Energy Hubs

Key for a successful energy transition

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Shape of future energy system:

• Massive penetration of renewable energy sources (weather dependent)

• Centralised and distributed production

• Multiple energy carriers

• Unlocking flexibility

• Cyber-physical systems

• Fit for purpose, business models, laws and regulation
The energy system is becoming complex: Integrated infrastructure

Low-carbon energy sources

- Solar
- Wind
- Geothermal
- Residual heat
- Biomass

Energy grids/systems

- Electricity grid
- Hydrogen grid
- Gas-grids
- Thermal grid

Energy demand (electricity, gas, heating/cooling, transport)

- Fuel cells
- ‘Power to gas’
- Steam-reforming
- Heat storage
The energy system is becoming complex: Energy Hubs

Input
- Electricity
- Gas
- Heat

Energy Hub
- Conversion
- Storage
- Infrastructure
- Smart Control

Output
- Electricity
- Gas
- Heat
Wind farms
Converter (AC/DC)
Substation
Electrolyser
1. Direct Air Capture (DAC)
2. Green feedstock
3. Electrolyser
4. e-Refinery
5. Wind farm
1. Wind farms
2. Electrolyser
3. Battery storage
4. Smart Control
5. Short distance e-transport (‘last mile’)
6. Electric charging plaza for passenger cars
7. Hydrogen fueling station
8. Electric charging plaza for heavy duty vehicles
9. Charging facility for buses

- Gas
- H₂O
- Electricity
It’s beyond traditional sector coupling

Mobility Hub

1. Parking
2. Train station
3. Bus station
Energy hub

Mobility hub
Governance model supporting Energy Hubs

- Supporting both central orchestration by the state and decision space at local and regional levels.

Reliability  
Hierarchical systems  
Hierarchy  
Fixed rules

Agility  
Holonic systems  
Holarchy

Autonomy  
Multi agent systems  
Heterarchy
What is 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:
  1. As autonomous wholes in supra-ordination to their parts
  2. As dependent parts in sub-ordination to controls on higher levels,
  3. In coordination with their local environment.
Characteristics energy holarchy (1/2)

- Self-organizing/ optimizing and adapting
- Combines as much as possible demand and production of energy
- Efficient use of distributed energy sources
- Each holon with a certain degree of autonomy
- Energy flow without specific routes
Characteristics energy holarchy (2/2)

- Cascaded decision-making
- Tailored decision-making possible (e.g. cooperative community)
- Data-driven
- Many opportunities for citizen participation
- Different business models possible
Example
Source: TUDelft
Requirements

• Technical proven and tested systems (hardware and software)
  Pilots and demo’s

• Business models supporting investments in and use of Energy Hubs

• Legislation and regulation supporting semi-autonomous systems (Holonic model)

• Skilled labour force on academic, higher professional and secondary vocational education
Labour force: present state

Aantal openstaande vacatures voor de relevante technische beroepen in de gebouwde omgeving
2016 – 2021 (per kwartaal) en aantal vacatures 2021 3e kwartaal

<table>
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<tr>
<th>Beroep</th>
<th>Aantal</th>
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<td>1 Werkvoorbereiders en calculatoren bouw en installatietechniek</td>
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<td>2 Loodgieters, installateurs gawalo</td>
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<td>3 Timmerlieden burgerlijk en utiliteit</td>
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<tr>
<td>9 Tekenaars en constructeurs bouwkunde</td>
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<tr>
<td>10 Managers bouw en installatiewerk</td>
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Labour force: future prospect

10,000 en vakmensen nodig voor energietransitie

bron: Klimaatbeleid en de arbeidsmarkt, verkennende studie naar de werkgelegenheidseffecten van CO₂-reduktiemaatregelen (feb 2021, Ecorys), visualisatie NVDE
Worrisome situation calls for unorthodox measures

- Education
- Retraining
- Digitization
- Innovative methods to reduce labour force (plug & play solutions)
- Innovative training and education methods
  → Learning communities
Thank you for your attention!

Graphic design:
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