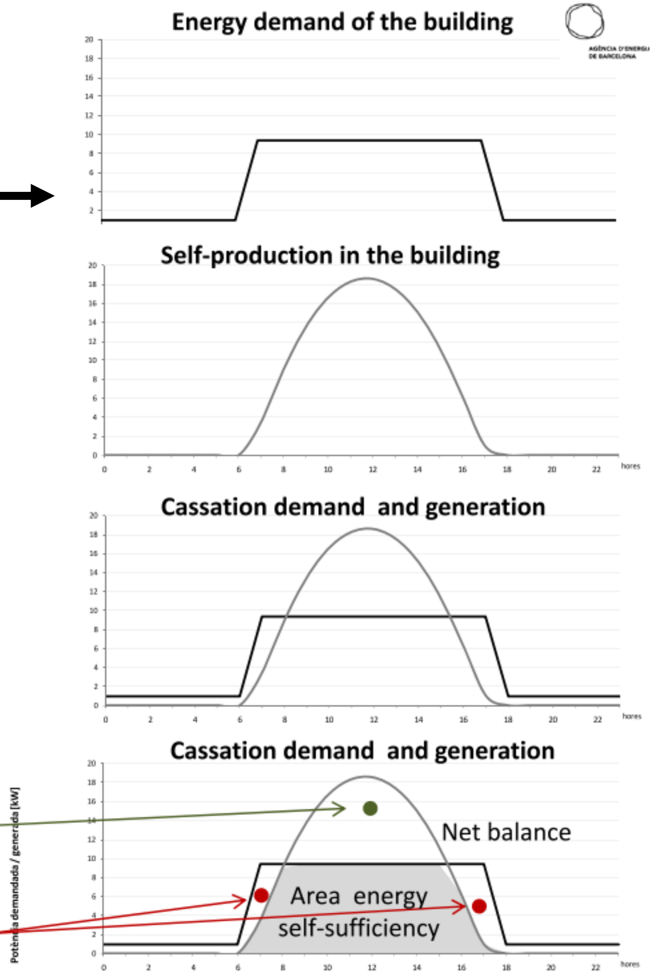
Daily demand vs. supply (electric energy)



RESIDENTIAL (NSW, Australia)

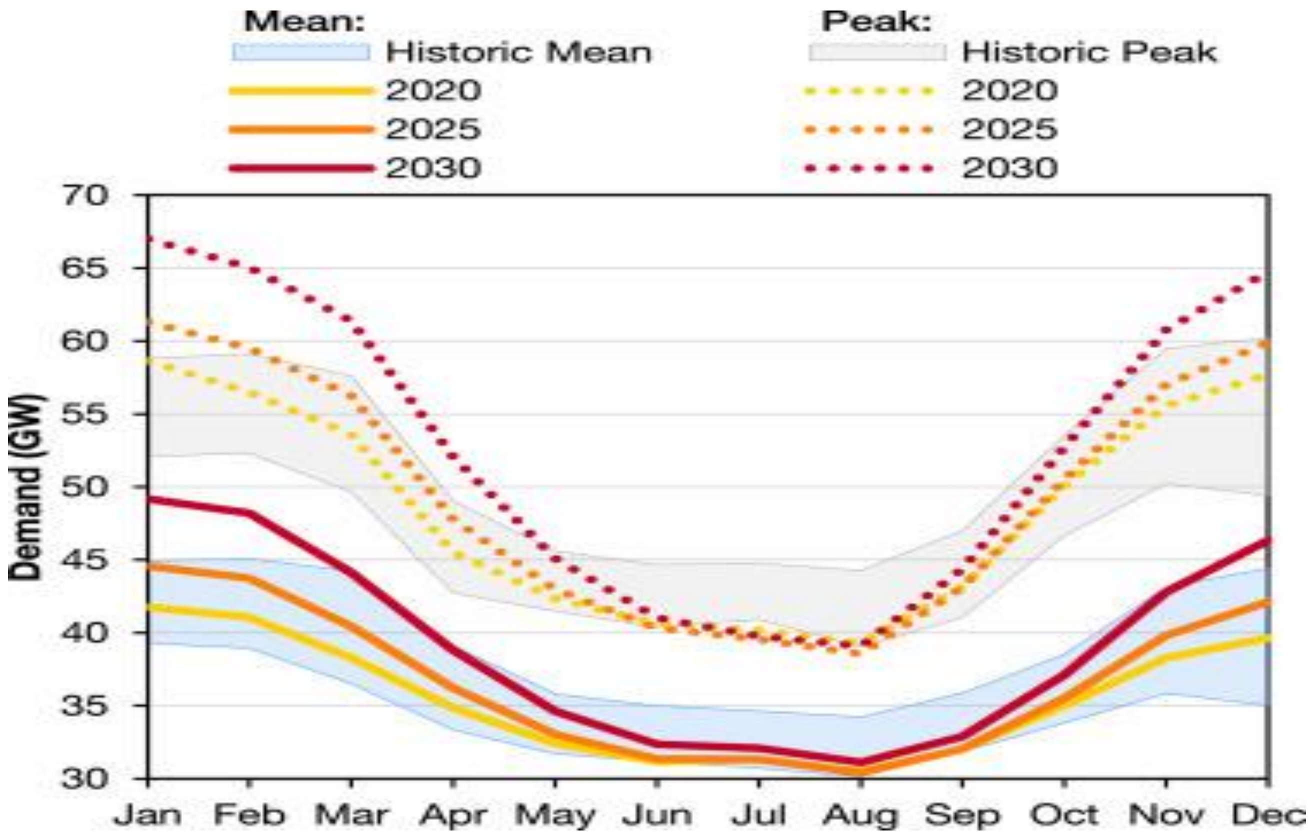
(source: https://www.solarchoice.net.au/wp-content/uploads/Average-NSW-household-in-summer-electricity-consumption-vs-PV-generation1.JPG

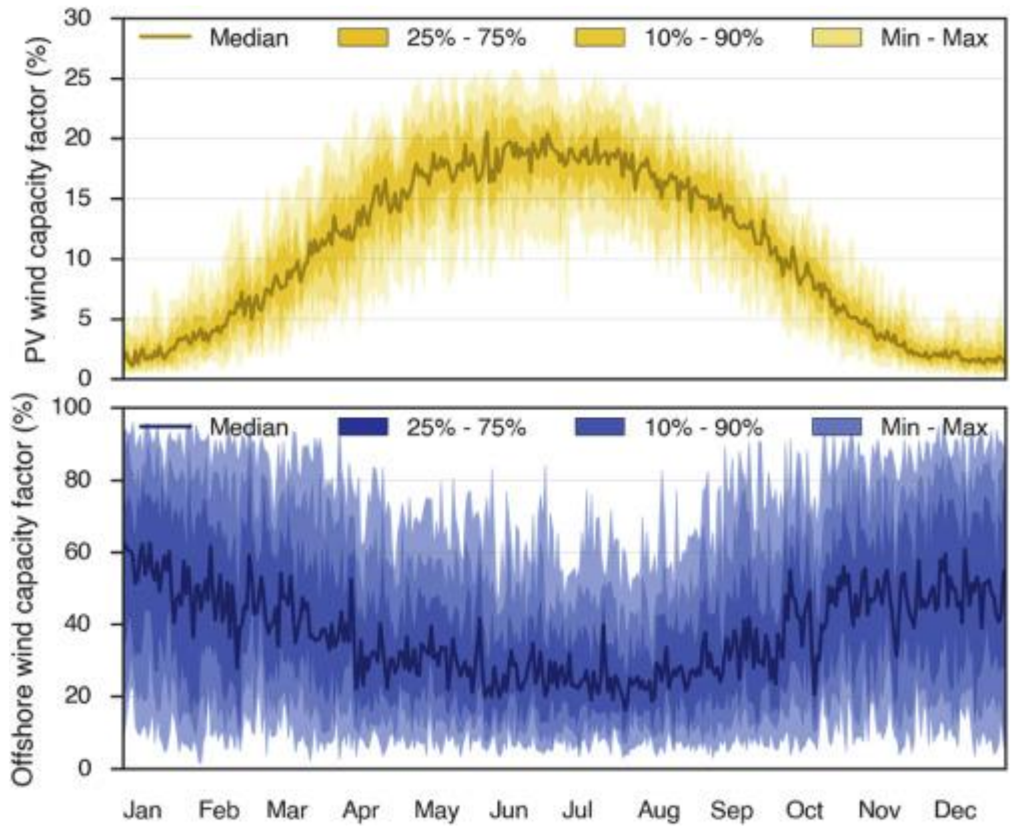
OFFICE



The installation can generate excess production that can not be made by the building	Building **export** energy
The building will demand energy sometimes when the photovoltaic installation is not delivering	Bulding **import** energy

Yearly demand vs. supply (electric energy)

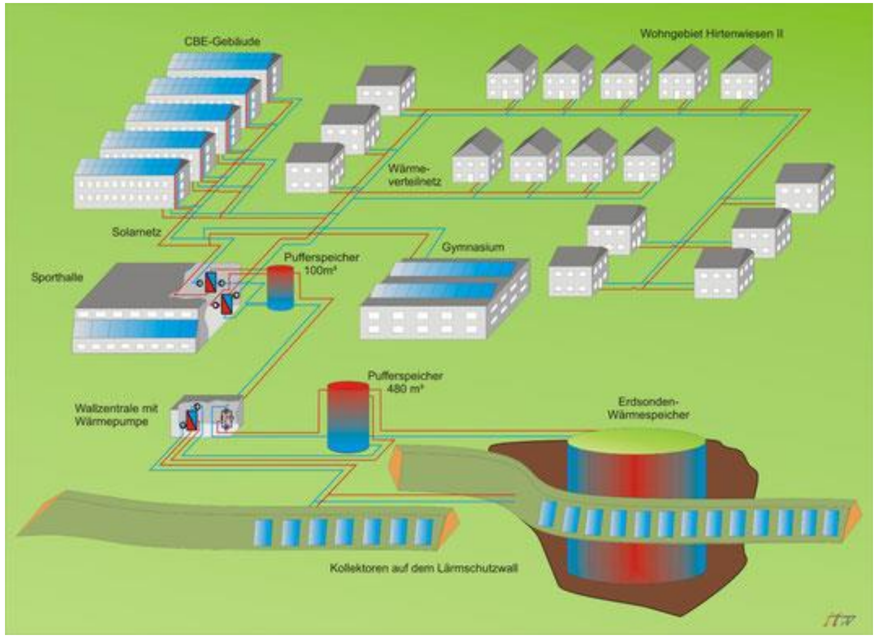


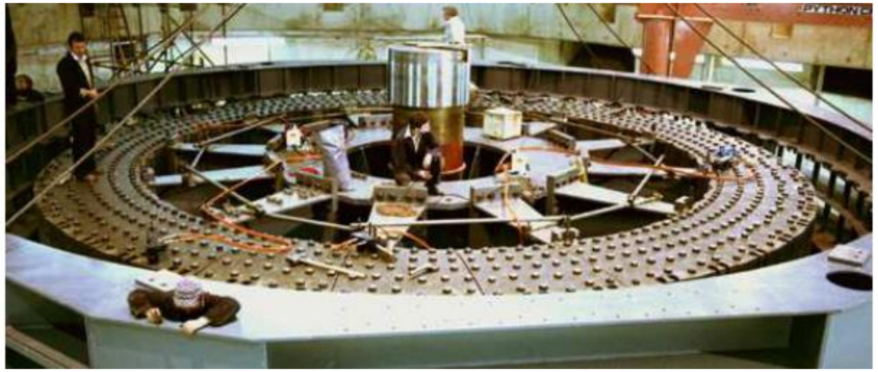


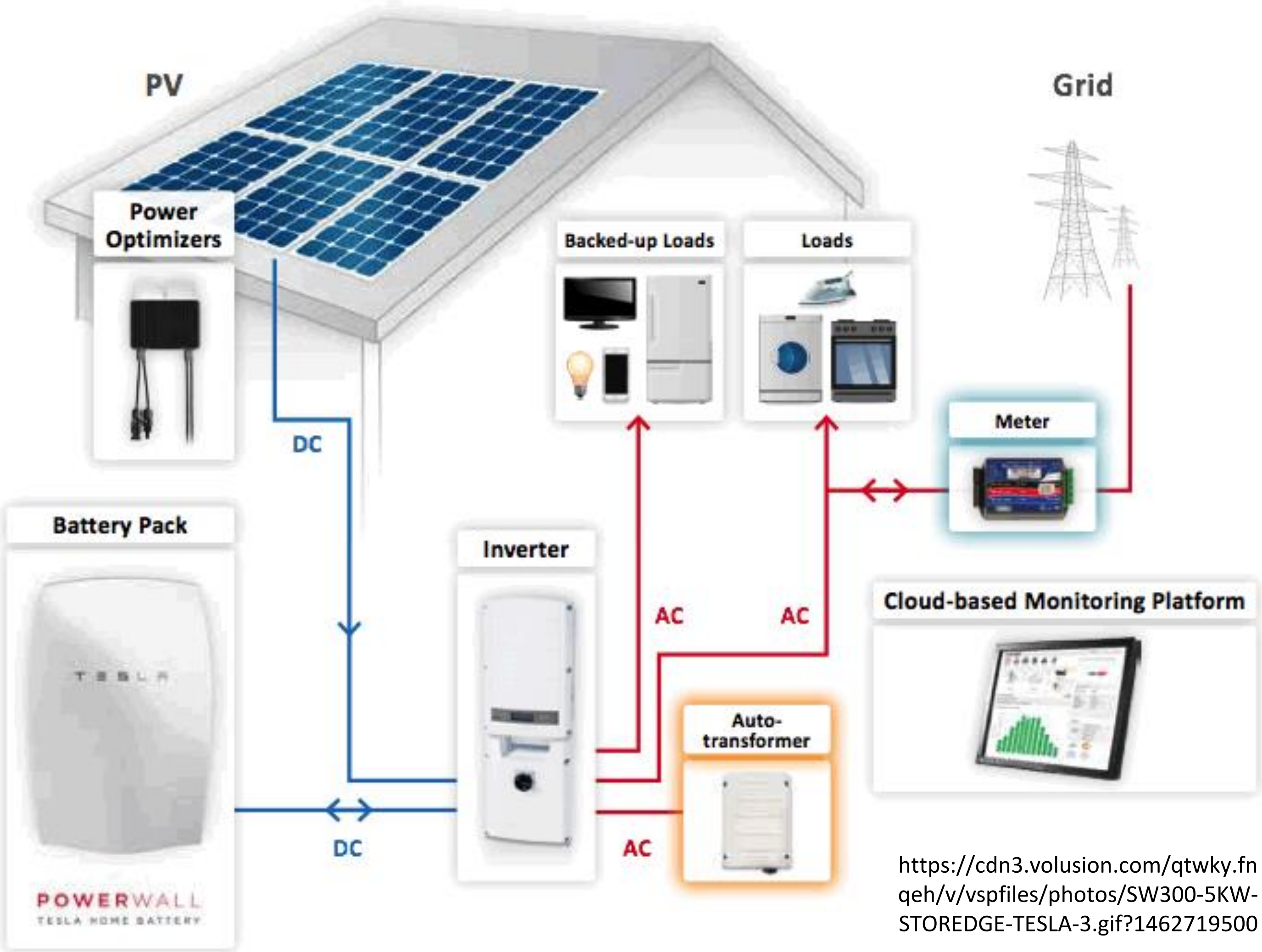
(Staffell & Pfenninger, 2018)

Energy storage

System Crailsheim © www.itw.uni-stuttgart.de







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Energy storage

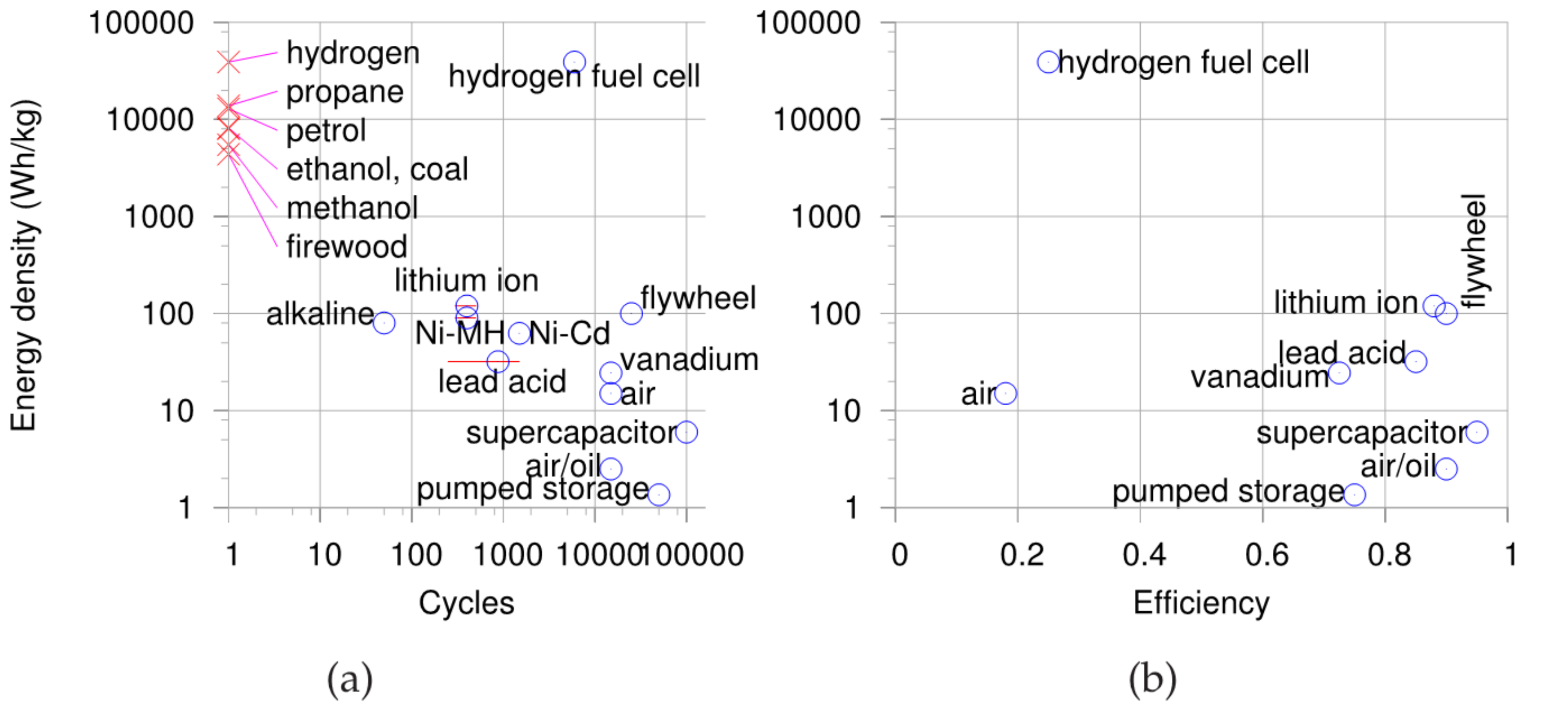

Figure 26.13. Some properties of storage systems and fuels. (a) Energy density (on a logarithmic scale) versus lifetime (number of cycles). (b) Energy density versus efficiency. The energy densities don't include the masses of the energy systems' containers, except in the case of "air" (compressed air storage). Taking into account the weight of a cryogenic tank for holding hydrogen, the energy density of hydrogen is reduced 39 000 Wh/kg to roughly 2400 Wh/kg.

Feldheim (Germany)

- **37 households**
- pop.: ~150 persons
- area: **0,5 sq km + ~15 sq km**

Heating:

Grid length: **3 km**

Cost: **1,725,000 €**

funds: **public 50% /private 50%**

Electricity:

Grid length: **7,2 km**

Cost: **400,000 €**

funds: **private loans**

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Feldheim

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Strom

Wärme

Windpark Feldheim:
42 Windkraftanlagen mit einer elektrischen Leistung von 81,1 MW (152,7 Mill kWh/Jahr), werden in Feldheim betrieben (Stand 2015).

Feldheim wind farm:
42 wind turbines with a power capacity of 81,1 MW, as well the separate power grid, are operated in Feldheim 2015.

Batteriespeicher:
Baubeginn August 2014; Kapazität: 10 MW; Lithium-Ionen-Module.
Speicherung überschüssiger Strommengen, die bei Bedarf zugeschaltet werden können.

Battery storage:
Construction starts: August 2014; Capacity: 10 MW; Lithium-ion module.
Storage of surplus amounts of power that can be brought online when needed.

Biogasanlage:
Elektrische Leistung: 526 kW; Wärmeleistung: 560 kW; Inputmaterial ist Rinder- u. Schweinegülle, sowie Maissilage und Getreideschrot als NaWaRo, die vor Ort produziert werden.

Biogas plant:
Electrical capacity: 526 kW; heat capacity: 560 kW; input material is cattle or pig slurry, as well as maize silage and crushed cereal as renewable raw material that is locally produced.

Holzhackschnitzel-Heizung:
Wird in Spitzenzeiten zur Wärmeproduktion zugeschaltet.

Woodchips:
Used during peak heating periods to produce heat.

Verbraucher, Haushalte:
37 angeschlossene Haushalte mit 145 Bewohnern.

Consumers, households:
37 connected households, with 145 residents.

Kommune:
2 kommunale Einheiten

Local authorities:
2 local authority entities.

Verbraucher, Agrarbetriebe:
3 Agrarbetriebsanschlüsse.

Consumers, agricultural enterprises:
3 farm connections.

Nahwärme-Netz Feldheim
In der Feldheim Energie GmbH & Co. KG sind Hausbesitzer, Gewerbe- u. Agrarbetriebe und die Stadt Treuenbrietzen Gesellschafter.

Feldheim local heating grid
Homeowners, businesses, farms and the municipality of Treuenbrietzen are all partners in Feldheim Energie GmbH & Co. KG.

Förderung des Fernwärmenetzes Feldheim durch:


https://nef-feldheim.info/photovoltaik/?lang=en

Feldheim

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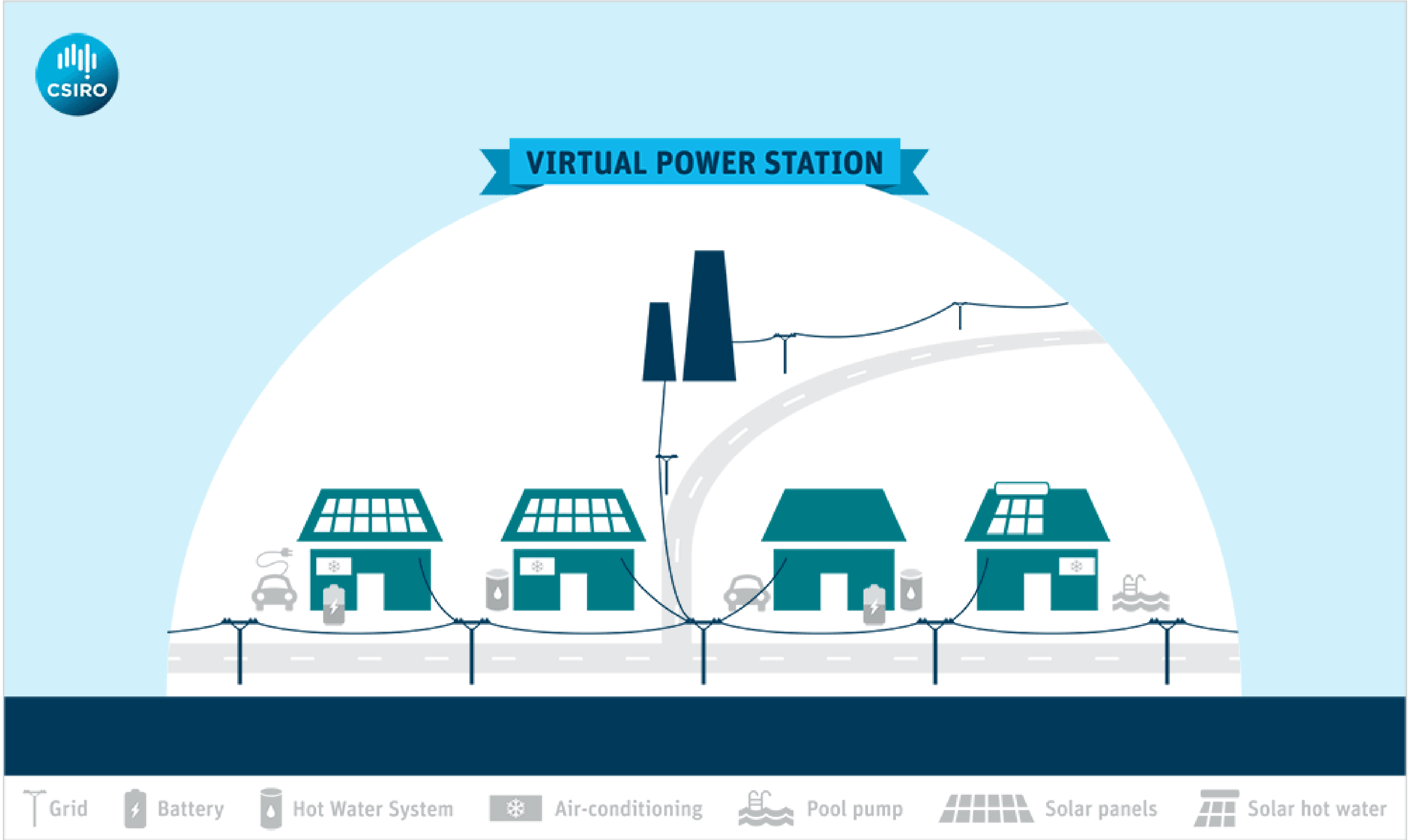
Virtual power plant



https://www.csiro.au/~/media/EF/CSIRO_VPS_Diagram_Animation_3-1000px.gif?mw=1600&hash=3C776E41DCB6C1430E653045C8933E74D833FF7D

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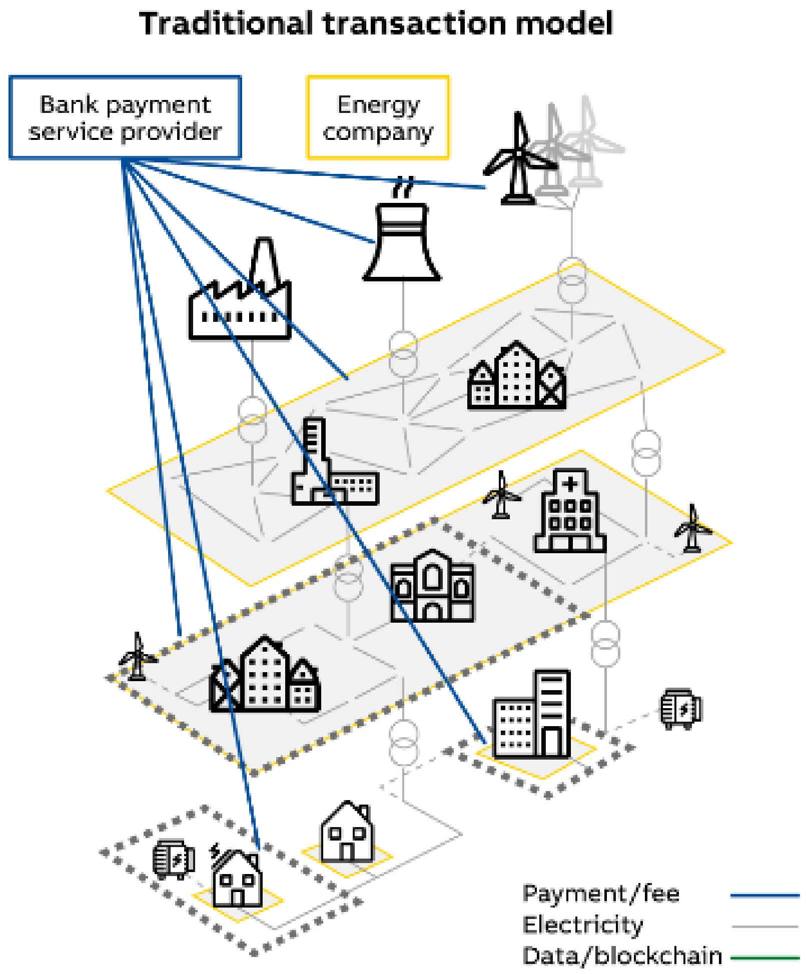
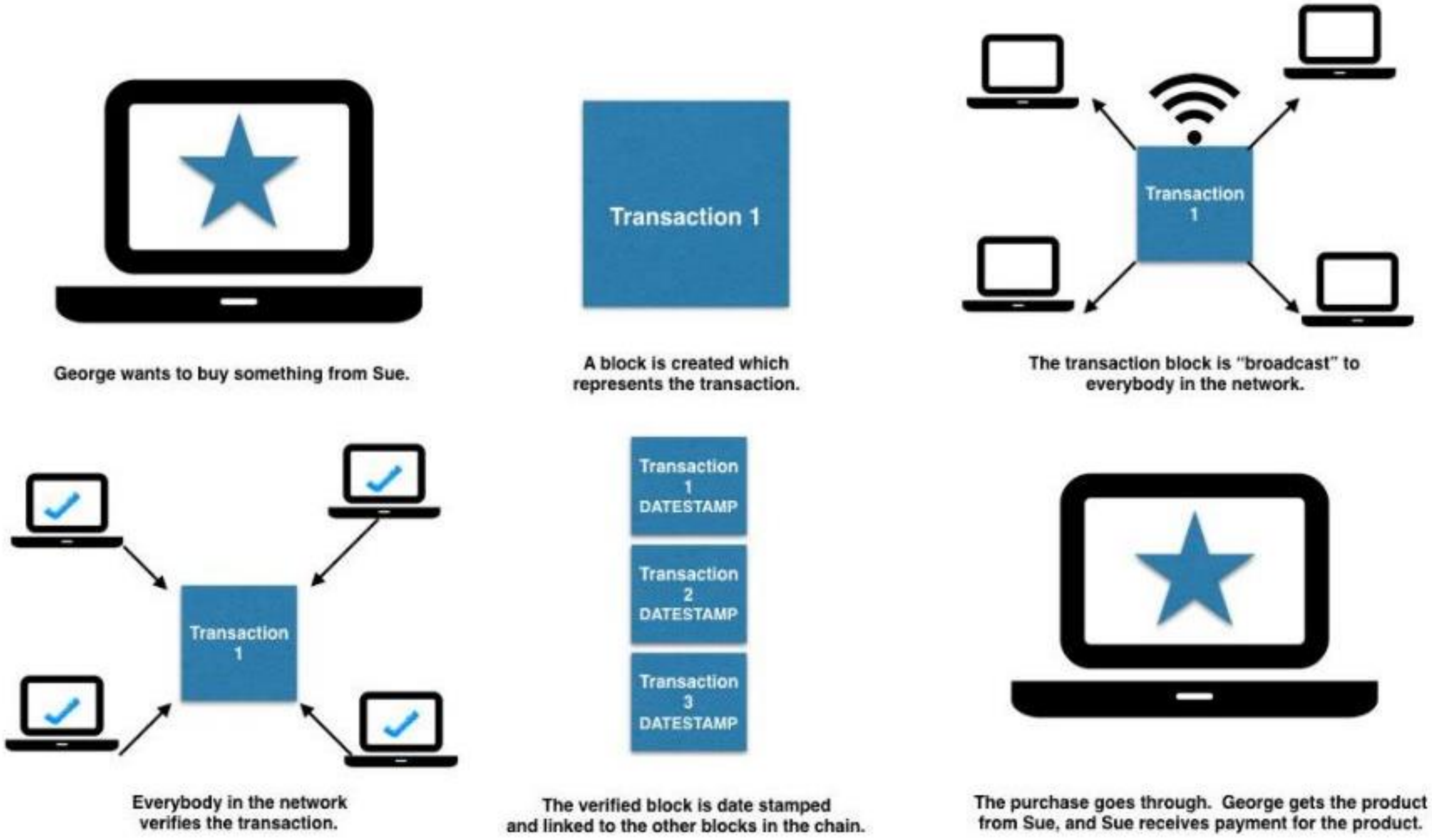
Blockchain transactions



- mechanism for secure verification of transactions
- invented in 2008 to exchange cryptocurrencies
- no intermediaries
- transparency of the entire history of transactions
- not vulnerable to hackers' attacks (Ukraine example)
- price in the transaction set automatically or manaully

http://energymarketintel.com/wp-content/uploads/2017/11/blog_blockchain-microgrids_Figure-2-Transformation-of-the-electricity-market-with-blockchain-technology.png

Blockchain transactions



http://scienceandentertainmentexchange.org/wp-content/uploads/2017/06/Blockchain.001-1024x768.jpeg

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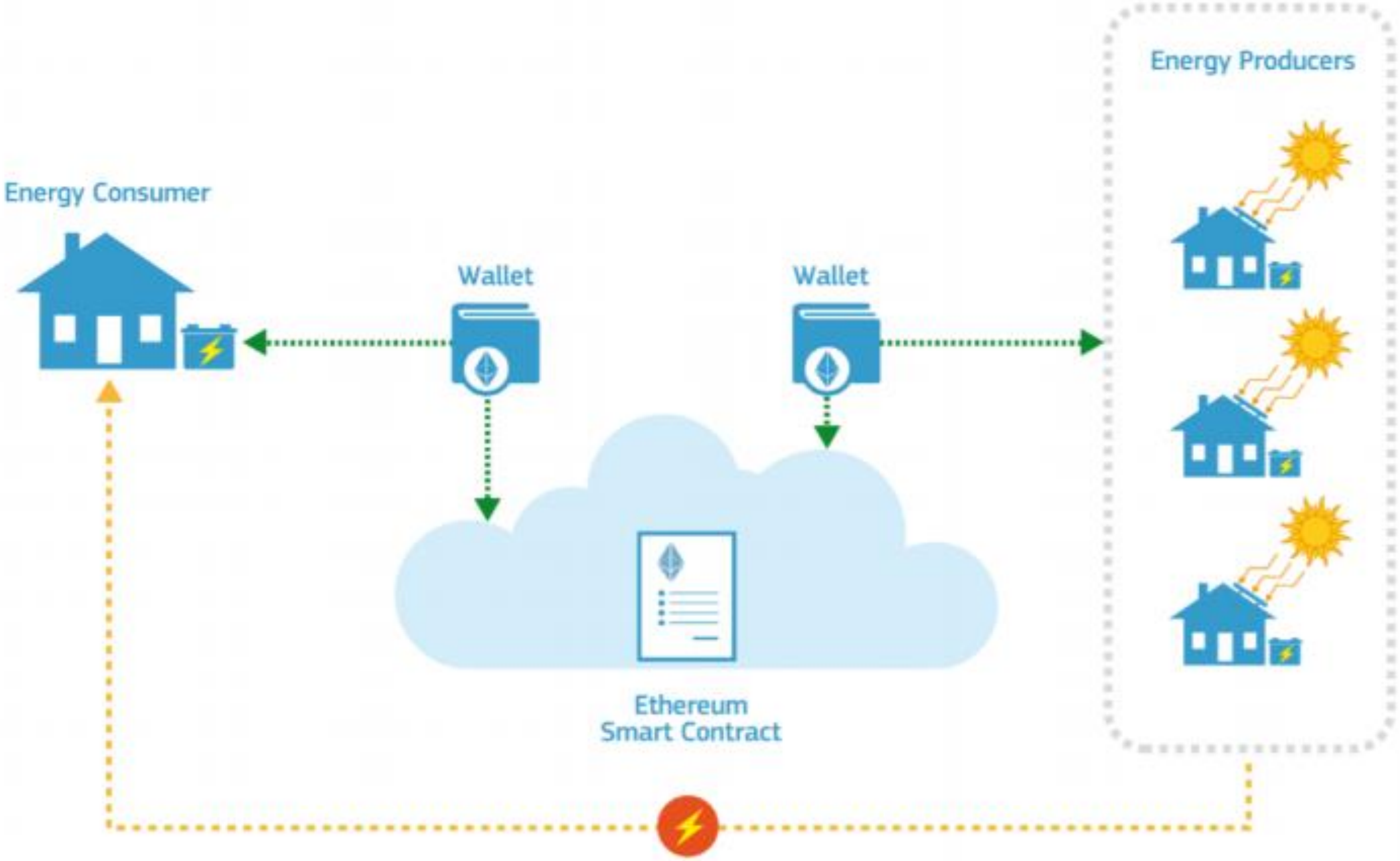
Blockchain transactions



(Ioannis et al., 2017)

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Conclusions

- motivations for achieving self-sufficiency for authorities & prosumers
  - financing sources
- going off-grid (absolute self-sufficiency) requires a lot of space and funds
- possible solutions which help achieve relative self-sufficiency (*zero net*):
  - (automatic) demand-side management ⬍
  - energy efficiency ⬆
  - energy consumption ⬇
- How local should we go? (spatial boundaries)

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