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D2Grids within Mijnwater Innovation

Partnerships with > 60 institutes/cities in Europe
D2Grids website

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

Sheet nr. 4 | Oktober, 5th 2021 | © Mijnwater Energy B.V.
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
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
5GDHC Cloud-approach

Buffer

Exchange

Source

Demand
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 ($I_{\text{ground}}$), 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
5GDHC elements, capitalisation call

- Solar green sources
- Local storage
- Delivery on network
- Smart control strategy
- Electric
- Mijnwater, thermal 80°C
- Enexis, electric
- Optimize energy, CO2, Euro
- PT, thermal, 250 m²
- Electric storage, 2000 batteries
- Mijnwater, thermal 10-50°C
- Thermisch
- Sectornet De Egge/Tarcisius
- Renovation buildings
- Centralized or cloud?
- Storage tanks 80°C 60 m³
- Storage tanks 80°C 60 m³
- ATES, max 25°C

SOLAR ENERGY SOLUTIONS
STORAGE FACILITIES
SMART MONITORING & CONTROL
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.
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 assessment

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

Improvement options

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

System boundary

KPI’s

- $E_{ext} = f(E_{ref}) \ldots 100\% \ldots 20\% \ldots 10\%$
- $E_{tot} = a \cdot E_{hh} + b \cdot E_{h} + c \cdot E_{0} + \ldots k \cdot E_{ll}$
- $E_{ext} = f(D=0)$
- $E_{ext,peak} = f(E_{average})$
- $E_{tot} = a \cdot E_{10km} + b \cdot E_{50km} + c \cdot E_{250km} + d \cdot E_{global}$

Weight factor

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

5gDHC label
System boundaries, Monitoring

Energy carriers:
- coal
- gas
- biogas
- nuclear
- biodiesel
- biomassa

Electricity plant

Bio generator

Balancing station

System boundary electricity

Pilot power grid

Measurement

CO2

hydro

PV

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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

\[ \text{KPI} = \frac{E_{\text{demand}} - E_{\text{supply}}}{E_{\text{demand}}} \times 100\% \]

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)

Is this data available?
- 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

Data needed
- Cold Demand [kWh]
- Heat Demand [kWh]
- External supply by biogas boiler [kWh]
- External supply by biomass boiler [kWh]
- External supply by waste heat 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 = \( \frac{\sigma_{\text{low-graded}} E_i}{\sigma_{\text{total}} E_i} \)
- Share of renewable and heat recovery sources = \( \frac{\sigma_{\text{RE&R}} E_i}{\sigma_{\text{total}} E_i} \)

With \( E_i \) = 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 extraction 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

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

\[
\text{Losses} = \sum_{i=T_{\text{min}}^{\text{AL}}}^{T_{\text{max}}^{\text{AL}}} \pi D_i L_i (T_i - T_{\text{soil}}) \times \lambda t
\]

\[
KPI_{1} = \frac{E_{\text{demand}}}{\text{Losses} \times 8760(\text{h})}
\]

KPI 2 = %Hot pipes = \frac{\text{Length hot pipes}}{\text{Length hot pipes} + \text{Ambient loop}}

KPI 3 = %Cold pipes = \frac{\text{Length cold pipes}}{\text{Length cold pipes} + \text{Ambient 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 (power)
- 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 backbone for hot loop, cold loop, intermediate loop
- We started from Power demand driven, however 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**

\[ P_{\text{min}} = \frac{\text{Total heat demand}}{8760} \]  
\( (= \text{virtual minimum capacity}) \)

\[ P_{\text{design}} = \text{actually designed installed capacity (excl storage, solar thermal,...)} \]

\[ \text{KPI} = \frac{P_{\text{min}}}{P_{\text{design}}} \times 100\% \]

**Only heating in operation**

\[ P_{\text{min}} = \frac{\text{Total heat demand}}{8760} \]  
\( (= \text{virtual minimum capacity}) \)

\[ P_{\text{act}} = \text{actually installed capacity} \]

\[ \text{KPI} = \frac{P_{\text{min}}}{P_{\text{act}}} \times 100\% \]

### Explanation
- We only look at heat
- We look at the min load needed to be operational: that can be calculated by 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 \([\text{kWh}]\)
- Maximum heat production capacity (design) \([\text{kW}]\)
### 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** = \( \frac{E_{\text{local}}}{E_{\text{local}} + E_{\text{region}} + E_{\text{national}} + E_{\text{international}}} \) *

**KPIelec** = \( \frac{E_{\text{local}}}{E_{\text{local}} + E_{\text{grid}}} \)

#### Explanation

- For local we only subdivided in the various categories mentioned
- We made different KPI's for electrical and for thermal: we think that 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]

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

- It should be available

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Sheet nr. 20 | Oktober, 5th 2021 | © Mij้นwater Energy B.V.
The only needed external energy is electricity (gasless solution) which can be derived from green generation.

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

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

Seasonal heat storage

MT Heat storage

MT Cold storage

< 25-28 °C

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 multiple users.

dwellings

local green generation

> 16-18 °C

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

Incluing 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.
5GDHC proven technology, but …

1. Concept & technology

Definitie van de 5GDHC techniek
- kaders stellen,
- standaardisatie protocollen
- IP’s claimen
- ‘industrialisatie en modulariteit’
- snelheid van 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.
Veel tools en modellen, vaak met hoog detailniveau, maar ze wisselen onderling geen data uit.
THANK YOU
• 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