Interreg North-West Europe D2Grids
European Regional Development Fund

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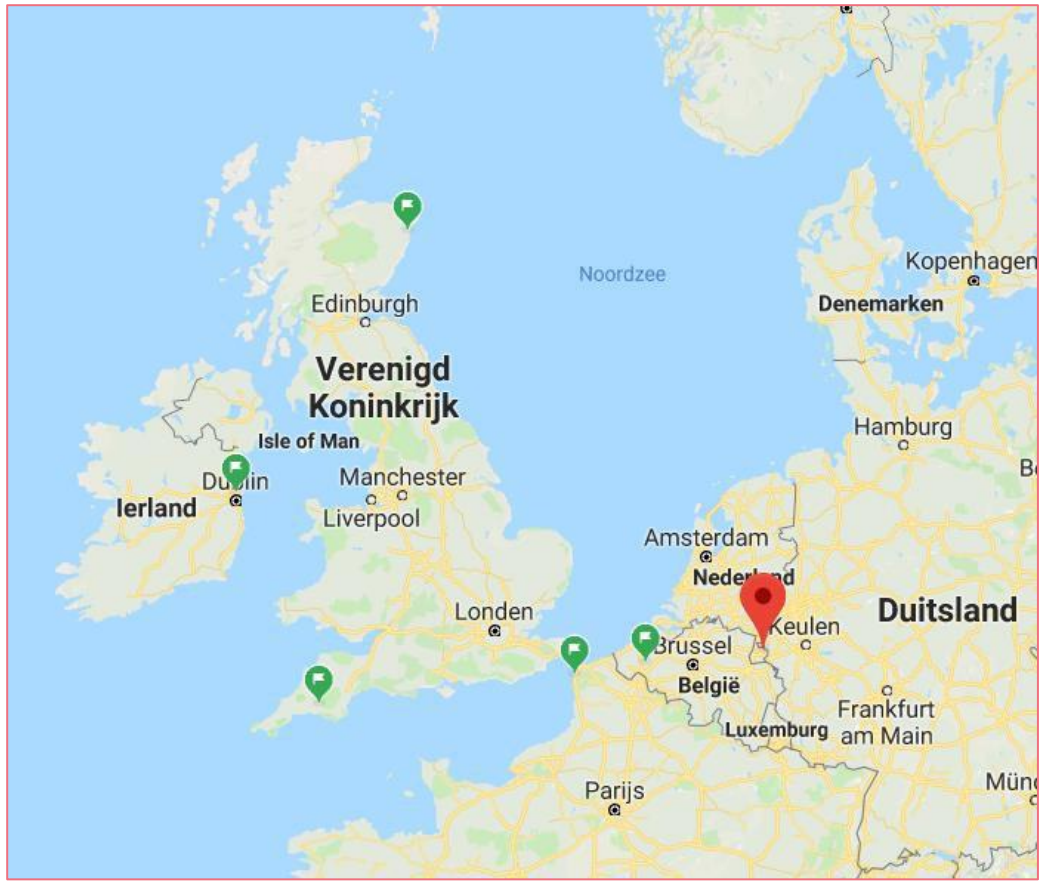

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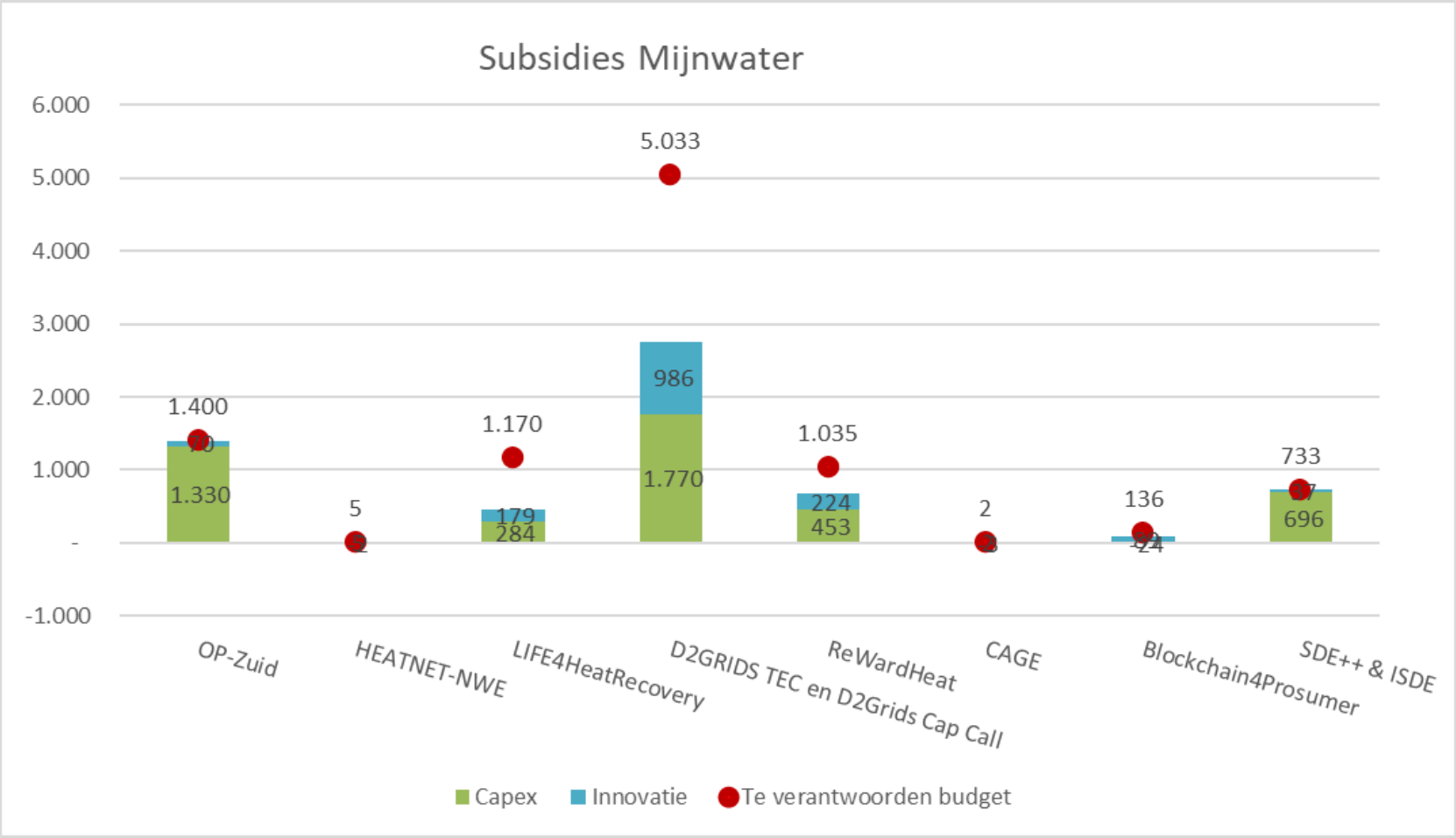
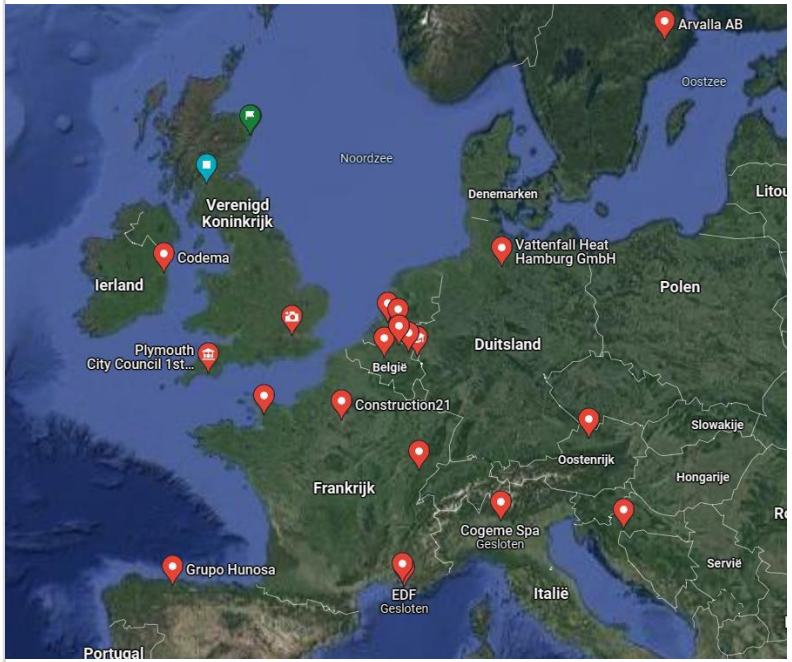
Interreg North-West Europe HeatNet NWE

OPZuid Europees Innovatieprogramma Zuid-Nederland

Life

D2Grids within Mijnwater Innovation





Partnerships with > 60 institutes/cities in Europe

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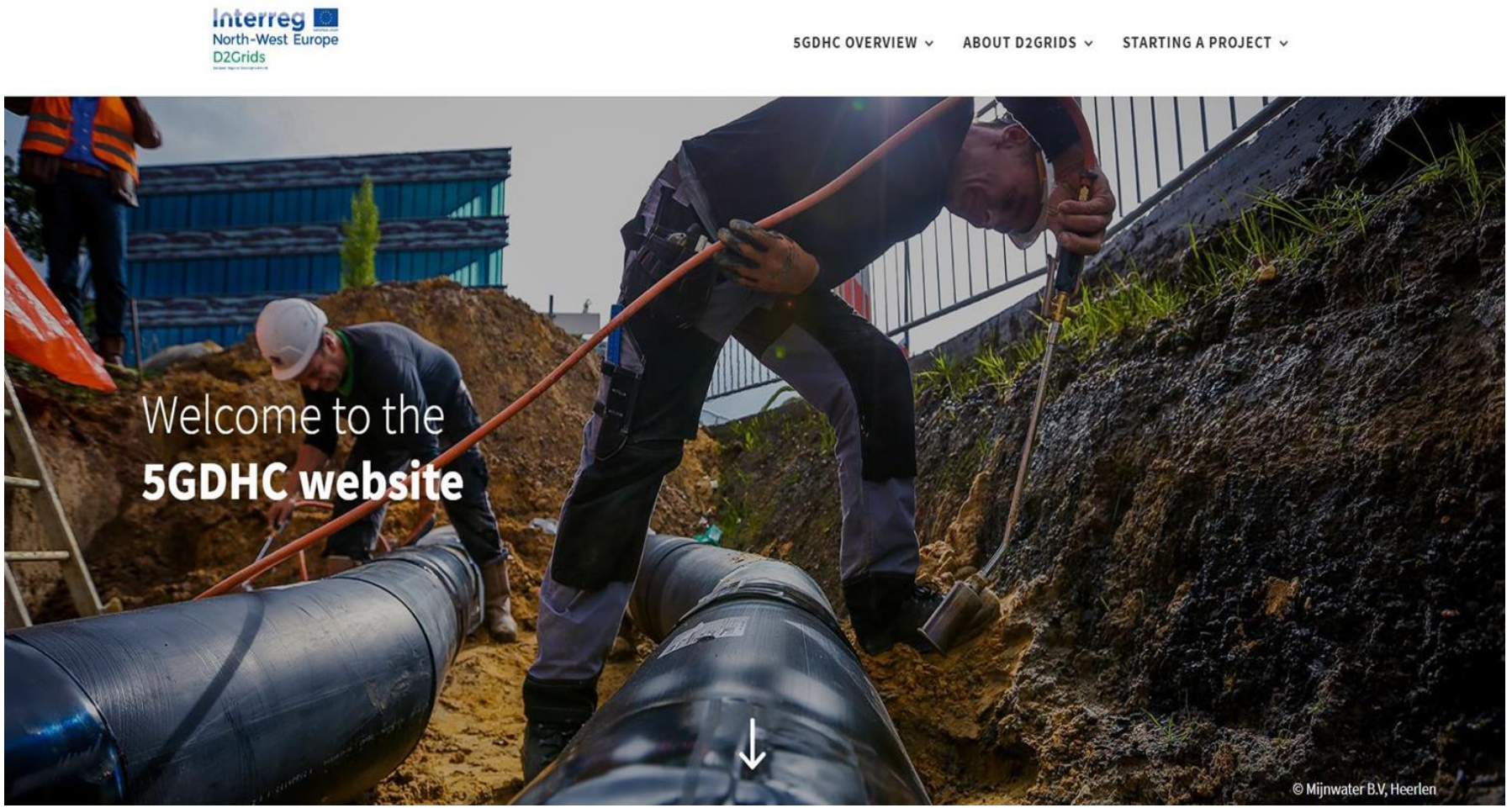
D2Grids website



https://5gdhc.eu/

[Midterm Event at COP26, Glasgow, please register here https://forms.gle/6MZX2pTgy2VHXt857]

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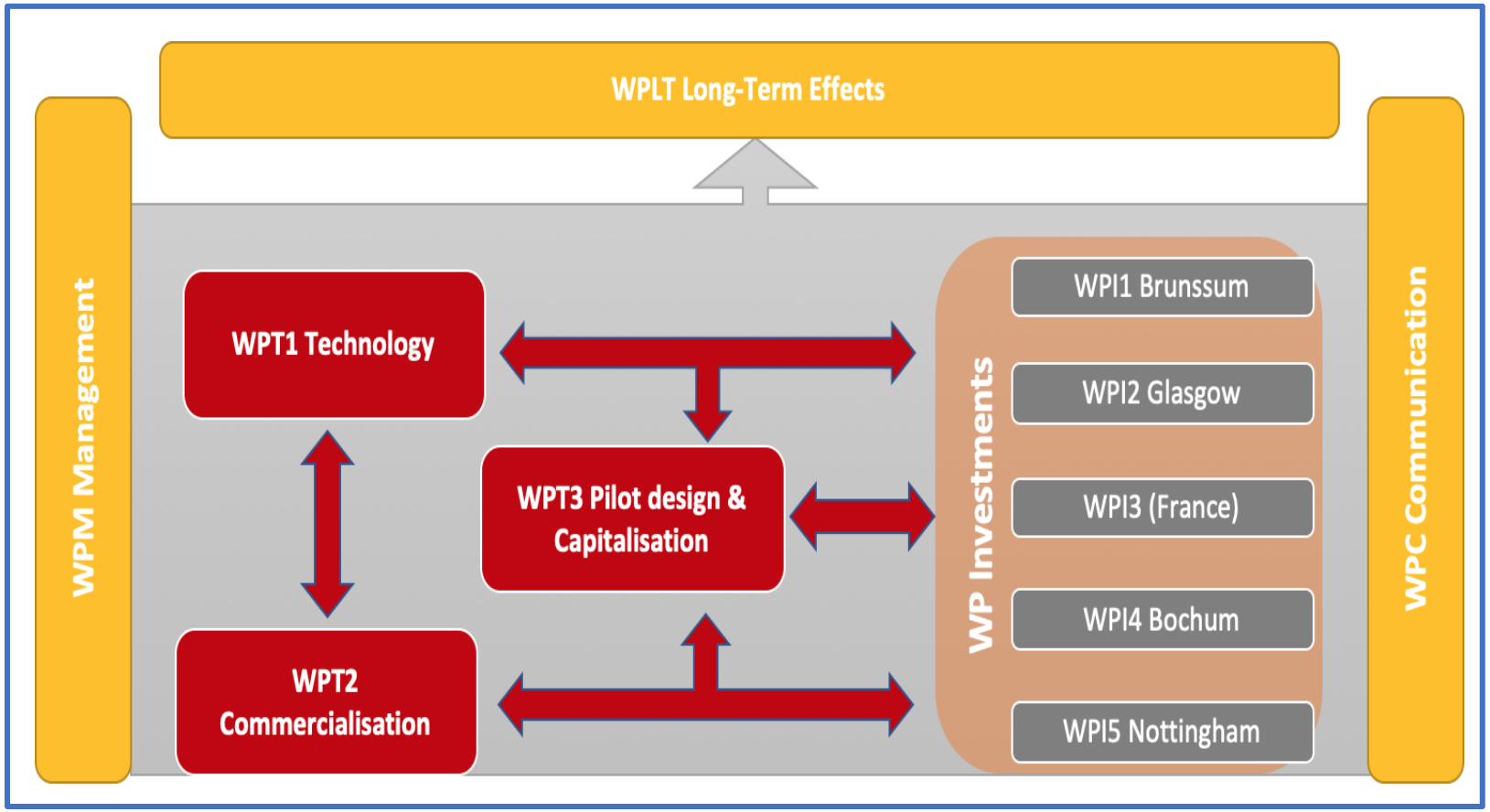
D2Grids – Goals & structure

"Increasing the share of renewable energy by accelerating the roll-out 5th GDHC, demand-driven smart grids delivering low temperature heating and cooling to NWE cities"



To demonstrate 5GDHC concept at pilot sites

To industrialize the 5GDHC technological model

To reduce market barriers hindering the uptake of 5GDHC system

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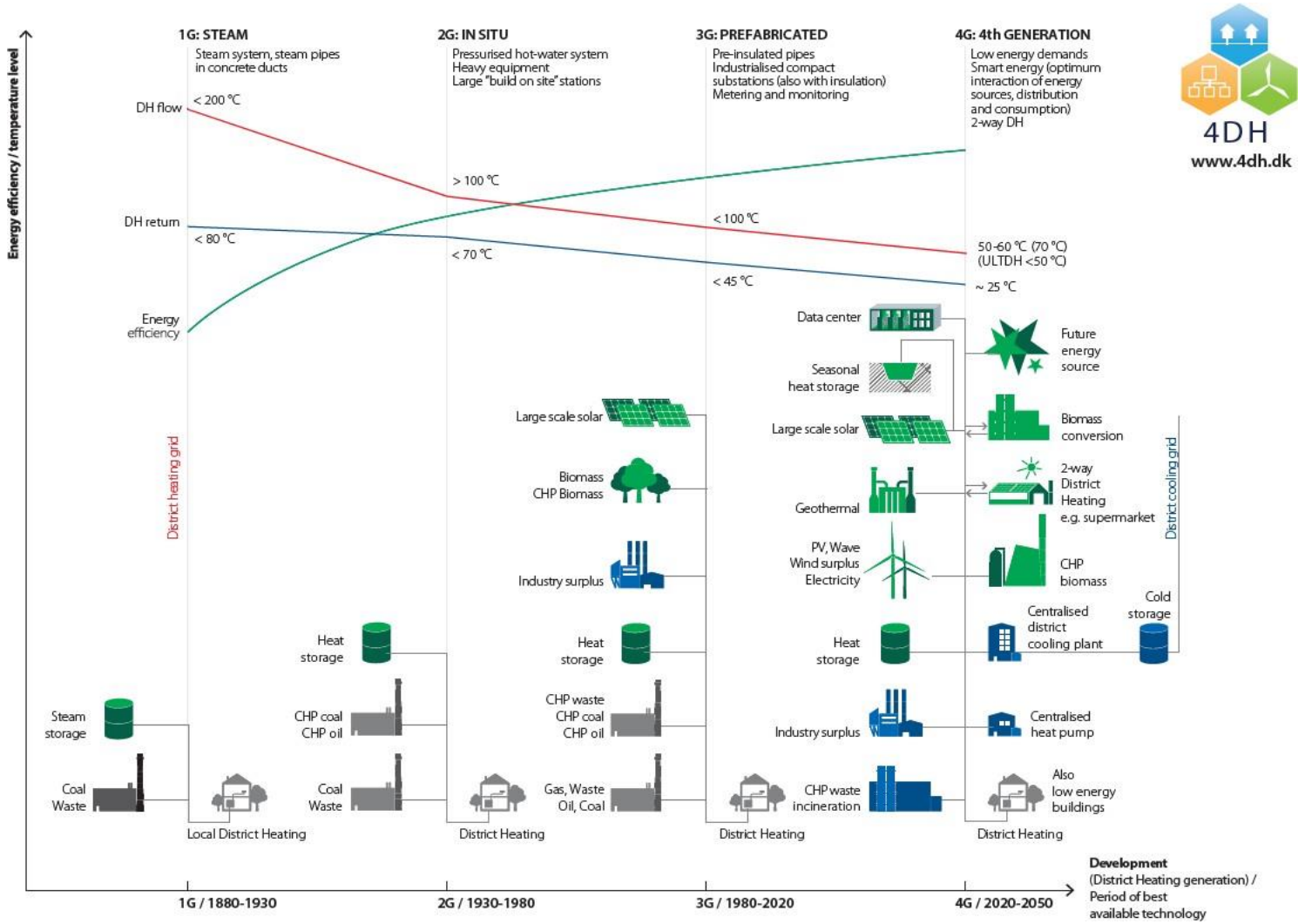
D2Grids - Partners

Heating Grids Evolution



We see in the development of grids a huge focus on central plants and generating energy in a greener way, but ….

which means:

- Dependant on weakest point in the grid
- Not flexible to enduser modifications
- 24/7 need for delivering heat ‘at the front door’ with large efficiency losses
- No cooling supply integrated

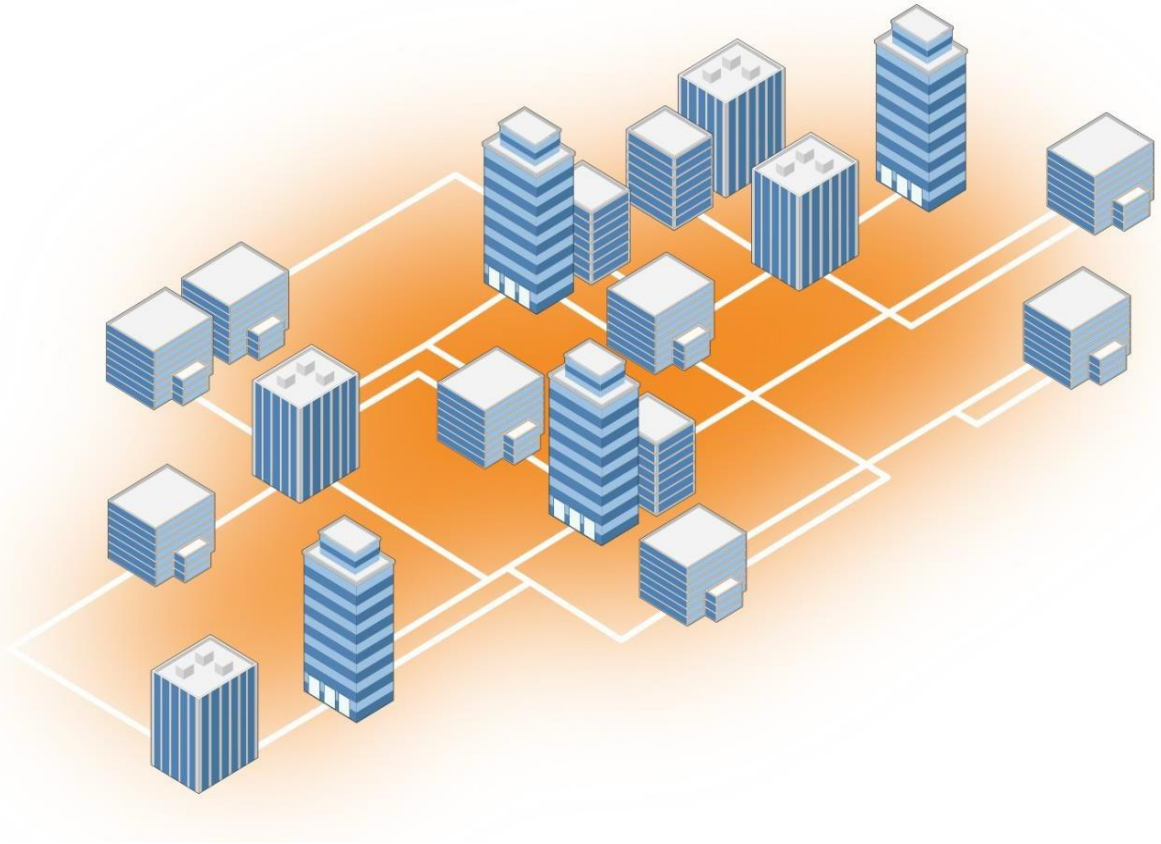
Heating Grids in NL Data

Koudelevering via netten (die meerdere gebouwen bedienen) bedroeg 0,6 PJ afgevoerde warmte (vaak koude genoemd) in 2018 . Het aantal geïdentificeerde koudenetten was 20.

Bron: Warmtemonitor 2019
TNO 2020 P11264

Verliezen in de orde van 25%

Decentralized network = cloud



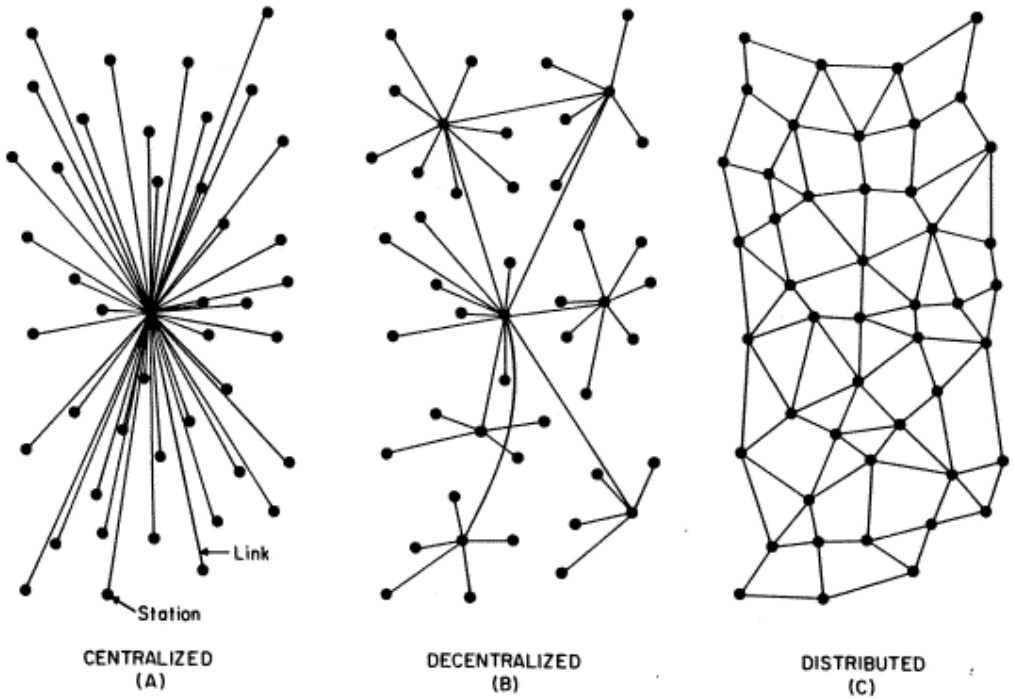
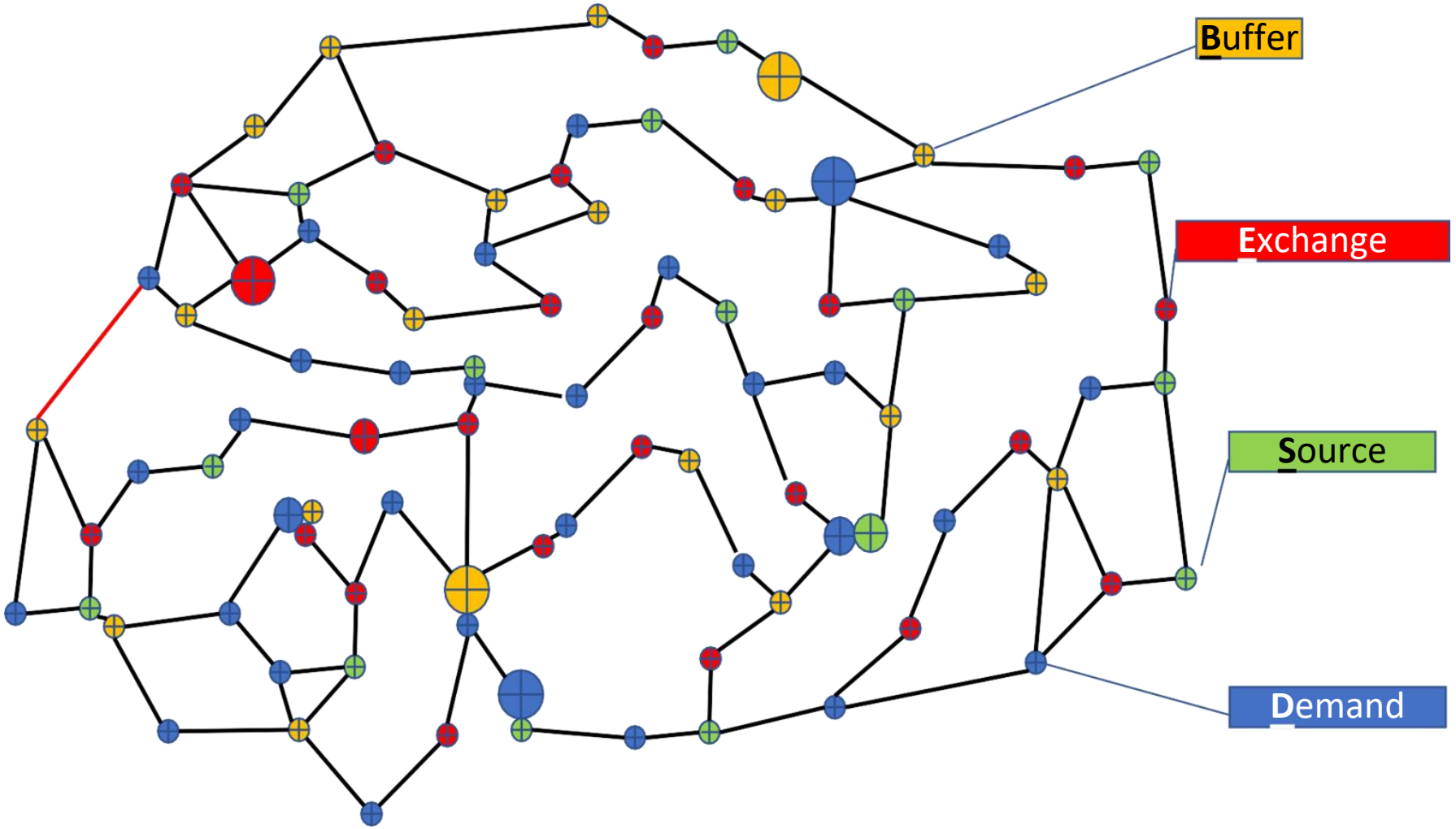


FIG. 1 — Centralized, Decentralized and Distributed Networks

5GDHC Cloud-approach



5GDHC modelling

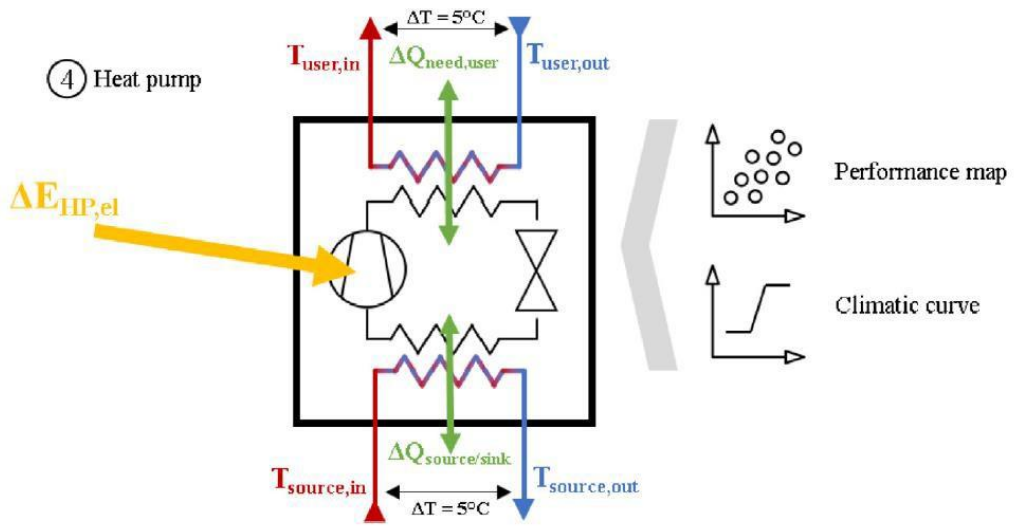
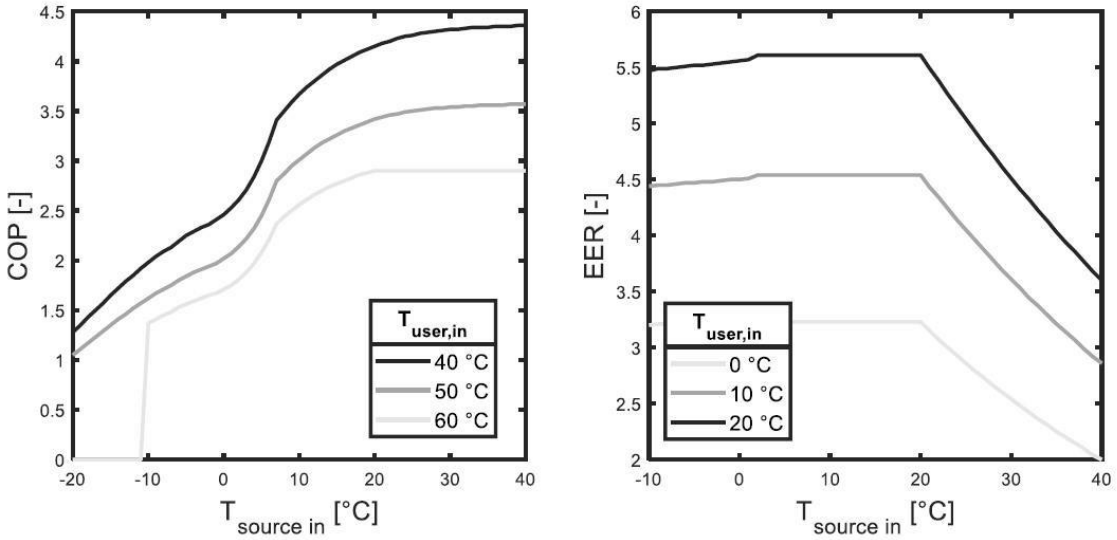
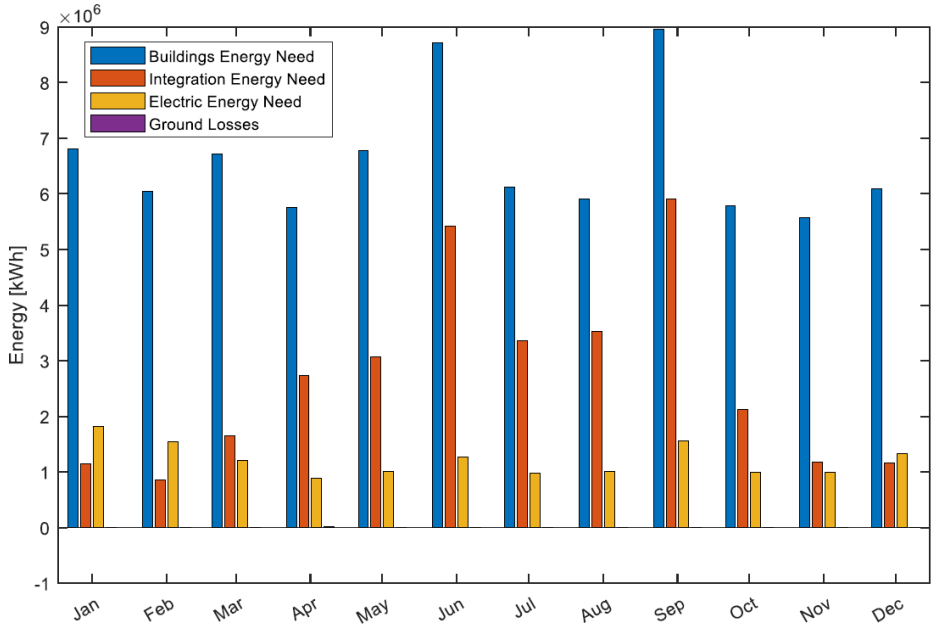


Fig. 7. WSHP model scheme.





The electrical energy spent weighs 19% of the energy required by buildings, while the integration heat has a weight of 41%. The energy loss towards the ground was also assessed using the ground index (I_{ground}), and weights 0.7% of the energy required by the buildings.

Bron: Modelling a fifth-generation bidirectional low temperature district heating and cooling (5GDHC) network for nearly Zero Energy District (nZED); Matteo Bilardo, Federico Sandrone, Guido Zanzottera, Enrico Fabrizio

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5GDHC elements, capitalisation call

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European Regional Development Fund

Solar green sources

Additional costs SDE++, innovation and incorporation 5GDHC

% PV, electric, already in planning

PT, thermal, 250 m²,

% PVT, E&W, 500 m²

Centralized or cloud?

Local storage

100 accu's 85,2 kWh

electric

Energy center Savelberg-straat, 120 m3

Electric storage, 2000 batteries

thermisch

Storage tanks 80°C 60 m3

ATES, max 25°C

Delivery on network

Enexis, electric

Mijnwater, thermal 80°C

Sectornet De Egge/Tarcisuis

Mijnwater, thermal 10-50°C

clusternet

Smart control strategy

Optimize energy, CO2, Euro

Spot market

Electric charging cars

cable

Renovation buildings

Outdoor climate

SOLAR ENERGY SOLUTIONS

STORAGE FACILITIES

SMART MONITORING & CONTROL

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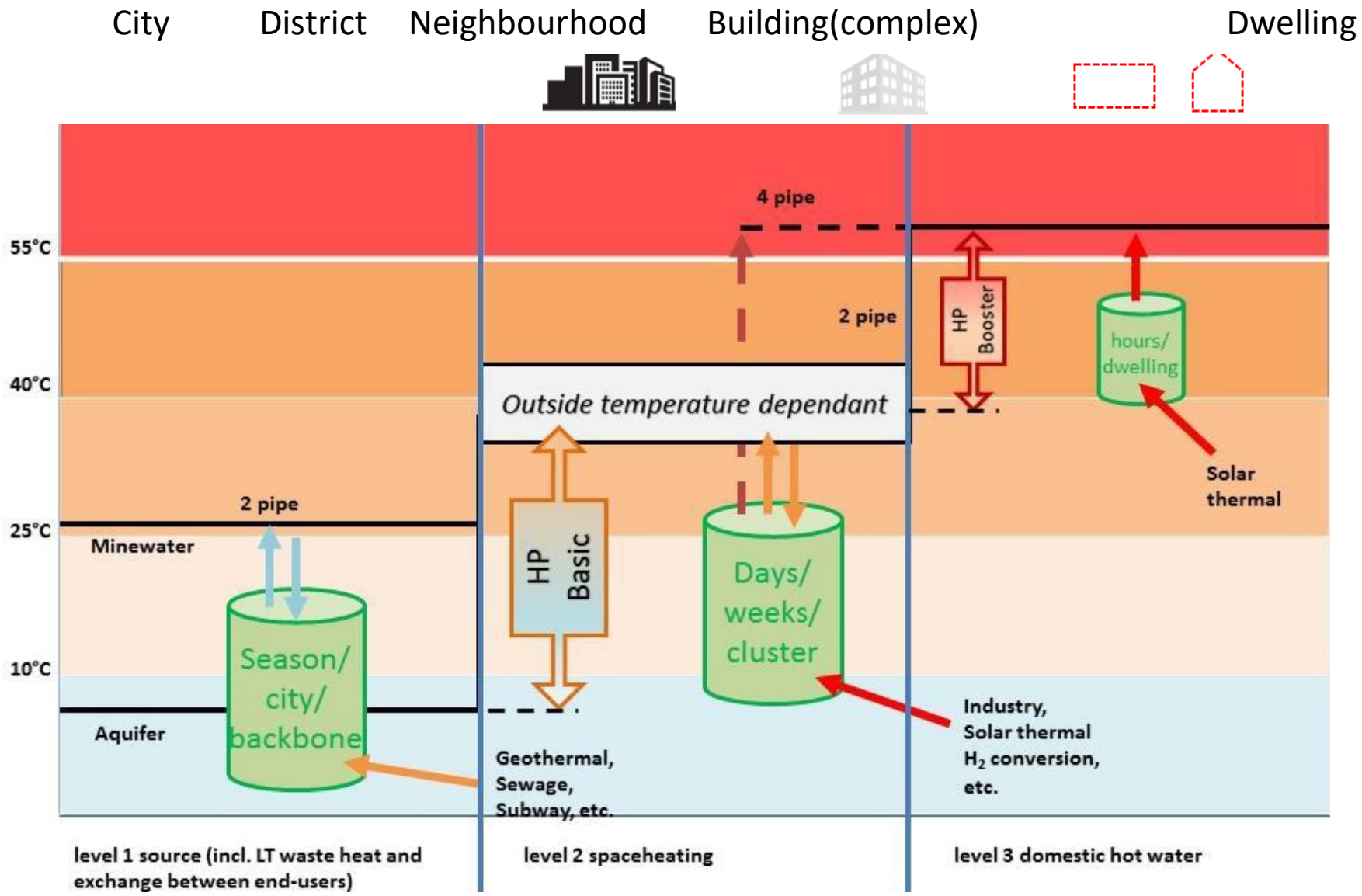
Multi source, multi level storage system



Demand-driven is seen as generating the highest temperature only where and when the demand is occurring, as such preclude excessive losses in the grid

5GDHC – 5 Principles

The 5 principles of 5GDHC

5th generation DHC is an urban thermal energy grid for heating and cooling based on the following 5 principles:

1/ Closing the energy loop

An optimized system allowing exchange of heat and cold between end users.

2/ Using low-grade sources for low-grade demand

In 5GDHC we match the supply with the requested quality level of the demand.

3/ Decentralized & demand-driven energy supply

Circulating energy within the system only when and where needed, as close as possible to the end-user.

4/ An integrated approach of energy flows

Connecting heating and cooling to other energy flows (power grid, hydrogen conversion, solar plants, etc.) to avoid energy waste across sectors and reduce peak loads.

5/ Local sources as a priority

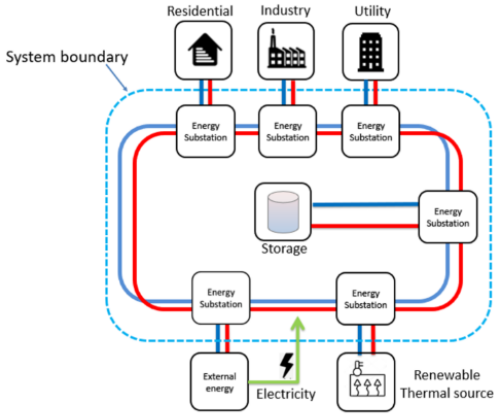
Avoiding big investments and energy loss during transport, while stimulating the local economy.

5GDHC assesment

Principles

1. Closing the energy loop
2. `Low-graded sources for low-graded demand
3. Decentralized & demand-driven energy supply
4. An integrated approach of energy flows
5. Local sources as a priority

System boundary



KPI's

- **E**ext = f(**E**ref) …… 100% …… 20% …… -10%
- Etot = a*Ehh + b*Eh + c*E0 + ….. k*Ell
- Eext = f(D=0)
- E,ext,peak = f(Eaverage)
- Etot = a*E10km +b*E50km + c*E250km +d*Eglobal

weighfactor

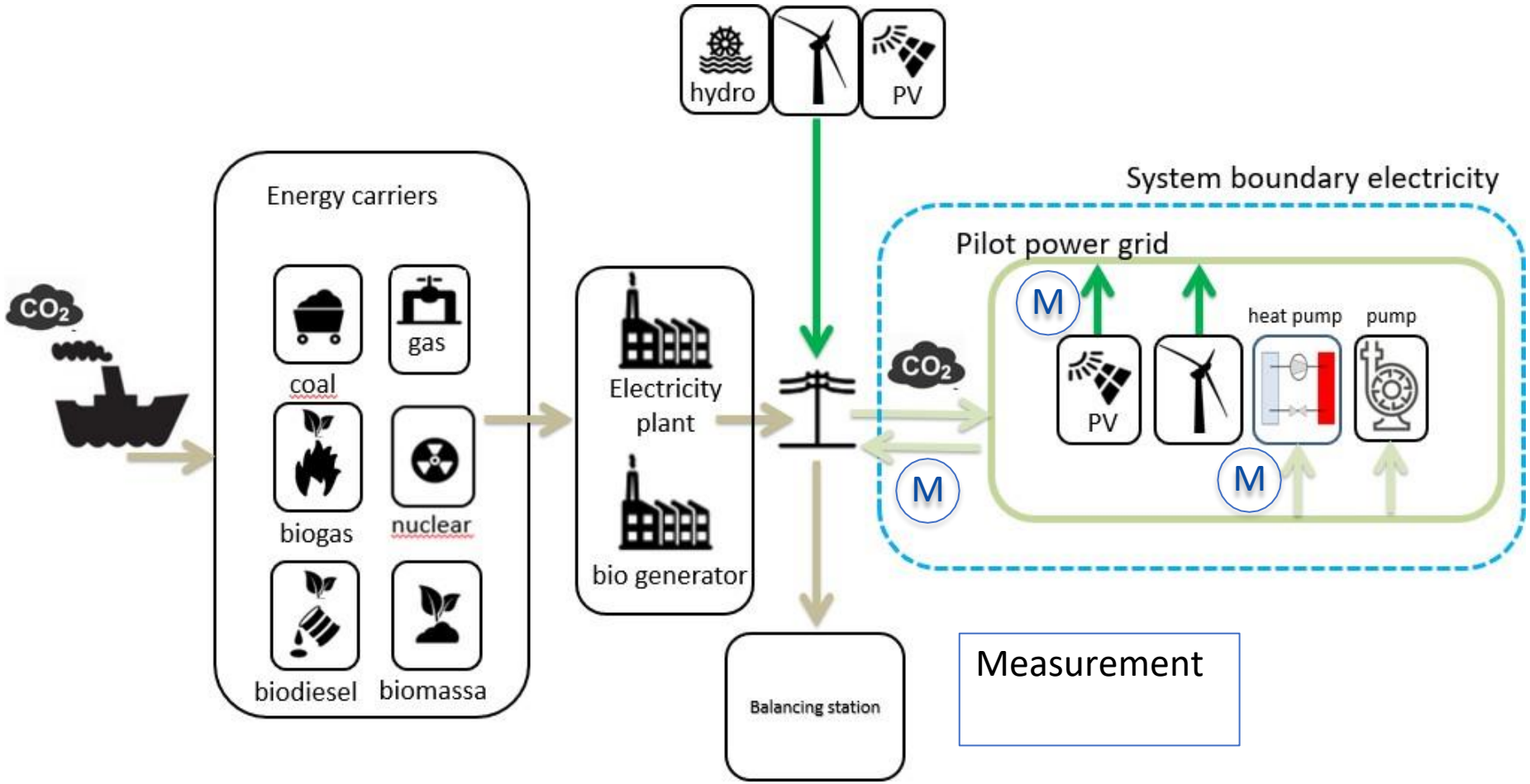
- 25%
- 30%
- 10%
- 20%
- 15%

5gDHC label

Improvement options

- Technology guidelines
- Datamining and analysis
- Smart control
- Key features….
  like multilevel storage,
  multisource,

System boundaries, Monitoring



Principle 1. Closing the energy loop

What to quantify

- Total heating and cooling demands (Edemand)
- Esupply: sum up all the external sources
- Only heating and cooling sources, no electrical sources
- Heat pumps: COP's and electrical consumption

Formula

$$\text{KPI} = \frac{E_{demand} - E_{supply}}{E_{demand}} x\ 100\%$$

Is this data available? Or could it be available (reasonably)

- E supply can be derived from bills/energy meters/sq m/reference building (can vary for design and implementation
- E demand is the sum of all connected building demands

Application to chosen pilot (Paris?)

- Ex Paris showed 18% not coming from external sources

Explanation

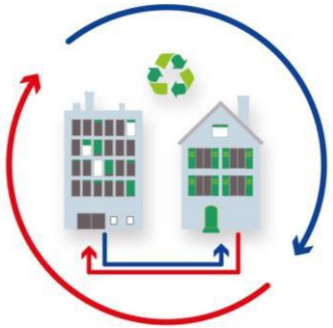
- Include electricity only for heating and cooling production but not for exchange
- We only consider the thermal part, not the electrical part (kWhth, not kWhelec)
- Geothermal energy internal or external source? Depends on the magnitude: if extracted more than naturally regenerated
- Not include electricity: electricity will come back in an other KPI
- Only indirect info on exchange, no further on this besides someone has a better input/vision

Considerations/doubts (internally)

o

Data needed

Cold Demand [kWh]
Heat Demand
[kWh]
External supply by biogas boiler [kWh]
External supply by biomas boiler
[kWh] External supply by waste heat
[kWh] External supply by cooling
tower [kWh] External supply by solar
thermal [kWh] External supply by gas
(kWh)



Principle 2. Low graded sources for low graded demand

What to quantify

- 2 KPIs:
  - Share of low-graded sources among the total of energy supplied (heating, cooling, elec):
  - Electricity is high-graded
  - Low-graded definition: sources between 10°C and 40°C (to adjust when tested on pilot sites)
  - Share of renewable and heat recovery sources among the total of heat/cold supplied.
  - Electricity from national grid is always considered as non renewable to simplify
- Data needed: quantity of energy supplied by each energy source: only external energy sources to simplify the calculation

Formula

- Share of low−graded sources = $\frac{\sigma_{low-graded} Ei}{\sigma_{total} Ei}$
- Share of *renewable and heat recovery* sources = $\frac{\sigma_{RNE\&R} Ei}{\sigma_{total} Ei}$

With Ei = total amount of energy supplied by energy i over the year

Is this data available? Or could it be available (reasonably)

- Yes, easily
- We need the temperatures of the sources

Explanation

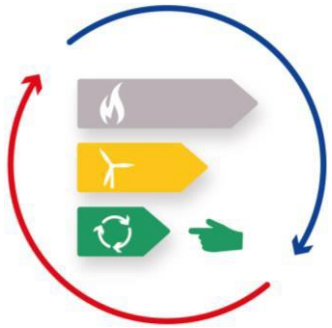
- Renewable or not is also considered as a quality aspect

Considerations / doubts (internally)

- Maybe reconsider and adjust the temperature range to define low-graded sources
- Electricity from national grid could be partly from NRE&R sources that could be taken into consideration
- Exergy was considered to be too difficult
- For now we included renewable and recoverable (waste heat) energy

Data needed

Temperature of water at the point of extration from geothermal well [°C]
Temperature of external waste heat sources [°C]
Temperature of water heated by solar thermal [°C]
Number of renewable external energy sources (can use inventory from KPI 1)



Principle 3. Demand driven generation

What to quantify

"Decentralized" aspect of the infrastructure : Limit the right temperature level production at the point of demand (high temperature pipes are as short as possible
Losses of the grid
- Losses in the ambient loop
- Length of hot pipes compared to length of ambient loop
- Length of cold pipes compared to length of ambient loop

Formula

Losses : Circulating volume (l/y) x Heat cap x Delta T – Energy extracted at heat exchangers (Volume x Delta T x Heat cap

$$Losses = \sum_{i=TminAL}^{TmaxAL} \frac{\pi \times Di \times Li \times (T_i - T_{soil}) \times \lambda}{t}$$

$$KPI1 = \frac{\cancel{Losses \times 8760(h)}}{E_{demand}}$$

$$\text{KPI 2 = \%Hot pipes} = \frac{\cancel{Lhot\ pipes}}{Lhot\ pipes + Lambient\ loop}$$

$$\text{KPI 3 = \%Cold pipes} = \frac{Lcold\ pipes}{Lcold\ pipes + Lambient\ loop}$$

Is this data available? Or could it be available (reasonably)

- Information should be available-

Explanation

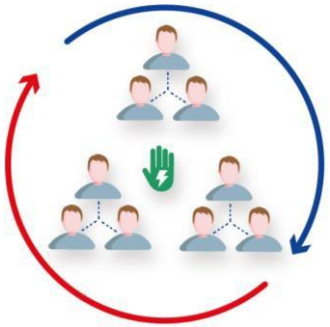
- Decentralized is already in the KPI
- Demand driven: all networks are Demand driven 5power)
- Demand driven (T) is not measured in this KPI: it is taken into account by calculating the losses
- We sum up the losses in the back bone for hot loop, cold loop, intermediate loop
- We started from Power demand driven, hower after the discussion we went to Temperature. This made us go for reduce losses in the network instead of looking the demand drivenness.

Considerations / doubts (internally)

- Heating and cooling season to be considered for losses calculation
- KPI for demand driven was not found in an elegant way

Data needed

Length of ambient loop [m]
Diameters of ambient loop for each pipe [m]
Average temperature of water inside (for each pipe) [°C]
Thermal conductivity of insulation
[W/m*K] Thickness of insulation [m]
Average temperature of soil [°C] (?)



Principle 4. Integration of energy sectors

What to quantify

- Installed thermal capacity: heat pumps, …
- Reference: sum of all consumer thermal peak loads = thermal capacity virtually installed (worst case scenario)

Formula

Only heating in design
Pmin= Total heat demand/8760 (= virtual minimum capacity)
Pdesign = actually designed installed capacity (excl storage, solar thermal,…)

$$KPI = \frac{Pmin}{Pdesign} x100\%$$

Only heating in operation
Pmin= Total heat demand/8760 (= virtual minimum capacity) Pact = actually installed capacity

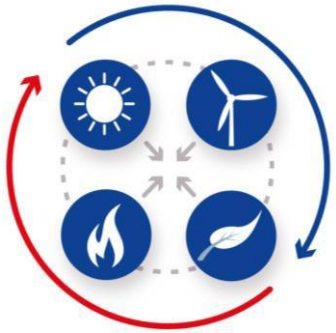
$$KPI = \frac{Pmin}{Pact} x100\%$$

Is this data available? Or could it be available (reasonably)

-

Explanation

- We only look at heat
- We look at the min load needed to be operational: that can be calculated by the dividing the total heat demand by the number of hours in a year
- We compare it to the actual installed capacity
- This gives you an idea on the oversizing of the installation



Considerations / doubts (internally)

-Do we make a KPI for cooling as well? (Follow up Koen and Dirk)
- Is this KPI still relevant for expansion on existing networks
- Is a reference still needed?

Data needed

Total heat demand [kWh]
Maximum heat production capacity (design) [kW]

Principle 5. Prioritise local sources

What to quantify

-Quantity of thermal source to
- DHCN municipal region
- (local) regional (<50km)
- national
- international (ex. Gas grid)

Quantity of electrical source to DHCN
- local (generated by the thermal grid operator)
- grid

Formula

-

$$KPIth = \frac{E_{local\ 100\%}\ Eregion\ 75\%\ E_{national\ 25\%}\ E_{international\ 5\%}}{Elocal\ E_{region}\ E_{national}\ E_{international}}$$

$$KPIelec = \frac{E_{local\ 100\%}\ Egrid_{5\%}}{Elocal\ Egrid}$$

Is this data available? Or could it be available (reasonably)

-It should be available

Explanation

- For local we only subdivided in the various categories mentioned
- We made different KPI's for electrical and for thermal: we think that a the proximity of thermal sources is more important than electrical sources.

Considerations / doubts (internally)

- Review the weight factors
- Will we have to diversify the thermal sources on source type
- (local) economic (sub) kpi s are left out. Possibly taken up in WP 2?
- Chillers are local sources???

Data needed

Thermal sources categorized
- [kWh] municipality
- region
- national
- international

Electricity from the grid [kWh]
Electricity self produced [kWh]

5GDHC concept in Heerlen

The only needed external energy is electricity (gasless solution) which can be derived from green generation

Due to low temperature grid gains from datacentres, greenhouses, solar collectors, etc. are utilisable leaving from 28 °C

industry

The gains from green generation are 10 % better utilisable due to sharing between mutiple users

Industry surplus

local green generation

dwellings

commercial

Including data centres, shops, etc.

Modern buildings need 35 % cooling energy (in thermal flow) against 65 % heating energy. The grid enables exchange of these flows in time.

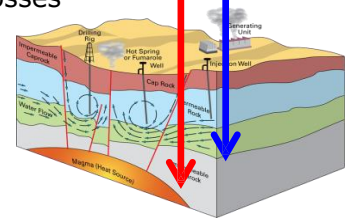
electricity

< 25-28 °C

Due to high temperature constant source the COP of Heat Pumps is 2-4 times higher than on ground water or outside air

> 16-18 °C

Shallow geothermal buffering stores energy unendless up to 30 °C with minimal losses



Seasonal heat storage

MT Heat storage

MT Cold storage

Mid term buffering in the area stores energy for months up to 130 °C with < 10% losses

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5GDHC proven technology, but …

1. Concept & technology

Definitie van de 5GDHC techniek
- kaders stellen,
- standaardisatie protocollen
- IP's claimen
- 'industrialisatie en modulariteit'
- snelheid van kunnen aansluiting te verhogen.

2. Simulatie & tools

Analyse, ontwikkeling en implementatie van een degelijk simulatiepakket voor het 5GDHC concept:
- doelgroepen en eisen in kaart brengen
- Ontwikkeling beslistools
- 'Concept & technology',
- 'Marketing & communicatie' en
- 'Finance'.

3. Marketing & communicatie

- Stakeholders en klanten informeren en overtuigen
- 5GDHC techniek ten opzichte van andere oplossingen
- Breed perspectief in MKBA

4. Wet- en regelgeving

- Onderhouden kennisbank actuele wet- en regelgeving
- Invloed op nieuwe wet- en regelgeving.

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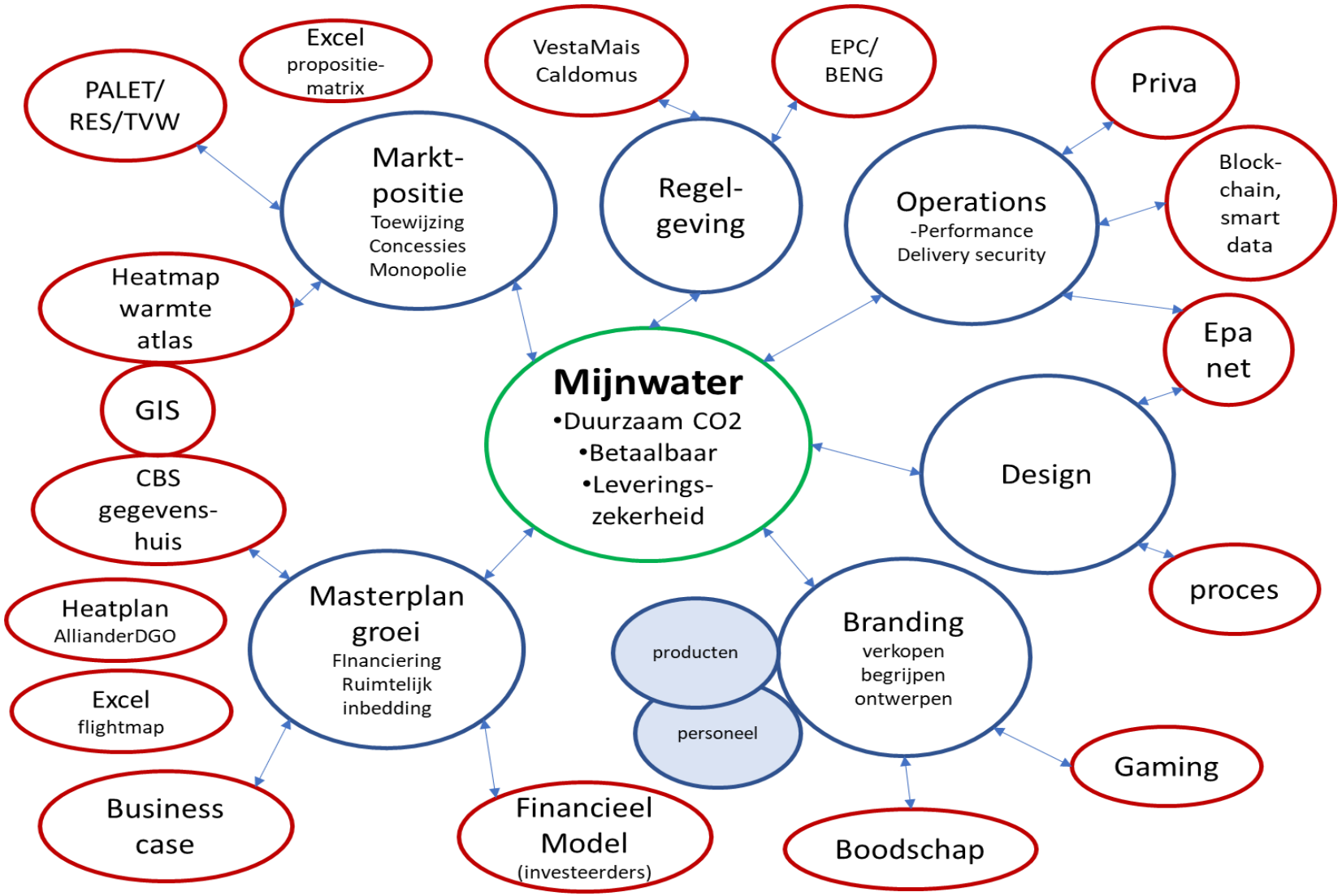
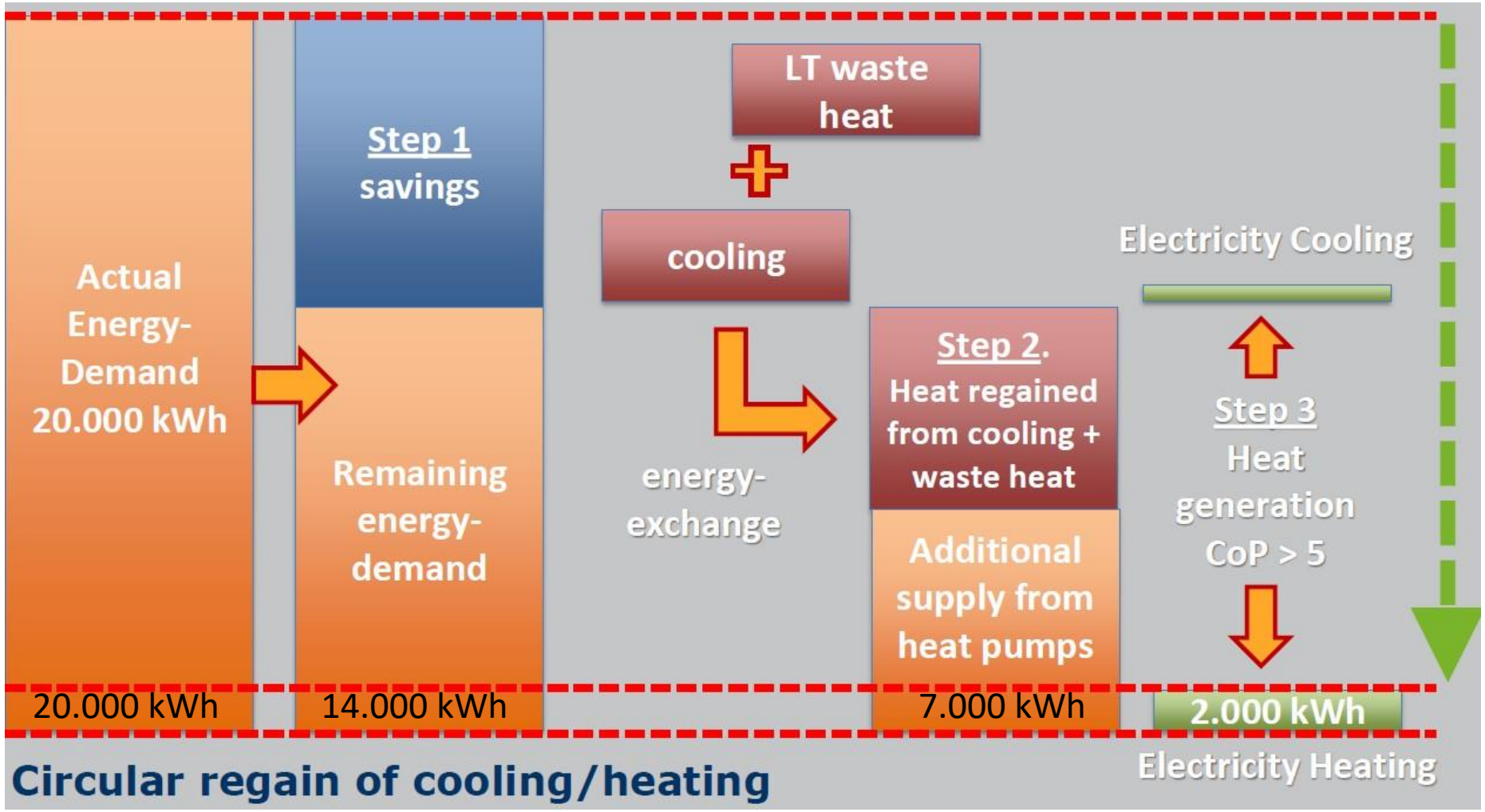
5GDHC Integrale benadering



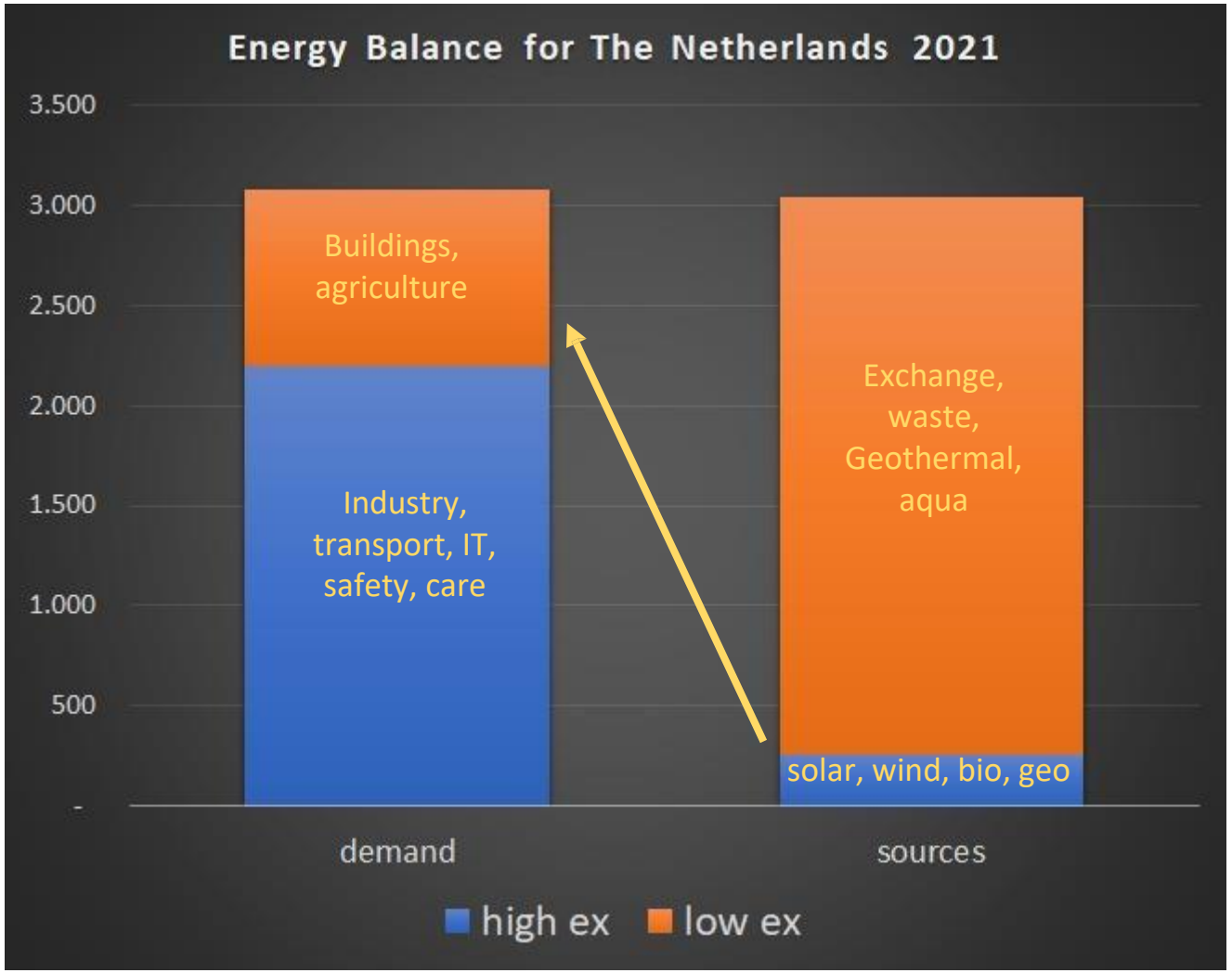
Veel tools en modellen, vaak met hoog detailniveau, maar ze wisselen onderling geen data uit

Urban Energy Concept



- 90% energy demand reduction potential via circular use & reuse and high-efficiency
- Especially advantageous for high-density, urban areas
  - 2,000 kWh= 10 PV panels

High and low graded energy



- We can distinguish high graded and low graded energy
- All fossils are (very) high graded
- High grade green sources are limited, because of spatial restrictions, timing, costs, time, raw materials ??
- Huge availability of low graded waste heat and low graded sources
- A limited share of demand can be supported by low grade

About 25% of the total energy demand is low-value energy (to be fed with exchange, residual heat, waste heat), the remainder is high-quality energy