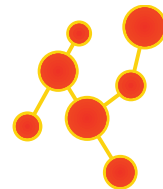


# Our future energy system: towards a 'Holonc' system!?

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**DRAFT** v1.0



**TOPSECTOR ENERGIE**

Empowering the new economy

# Characteristics current energy system

- Separate systems for energy carriers
- Dominated by fossil based energy sources
- Central production and (hierarchical) control
- Energy flow in one direction (from production to users)
- Largely based on hardware



# Energy systems of the future 1/2

## Fundamental changes

- Massive penetration of renewable energy sources (weather dependent)
- Coming from some central **and** many distributed sources
- Multiple energy carriers
- Shift in demand of energy (e.g. due to electrification of industry and transport)
- Users become also producers (prosumers)
- New 'players' become active (e.g. 'aggregators')
- Strong growth in power demand
- Digitization



# Energy systems of the future (2/2)

## Leads to:

- A complex energy system
- Unprecedented stability phenomena (power disruptions or blackouts)

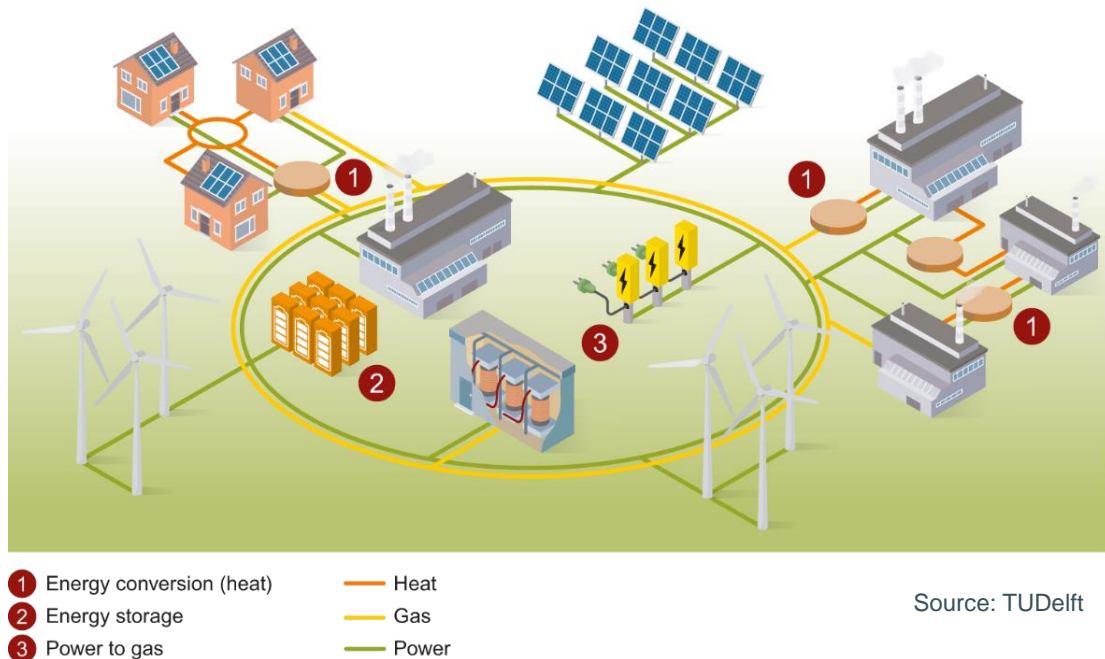
## This requires:

- New future- proof concepts for designing and controlling energy systems, to keep the system reliable, affordable and safe



# Shape of future energy system:

- Centralised **and** distributed production
- Cyber-physical systems
- Unlocking flexibility/sector coupling
- Fit for purpose, business models, laws and regulation
- Functioning by adopting a '**holarchy**' principle

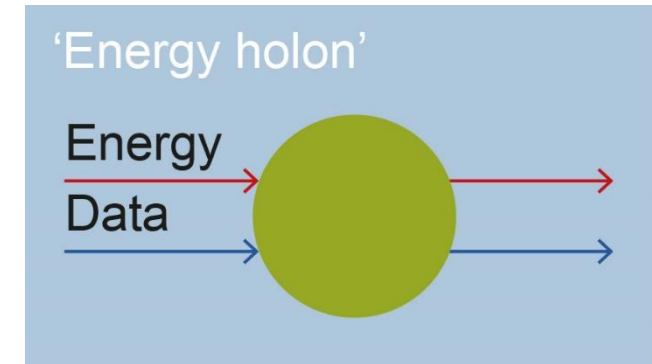
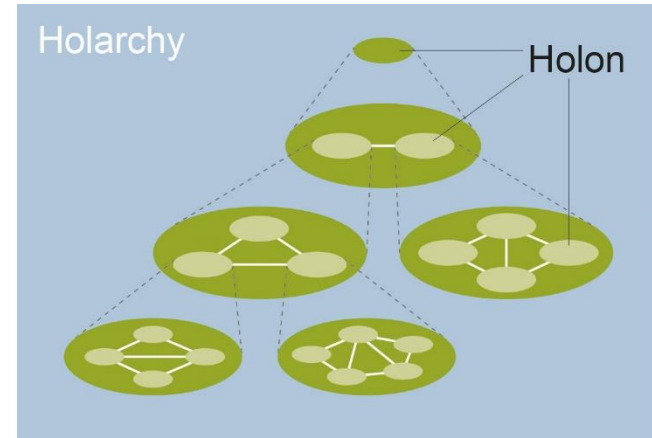


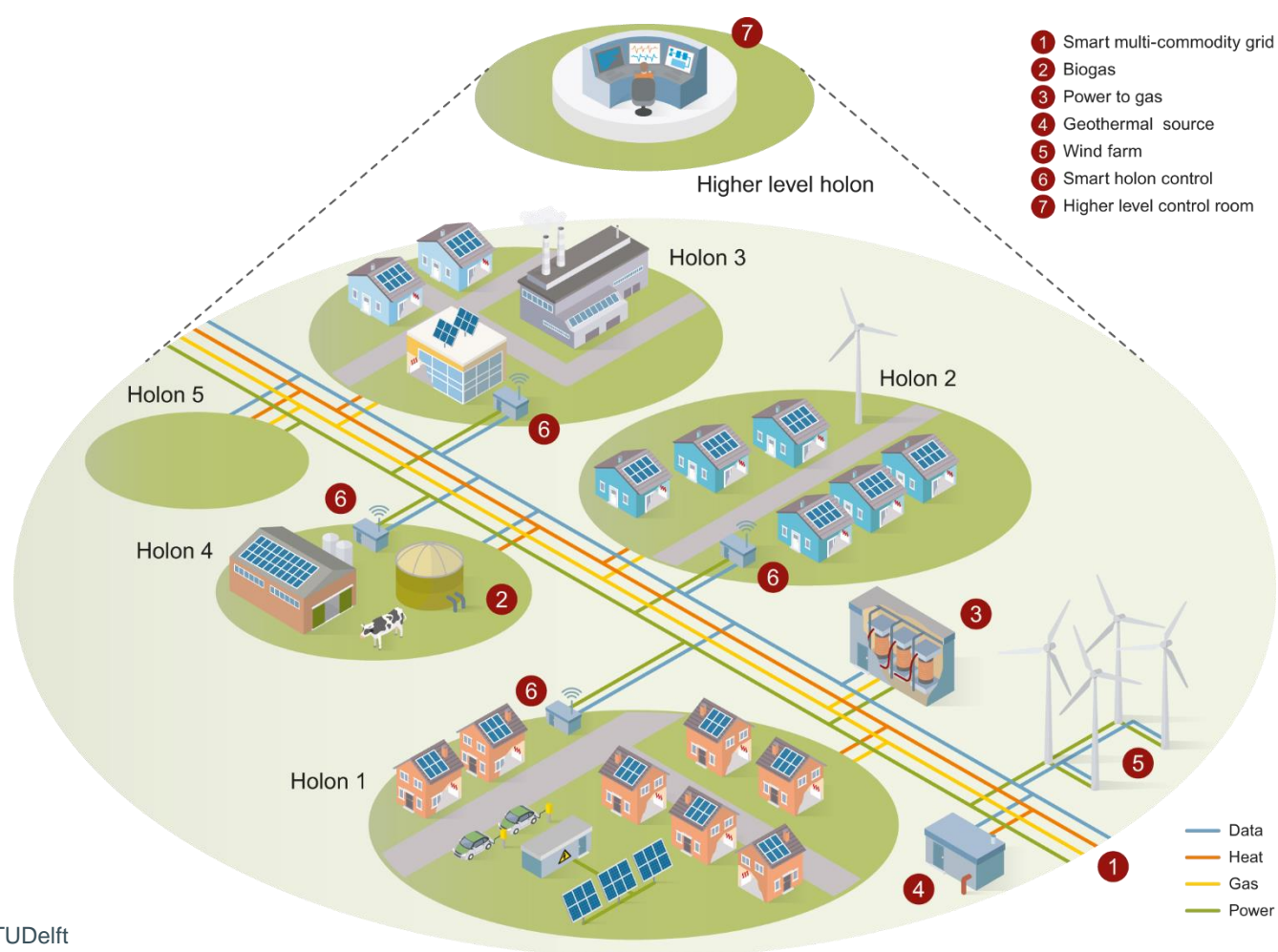
Source: TUDelft



# Shape of future energy system: 'a holarchy'

- **Holon:** an entity being simultaneously a whole and a part. Holons are self-reliant units that possess a degree of autonomy but are also simultaneously subject to control from one or more higher levels.
- **Holarchy:** a hierarchy of self-regulating holons that function first as autonomous wholes in supra-ordination to their parts, secondly as dependent parts in sub-ordination to controls on higher levels, and thirdly in coordination with their local environment.

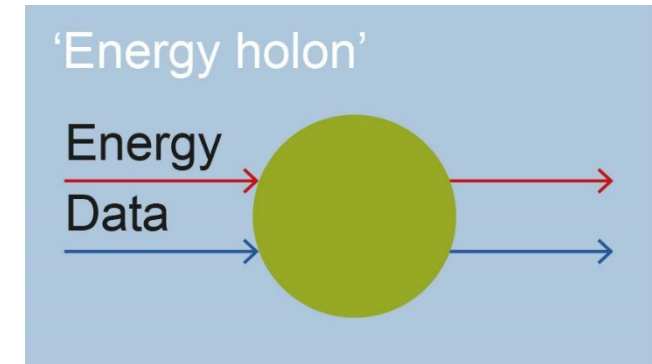
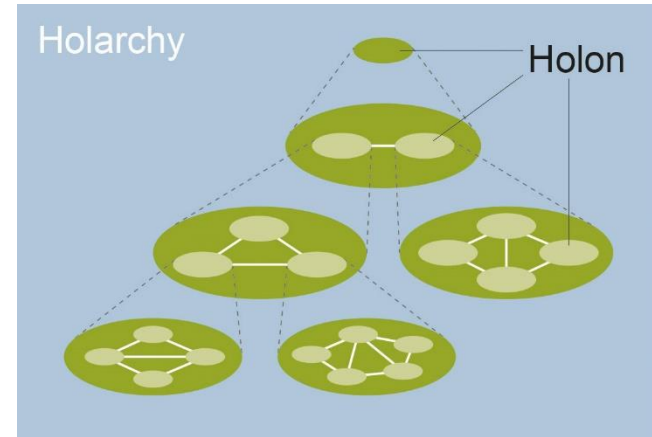




Source: TUDelft

# Characteristics energy holarchy

- Self-organizing/ optimizing and adapting
- Each holon with a certain degree of autonomy
- Multi energy carriers
- Efficient use of distributed energy sources
- Combination of hardware and software
- Energy flow without specific routes
- Distributed intelligence





# Dimensions energy holarchy

## **Technical:**

- Everything is connected
- Cyber/physical system
- Unlocking all available sustainable energy sources
- Safeguarding reliable and resilient systems

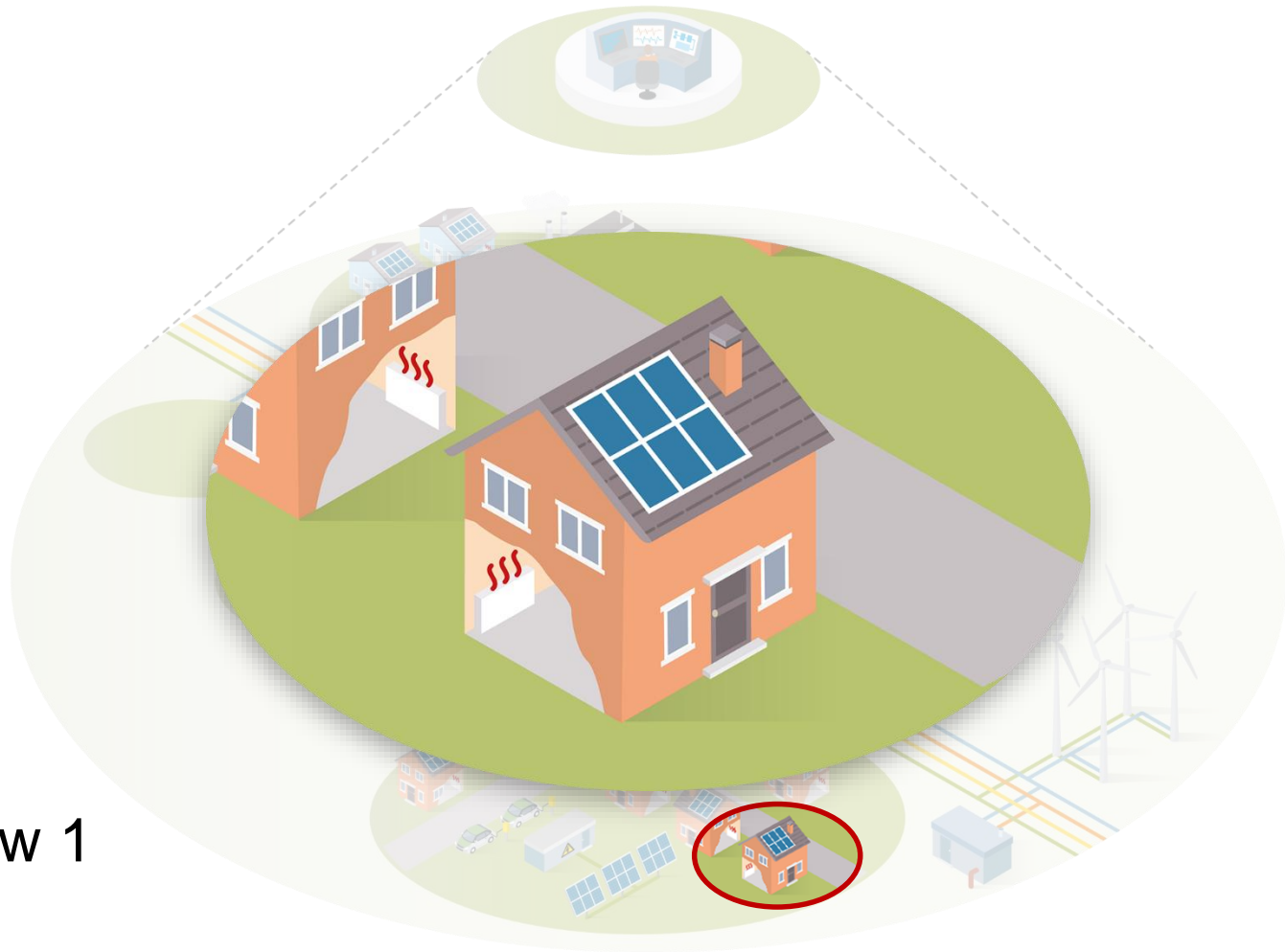
## **Economical:**

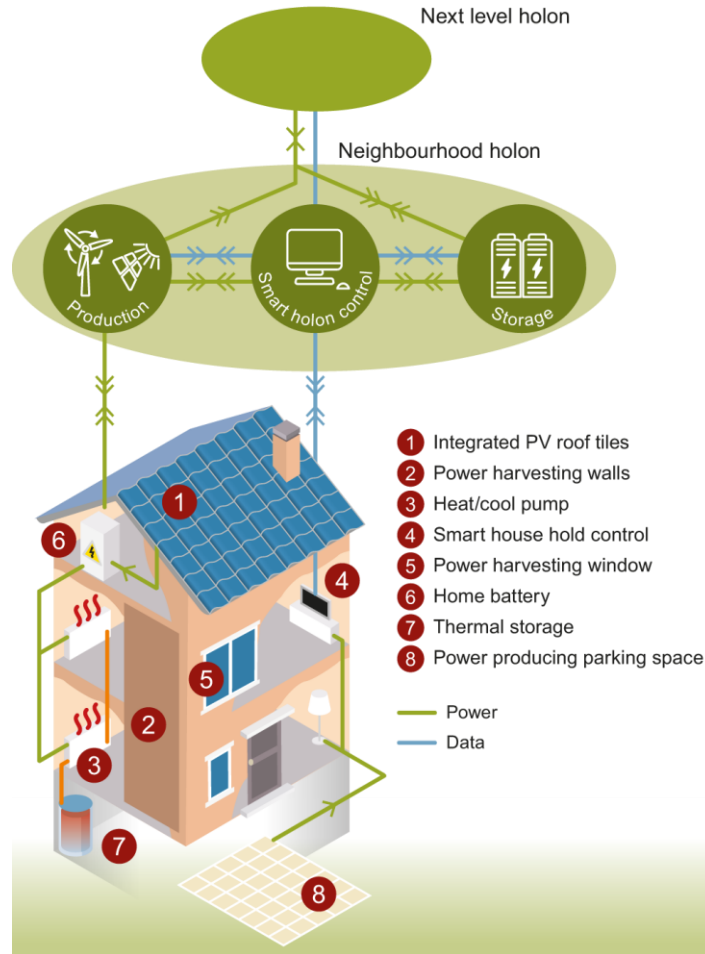
- Adopting transactive control: data driven self organising and flexible

## **Social:**

- Stepped decision making
- Customised governance
- Many options for citizen participation

# Window 1





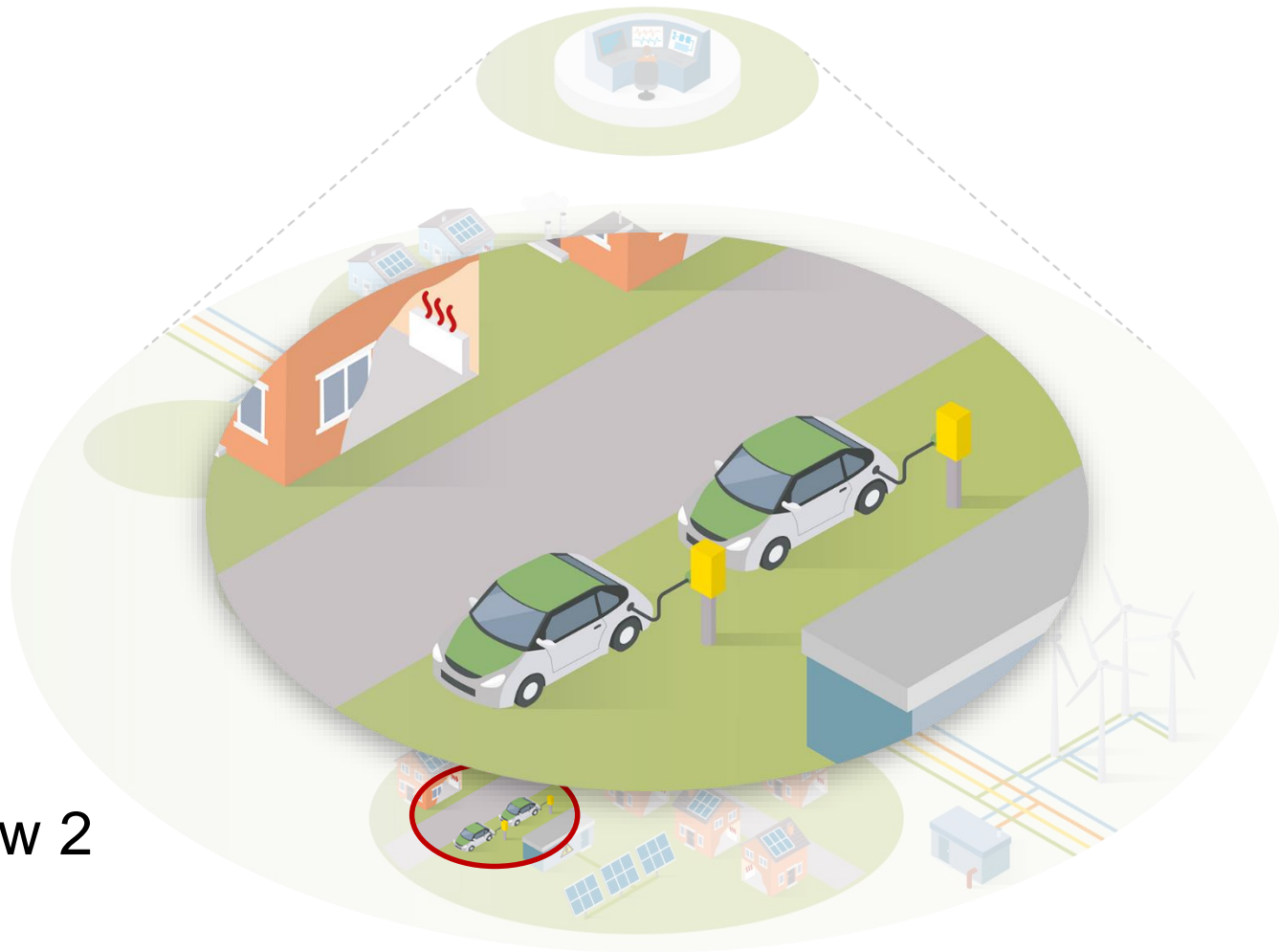
Unlocking available  
sustainable energy  
sources:

towards millions of production  
devices

# Unlocking available sustainable energy sources:

- Harvesting multiple energy sources
- E.g. power: every m<sup>2</sup> paved surface produces electricity
  - Roofs/windows/facades
  - Roads
  - Parking spaces
  - Etc.
- Network of many connected nodes
- Smart energy control

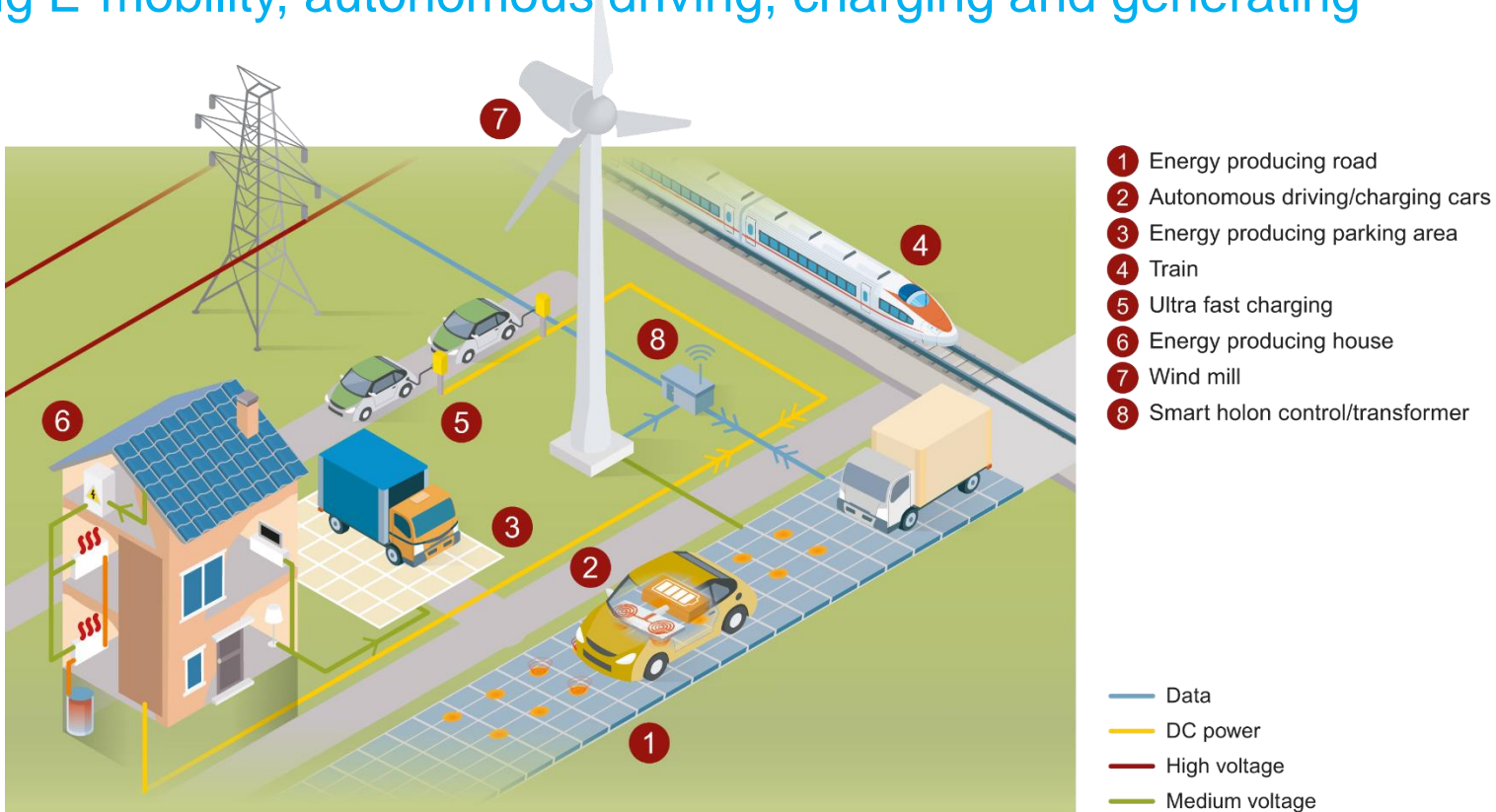
## Window 2





# Everything is connected:

Integrating E-mobility, autonomous driving, charging and generating energy

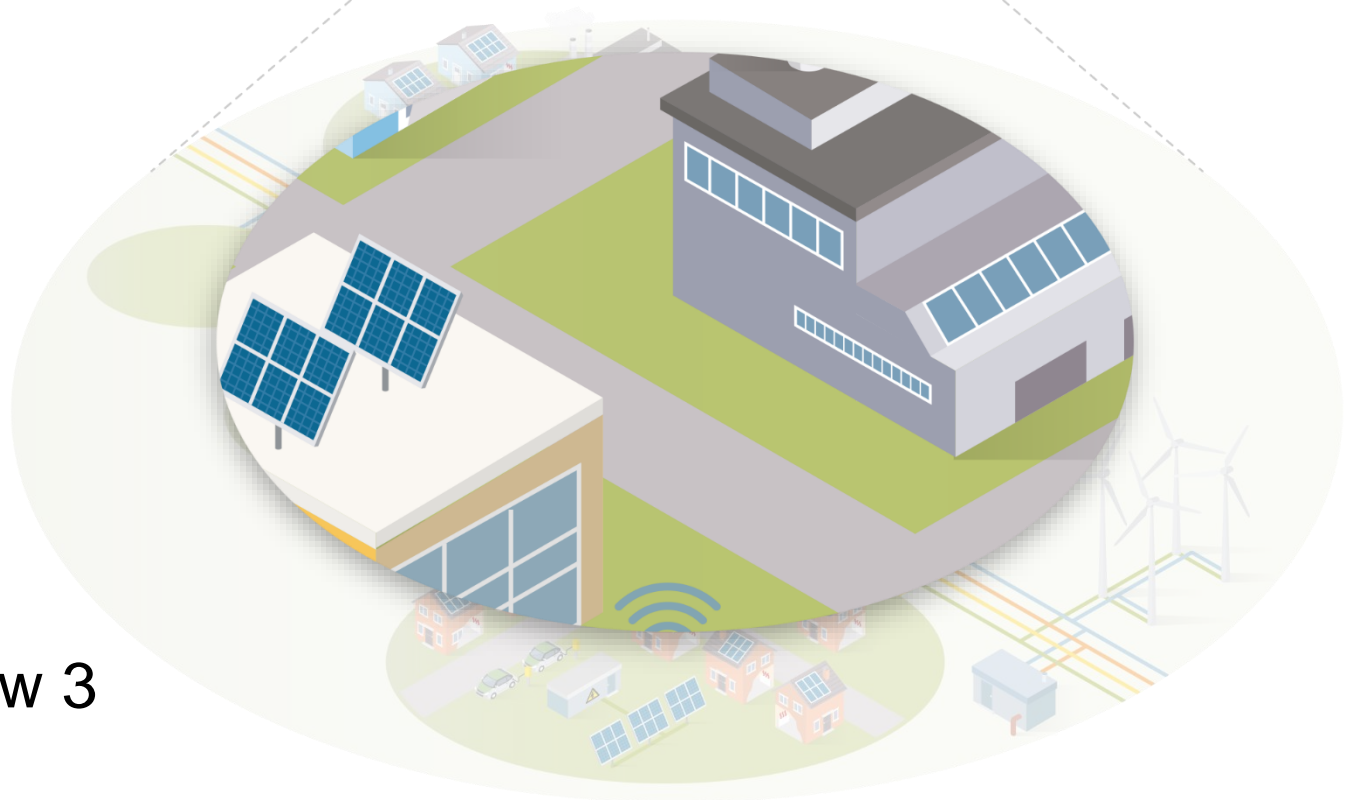


Source: TUDelft

# Everything is connected:

Integrating E-mobility, autonomous driving, charging and generating energy

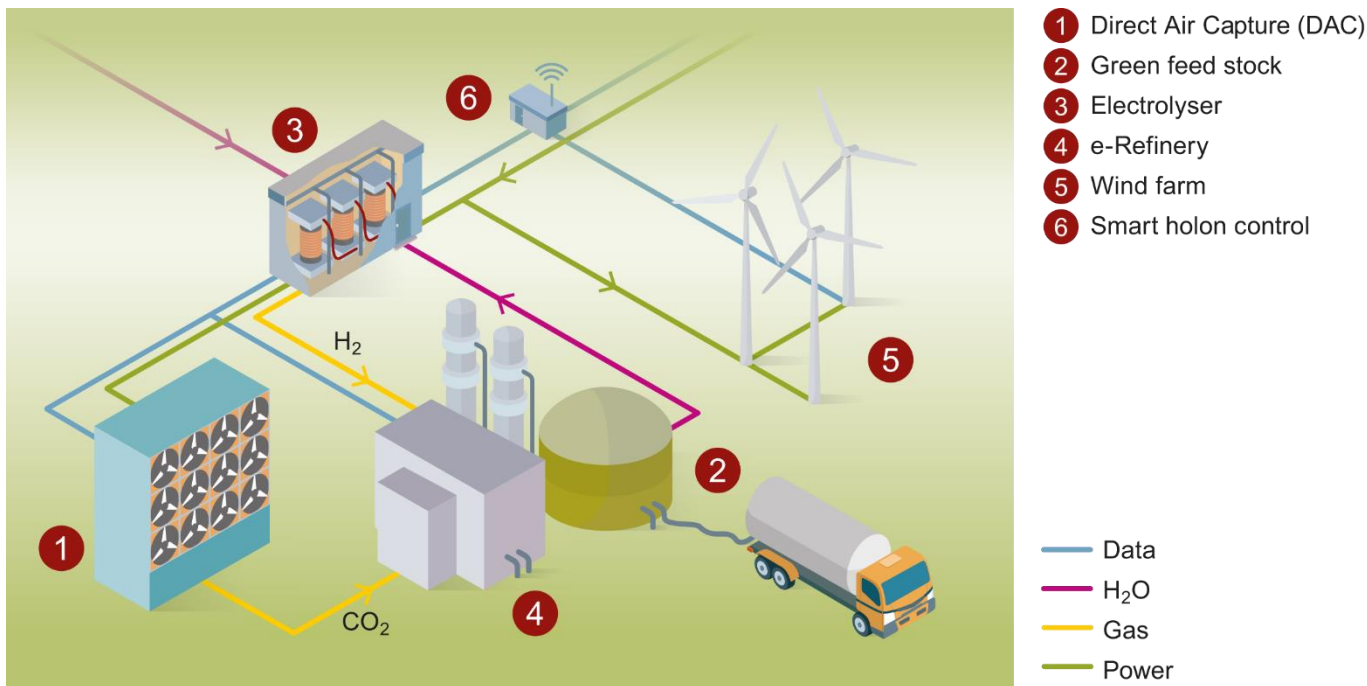
- multiple energy sources
- Local storage and/or conversion of energy
- Unlocking flexibility (demand response, batteries etc.)
- Smart residential and commercial buildings
- Direct current (microgrid) systems
- Autonomous and self driving vehicles
- Contactless charging vehicles/ efficient and (ultra)fast battery charging



Window 3

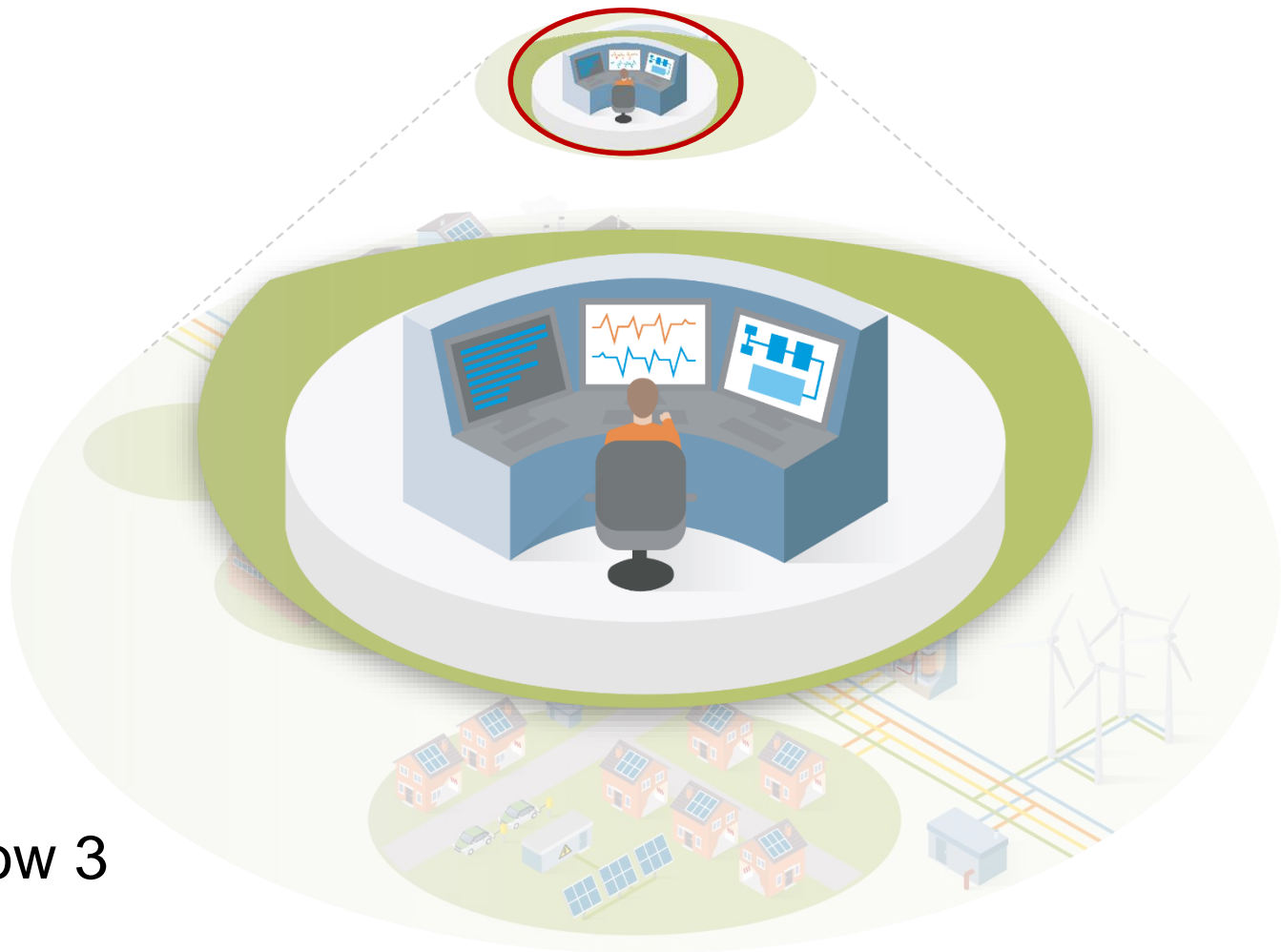
# Storage is key:

more efficiency, intelligent, compact, safe and reliable



Source: TUDelft

Window 3

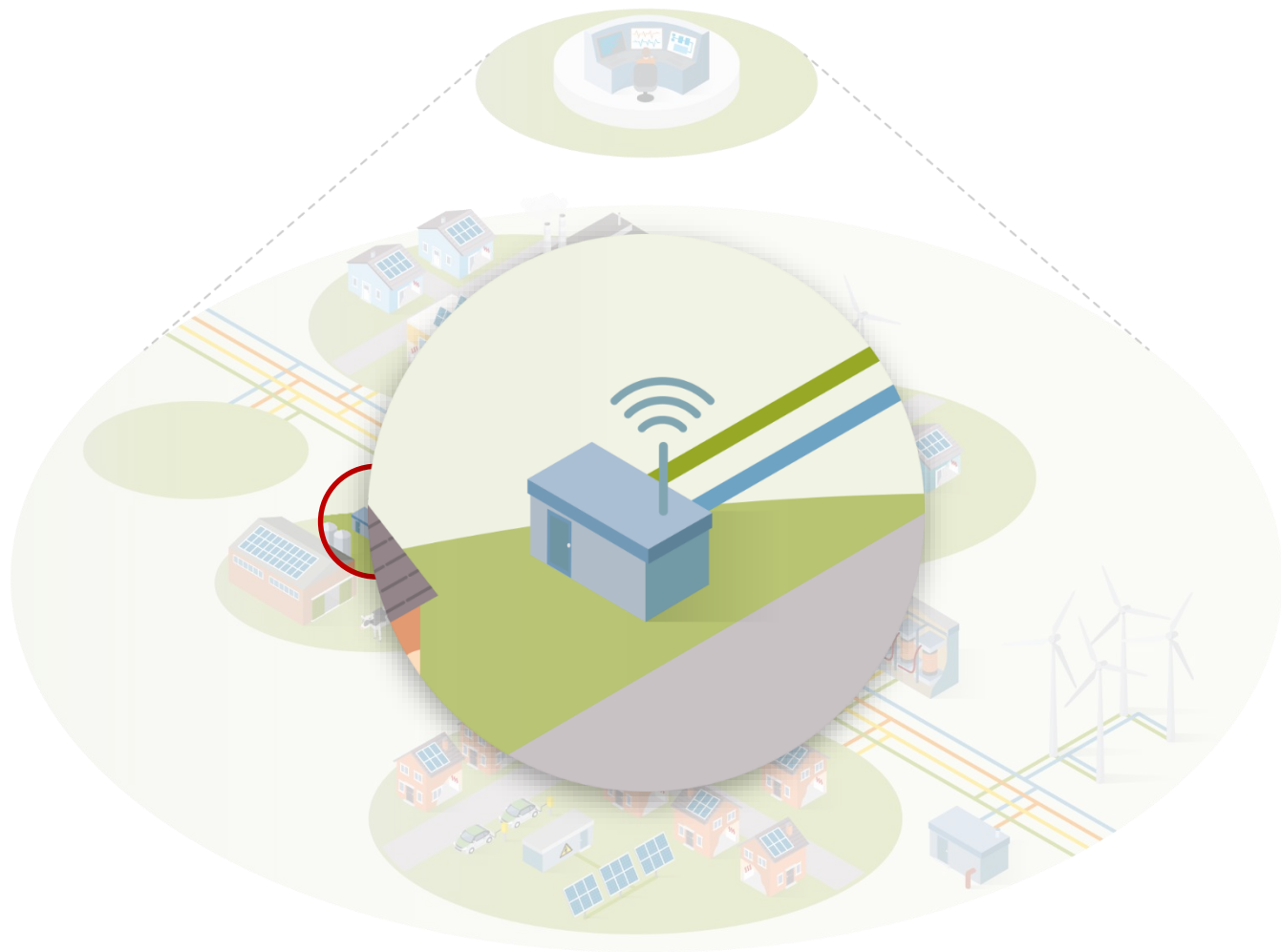






# Adopting transactive control: data driven, self-organizing and flexible

- Cyber-physical system
- Cyber-security
- Planning, operations and market integration
- Cloud-based control infrastructure
- Aggregation and disaggregation of flexibility
- AI and machine learning



Source: TUDelft

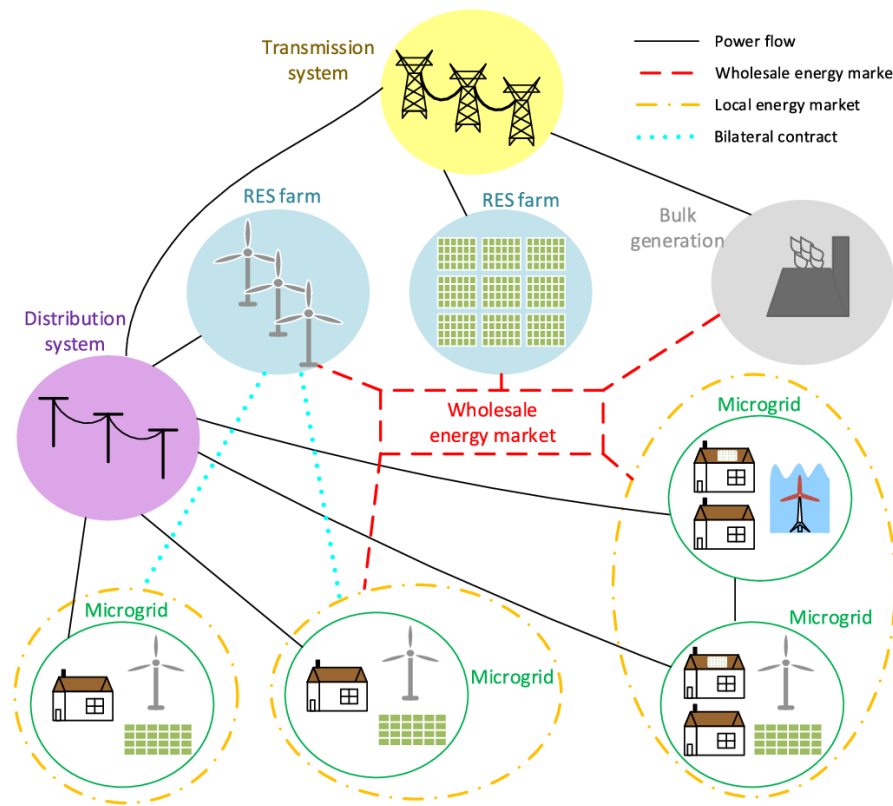
# Safeguarding reliable and resilient systems

System reliability enhancement by early detection and avoidance of possible catastrophic events

- Real time monitoring
- Cyber security and resilience to cyber attacks
- Failure and risk analysis

# Transactive energy

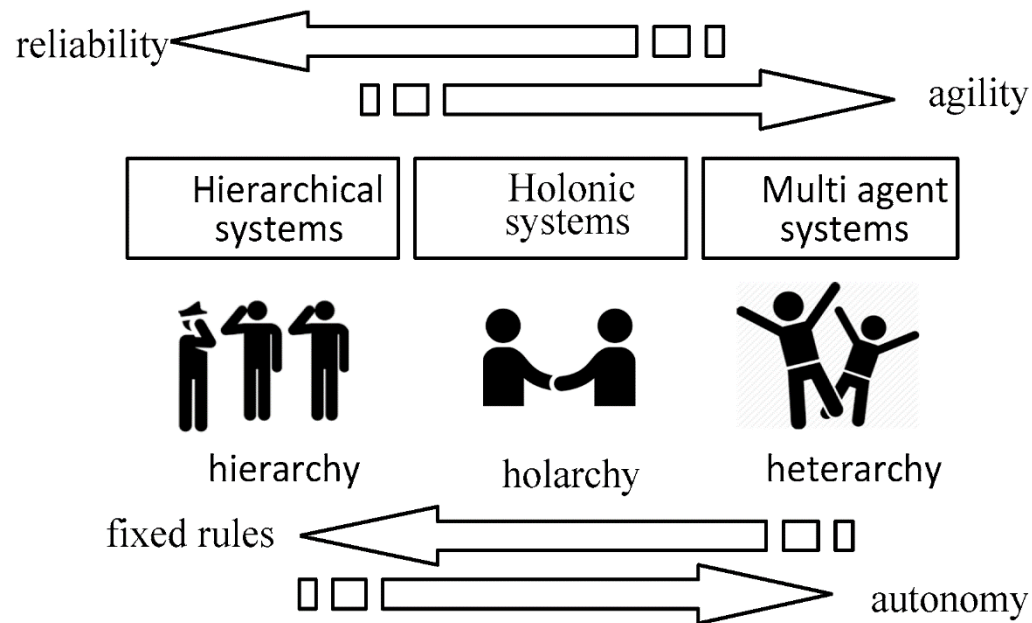
- Flow or exchange of energy within an energy system based on economic incentives
- Anyone can trade energy on the grid
- IoT and smart devices are mandatory
- Blockchain based?





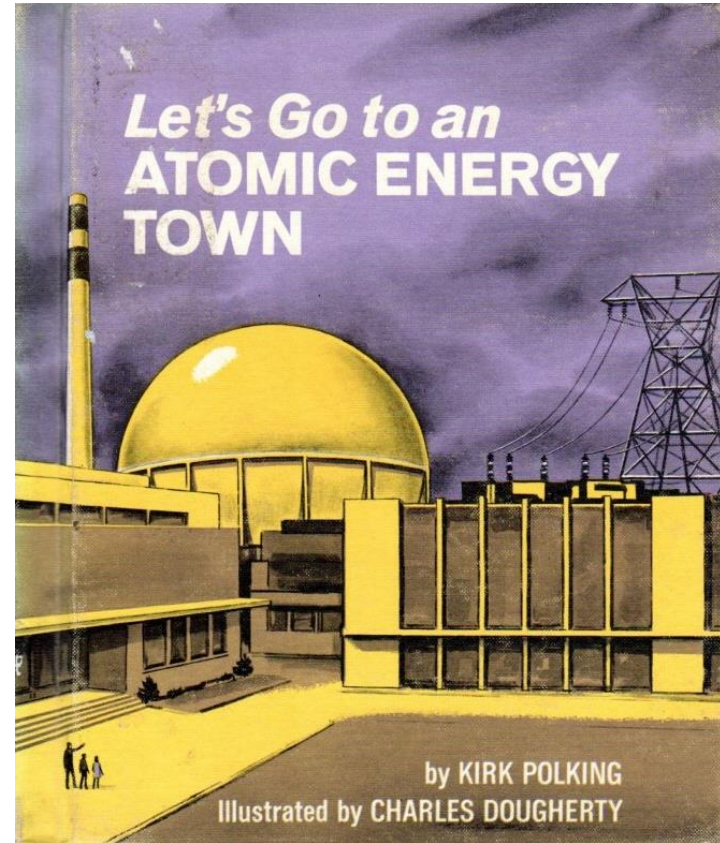
# Decision making

- Based on Holonic principles
- Chain of responsibilities geared to each holon, or level of holons
- Plenty options for tailor-made arrangements



all true, but .....

Prediction  
is very  
difficult,  
especially  
if it's about  
the future.  
- Niels Bohr





Thanks for your attention