MODELLING ENERGY SYSTEMS

- OR –

THE LINGUA FRANCA FOR THE ENERGY TRANSITION

Drs. E. Werkman
Dept. of Monitoring & Control Services
TNO – Dutch Institute for Applied Scientific Research

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THE NEED FOR INFORMATION EXCHANGE

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- Energy Transition requires extensive information exchange
  - Infrastructure:
    - Who can share a heat network topology with me?
    - Matlab table with nodes and edges?
    - Shapefile?
  - Profiles
    - CSV, Comma, Semi-colon, Thousand-separator, Excel, Language-dependent
    - Giga Joules or GWh, tce?
    - UTC, Daylight savings?
  - KPIs, Facts
    - Price of assets
    - Emissions
    - Data source references

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 \\ -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & -1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \end{pmatrix}$$

$$B = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \end{pmatrix}$$


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A LANGUAGE FOR ENERGY

- We communicate the energy transition in:



- Smart Energy Systems require system integration
  - (Simulation) models need to be integrated, but how?
  - Co-simulation

- People use language to exchange information
  - English is a common natural language

- Wouldn't it be nice if we would invent a common digital language for our energy transition?

INFORMATION REQUIREMENTS

- System integration is complex
  - Lots of dependencies and relations

- Objective and complete information basis
  - Many asset types (pipes, cables, wind turbines, P2H, …)
  - Different scales (house/street/municipality/region/country)
  - Spatial – Geografical information (location, area, …)
  - Potential – Geothermal, Waste energy, Wind, Solar
  - Measures – deploy heat network, add wind turbine
  - Key figures – Cost, KPIs, References
  - Profiles – Static data, dynamic data
  - Energy carriers – Natural gas, H2, coal, heat, electricity

ENERGY SYSTEM DESCRIPTION LANGUAGE

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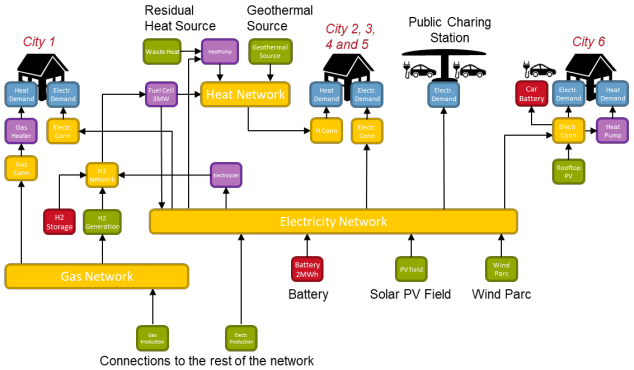
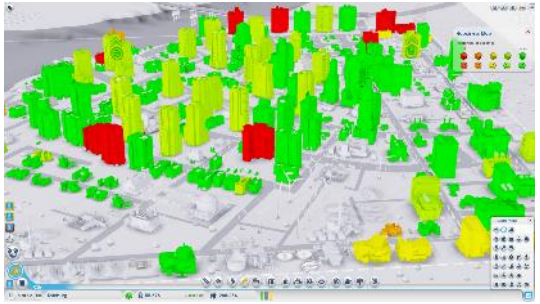
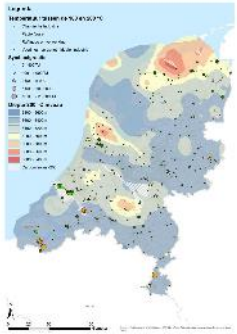
Describe energy system components

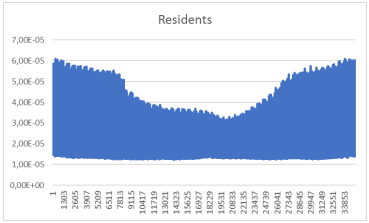


Describe geographical information



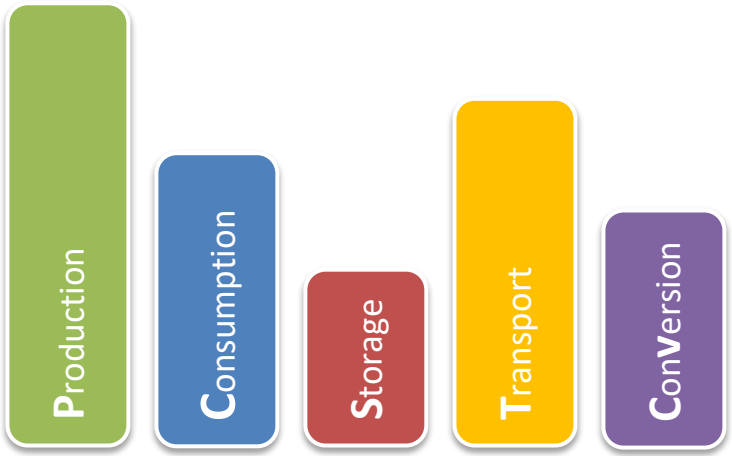
Describe profiles and potential





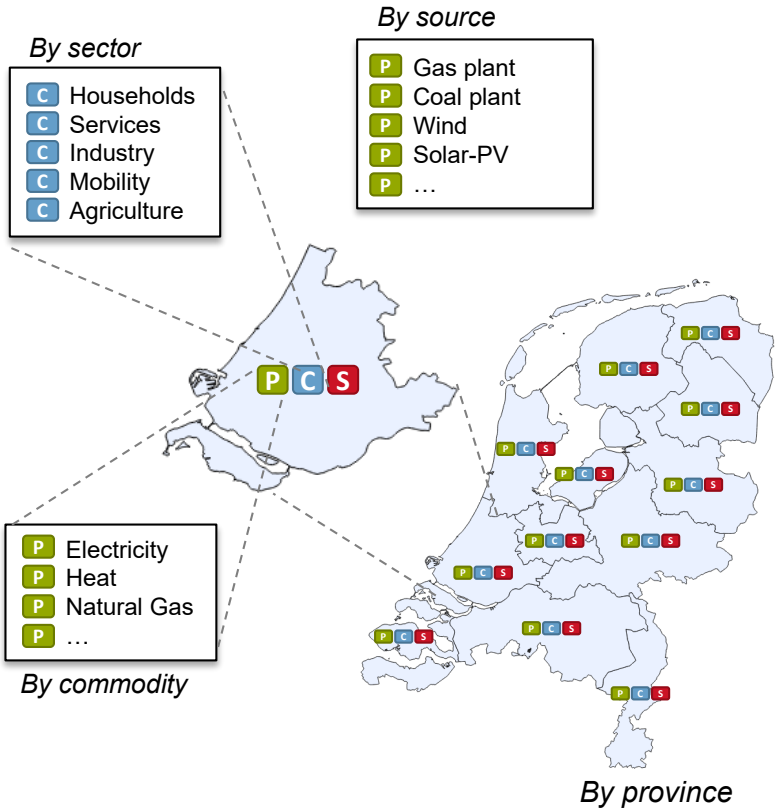
Describe solution space

CAPABILITIES OF AN ENERGY SYSTEM

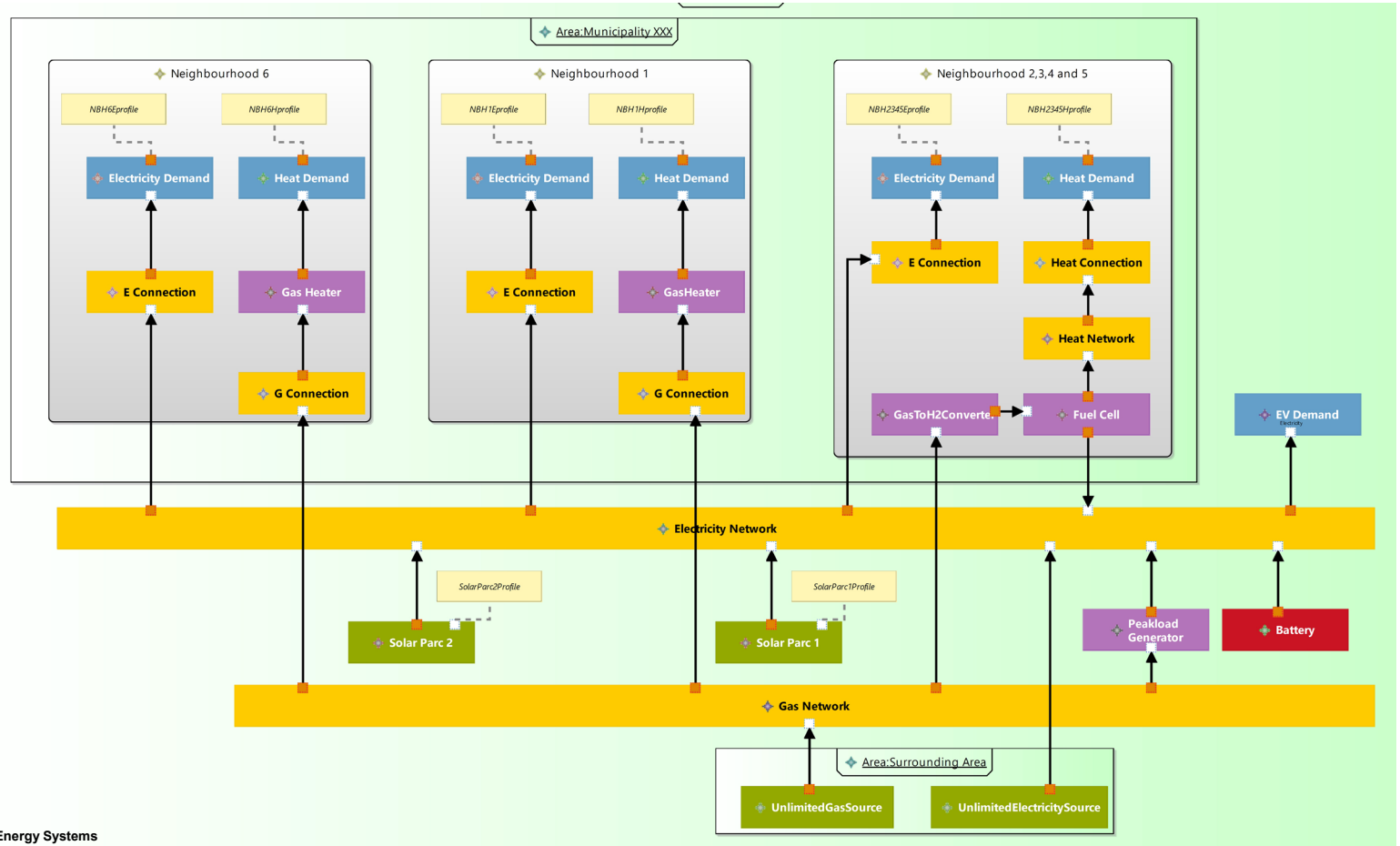


- **Production**: The ability to produce energy
- **Consumption**: The demand for energy
- **Storage**: The ability to store energy
- **Transport**: The ability to transport energy
- **ConVersion**: The ability to convert energy

Aggregate:



A PART OF A CITY



A HEAT NETWORK

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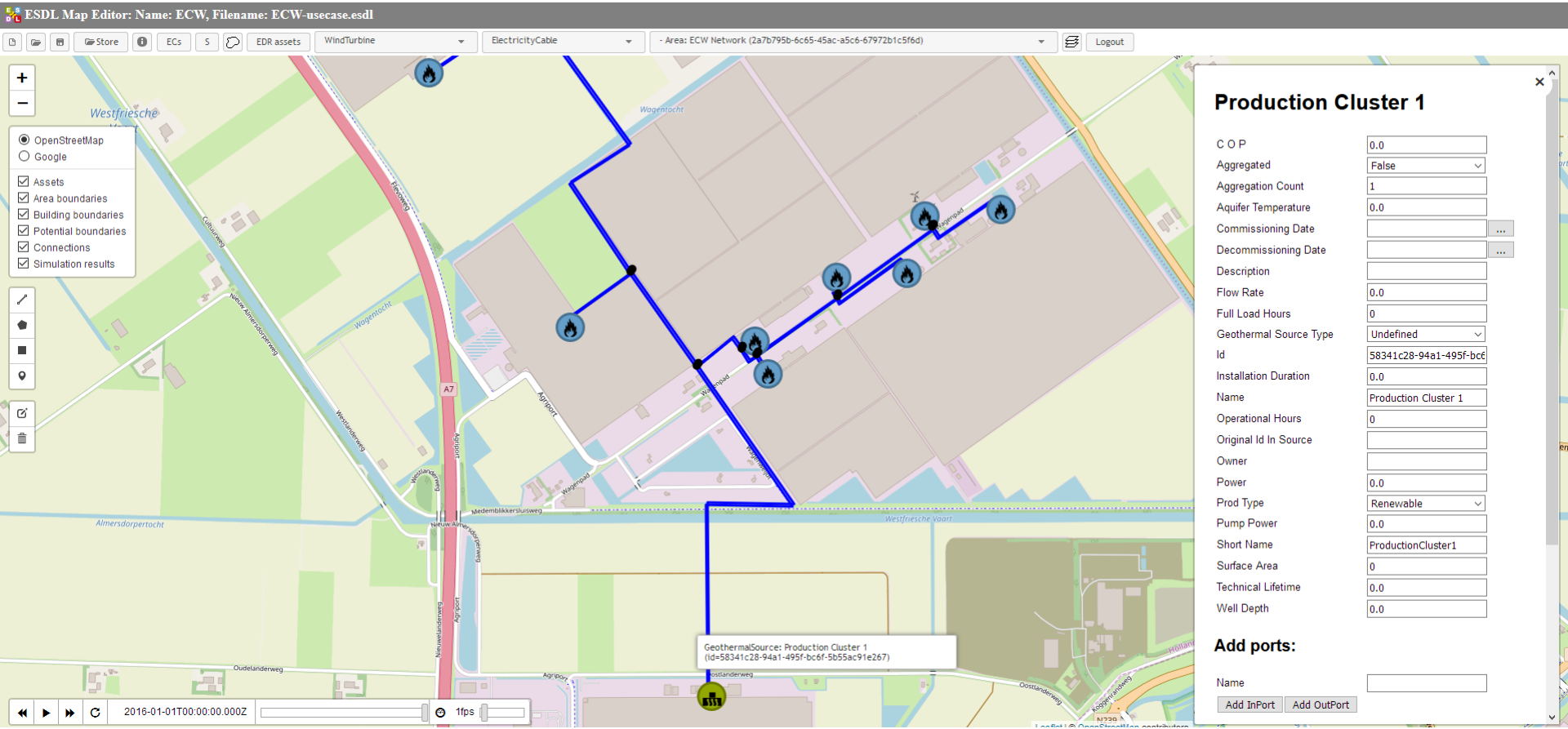

STATUS

- Digital languages need tool-support to get adopted
  - Open sourced at https://github.com/EnergyTransition/ESDL
  - Extensive documentation at https://energytransition.gitbook.io/
  - Detailed class documentation at: https://energytransition.github.io/
  - Extensive tooling
    - Web-based editor with GIS support: https://mapeditor.hesi.energy/
    - Eclipse visual plugin
    - Matlab plugin
    - Python and Java libraries

- What happened at TNO?
- ESDL adoption in one year in a dozen tools
    - Better integration of our toolsets
    - Better understanding
  - Several projects with external partners
    - EnergyTransitionModel / PICO / VESTA

ESDL compatible tools within TNO	
HeatMatcher	Heat Network Controller
CHESS	Heat Network simulator
GEIS	Geographical Energy Information System
EDR	Energy Data Repository
EYE	Electricity price forecaster
DIDO	Agent-based investment model
Waterbattery	Storage tank calculator
ESSIM	Energy System Simulator

THANK YOU FOR YOUR ATTENTION

Ewoud Werkman
ewoud.werkman@tno.nl

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Take a look:
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