Process industry on renewable electricity

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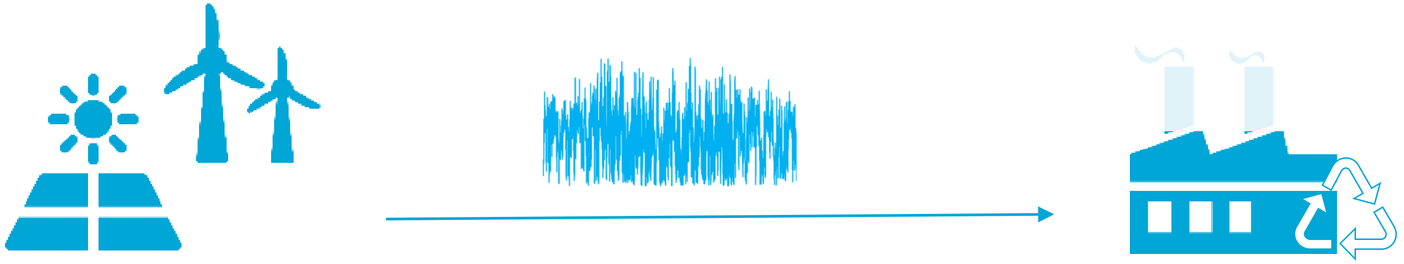
Process industry on renewable electricity

CURRENT SITUATION

Process industry based on fossil fuels as energy input

- About 80% of energy consumed for heat generation
- Nearly all consumed (fossil) heat is cooled away at lower temperatures

FUTURE SITUATION



Process industry based on 100% renewable electricity, challenges:

- Variability of electricity supply
- Annual production volume/utilization rate of industrial asset

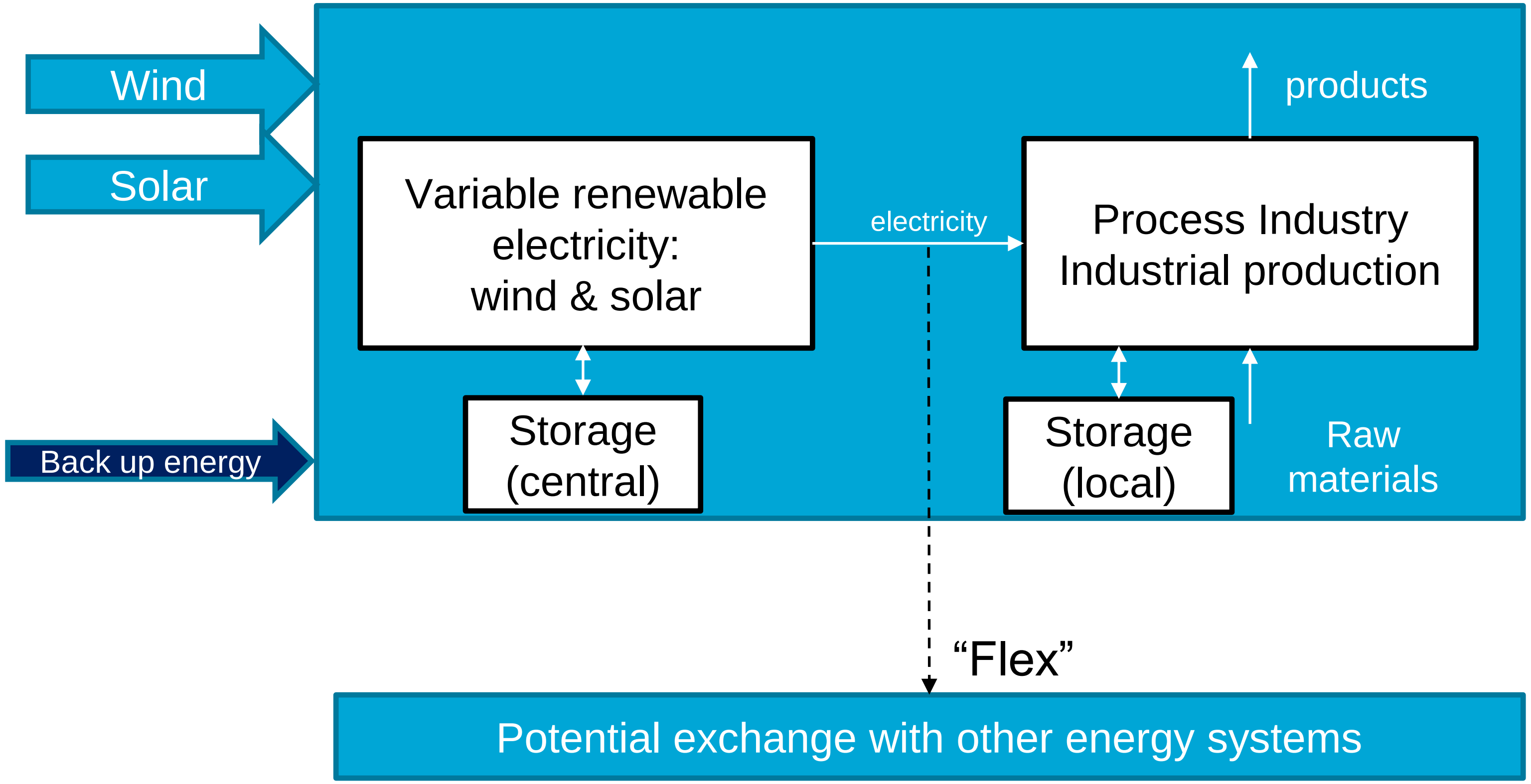
Content

- System analysis
- Typical design parameters for a fully electrical process industry plant
- Comparison of different design options & preliminary financials
- Actieplan efficiente en flexibele elektrificatie van de procesindustrie

System : industrial consumption of electricity coupled to renewable power generation

Variable renewable energy (VRE):
production by wind & solar

Back up energy:
alternative energy source in case of shortage of energy in the system.
For example: natural gas, hydrogen or power from thermal generation



Industrial production:
electricity intake (load) by industry

Components of system analysis

Assumptions:

- Virtual system, renewable generation of electricity and industrial consumption of electricity are considered as one system
- All variables scaled with the annual average demand of electricity by the industrial installation (e.g. total annual demand = 8500 MWh: 1 MW during 8500 hrs)
- Constant annual industrial production volume
- Full foresight of renewable energy production
- In case of shortage of energy in the system: extra energy delivered from back up energy
- In case of excess of energy in the system: curtailment of renewable generation
- Back up energy to be minimized => target: fully renewable system
- Production = Intake of power, no penalty from flexible operation of the industrial installation
- Not limited by storage capacity of products and raw materials
- Not limited by transport capacity of electricity between generation and consumption
- Portfolio of 75% (MWh) off shore wind and 25% solar (MWh)

Renewable generation
installed capacity
utlization

Transport capacity
between renewable generation and industrial consumption

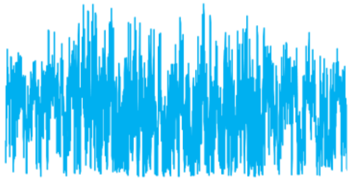
Production asset
Capacity
Flexibility

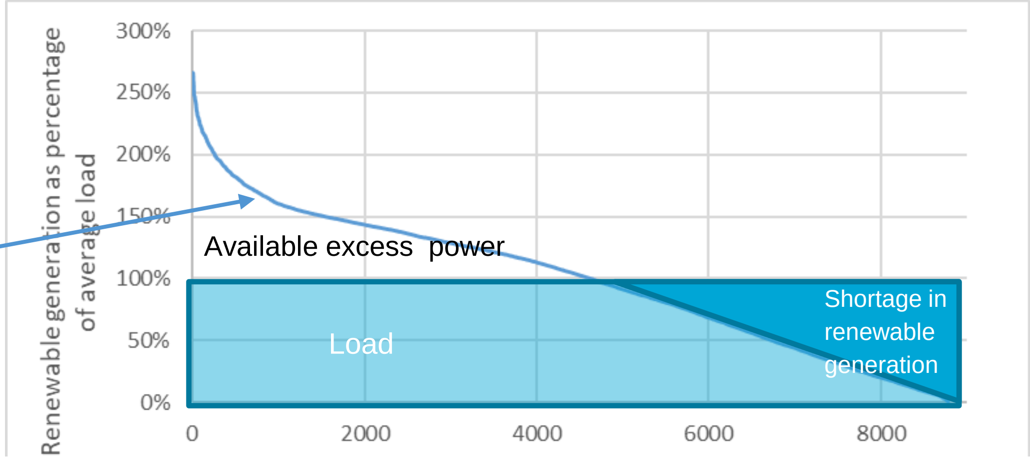
Energy storage
Size
Local/Central

Backup energy
Annual volume
Capacity

System analysis divided into two parts

Annual duration curve:
Renewable production per hour sorted from maximum to zero





(2) Excess of renewable energy:

- Extra production by extra intake of electricity
- Storing extra electricity into energy storage

(1) Shortage of renewable electricity:

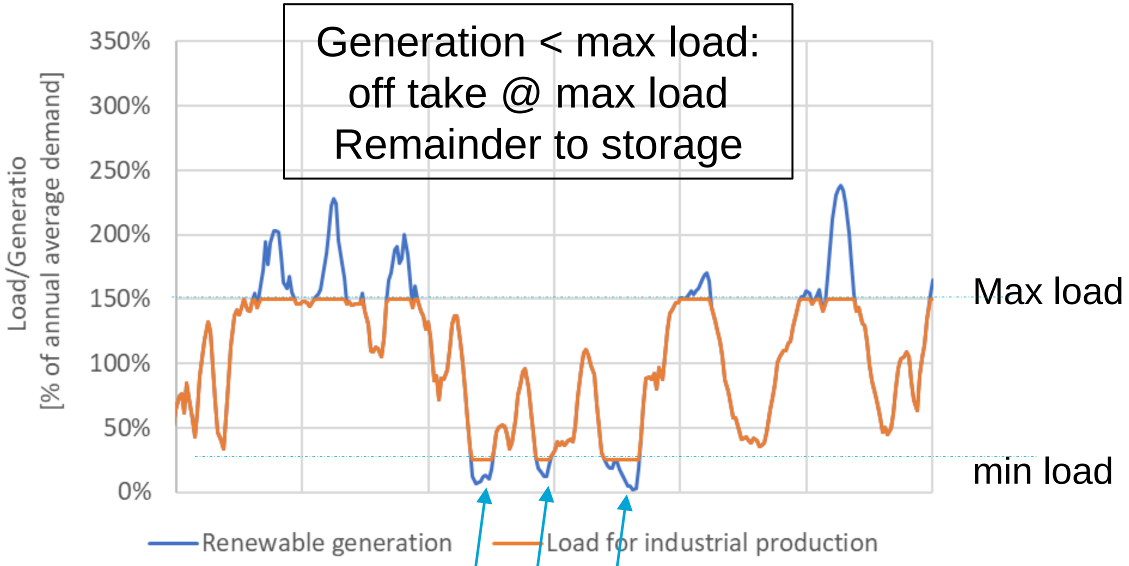
1. Demand side response & start/stop demand
2. Energy from storage
3. Back up energy

1 MWh/yr load: 0.75 MWh/yr off shore wind, 0.25 MWh/yr solar
1 MW load ; 1,8 MW_p off shore wind, 1,7 MW_p solar

Shortage of renewable energy: Demand side response

NO START/STOP

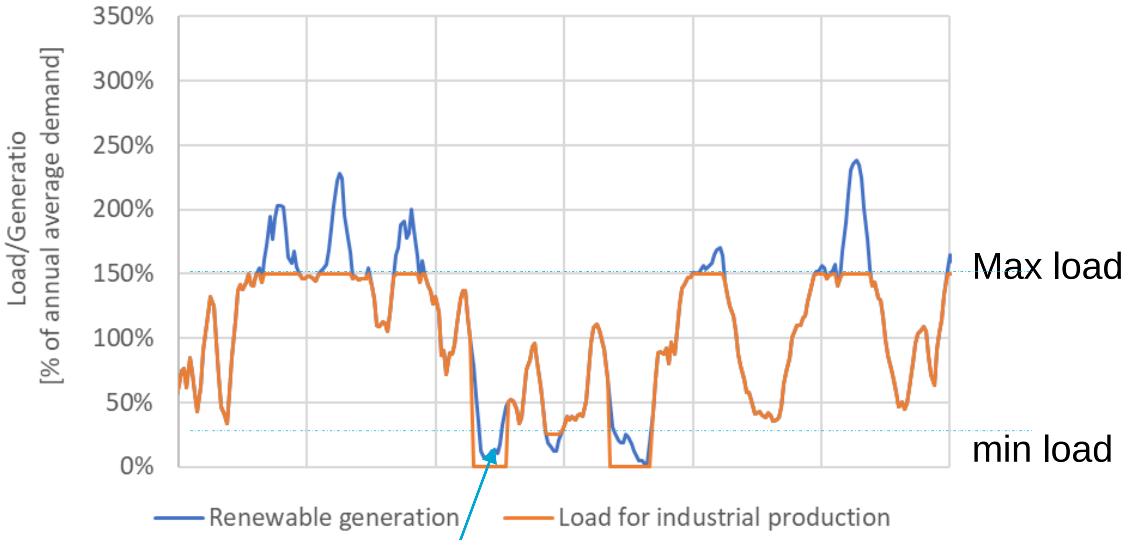
Off take follows generation between min and max load



Generation < min load:
off take @ min load

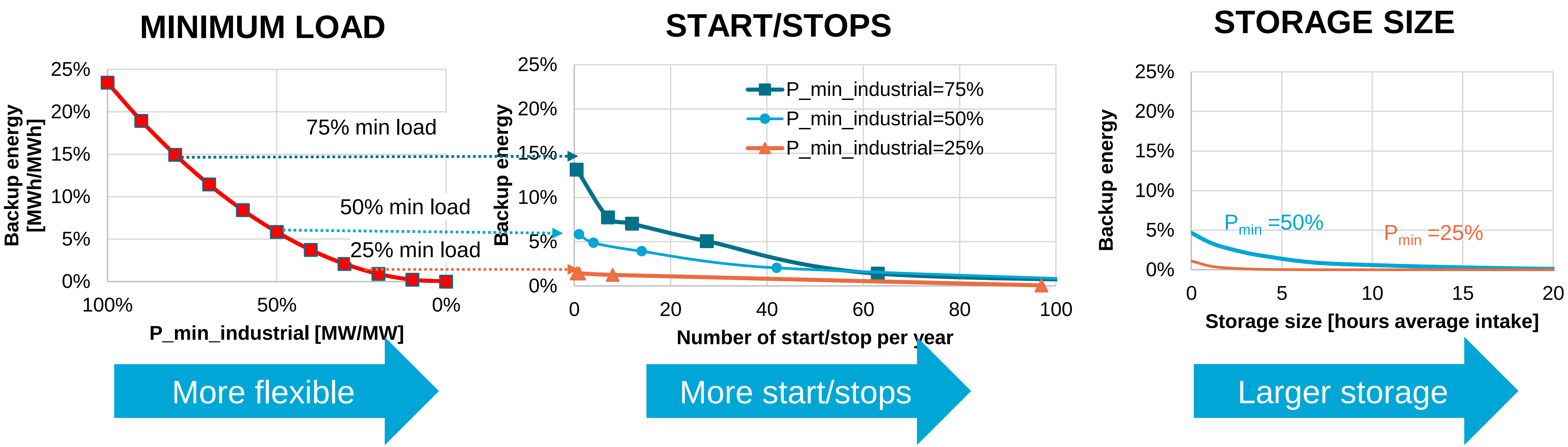
WITH START/STOP

Off take follows generation between min and max load



Average generation < min load (time scale > X) :
off take stopped

Reduction of Back up Energy requirement by Flexibility, Start/Stop operation and Energy Storage



- Lower minimum load => strong reduction of back up energy requirements
- Start/stop further reduces back up energy, especially at higher minimum load
- Storage size 5-10 hr: reduces back up energy requirement significantly

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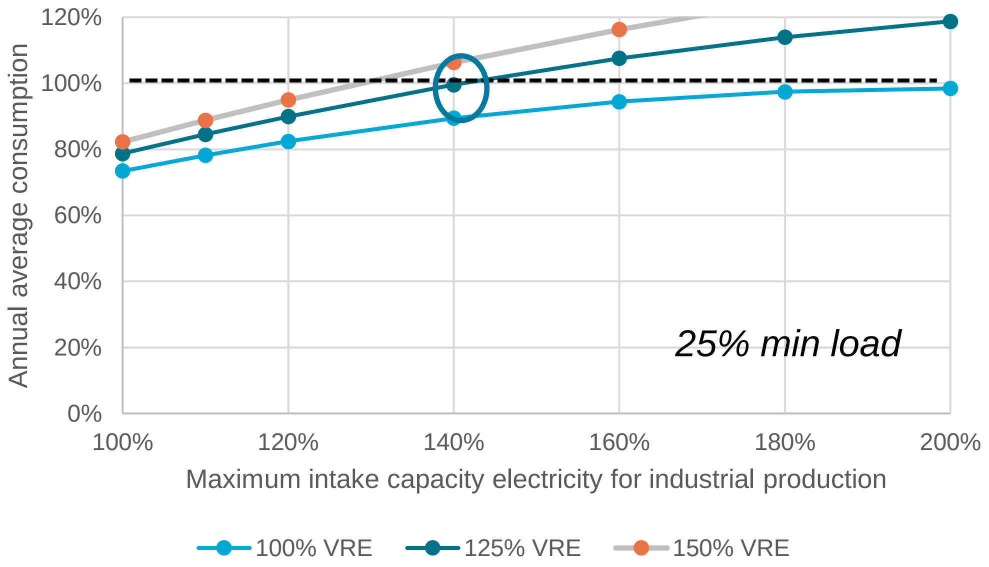
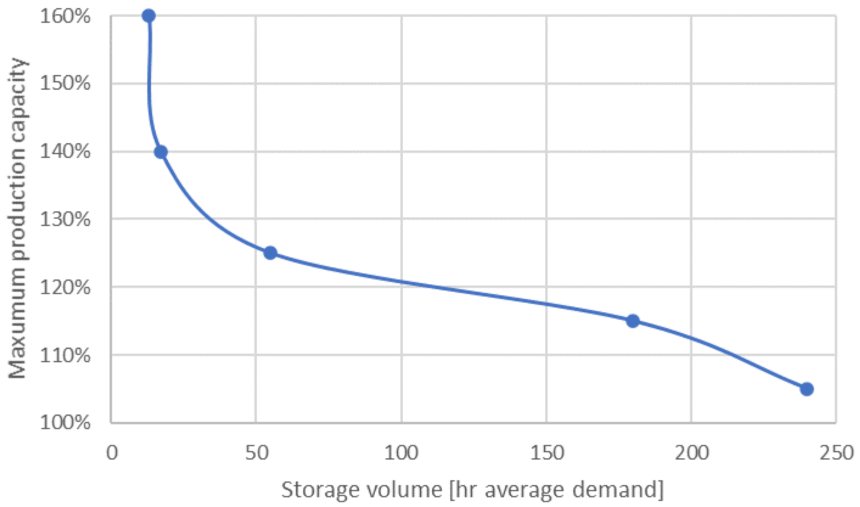
Achieving the annual production volume
Maximum capacity versus value of storage

DIRECT USAGE: MAXIMUM CAPACITY



Capacity industrial production:
>140% of average annual demand level

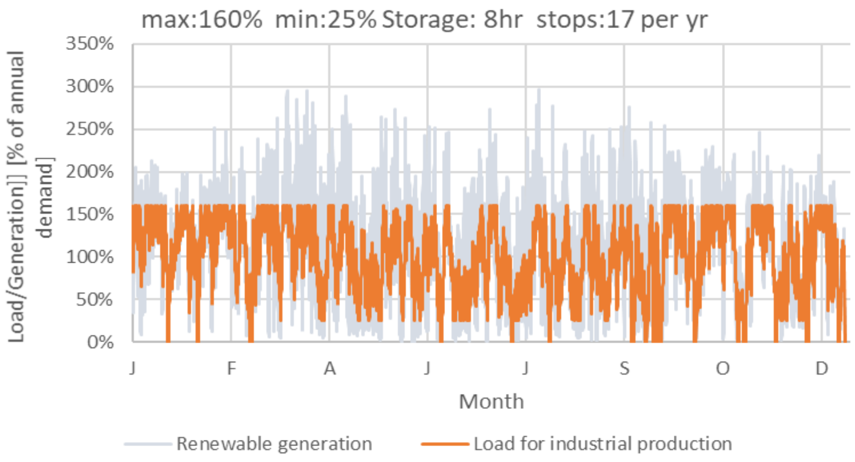
INDIRECT USAGE: ENERGY STORAGE



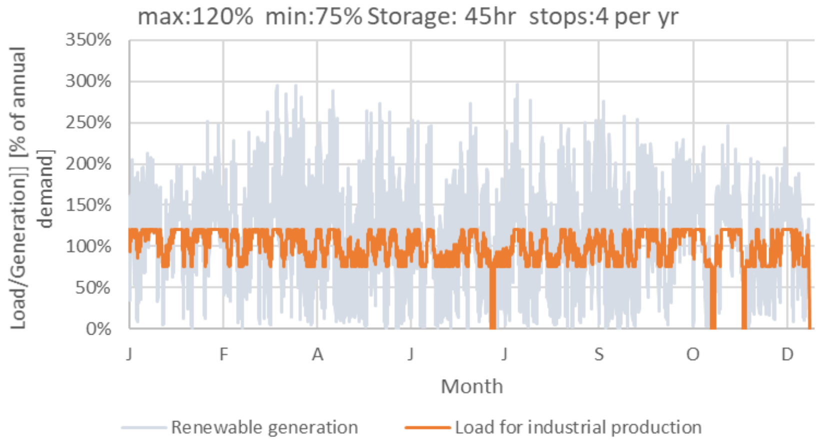
Storage of circa 50 hours reduces required production capacity to120%

Typical design parameters

Installed renewable power capacity >110%	Transport capacity Capacity: Production asset + Local storage 100%-200%	Energy storage : 4-50 hr (> 250 hr required for base load)	Production asset: Capacity: 120%-150% Minimum 25%-75% (stops 2-50 / yr)	Back up energy: Balance with flexibility and storage (0%-25%)



Fully flexible operation



Semi baseload

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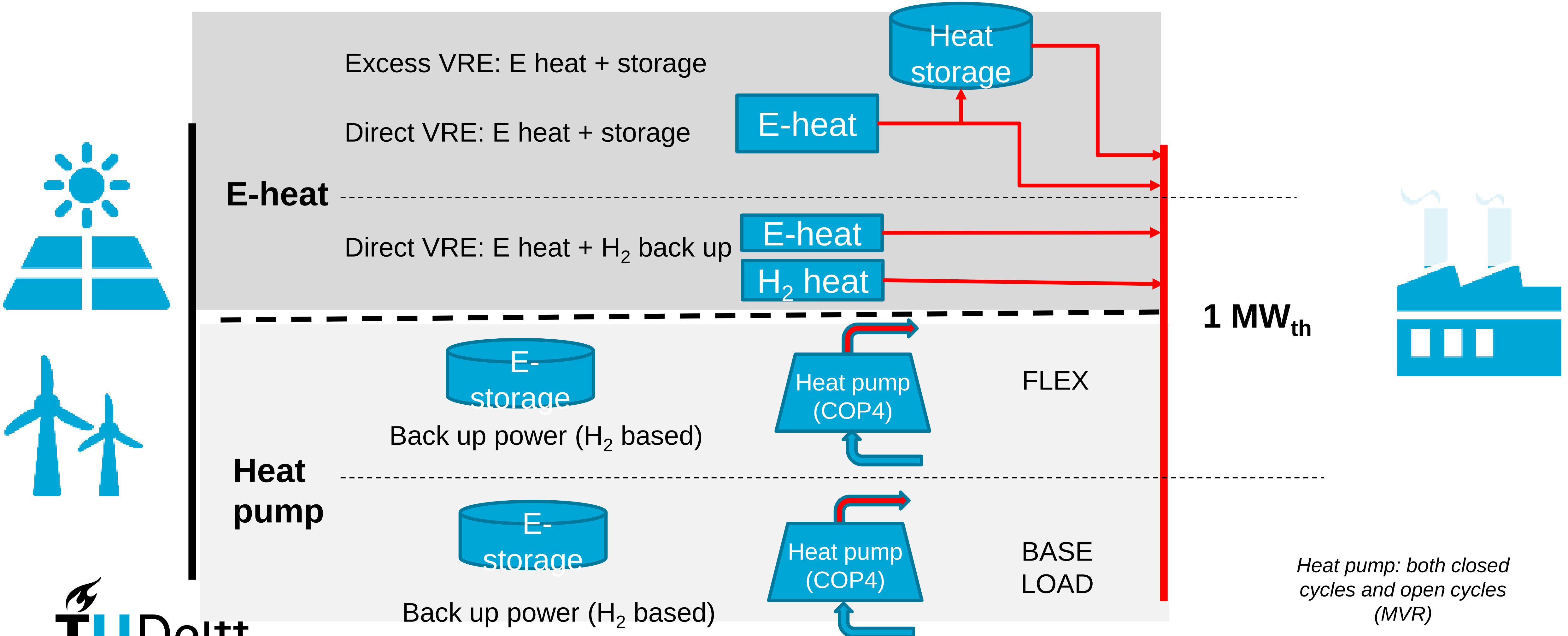
Comparison of different design options

Production of 1 MW_{th} of heat (8500 MWh/yr)



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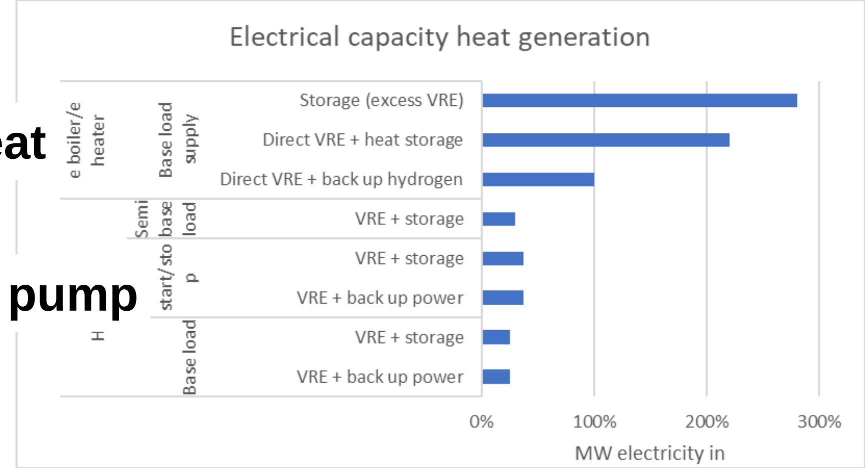
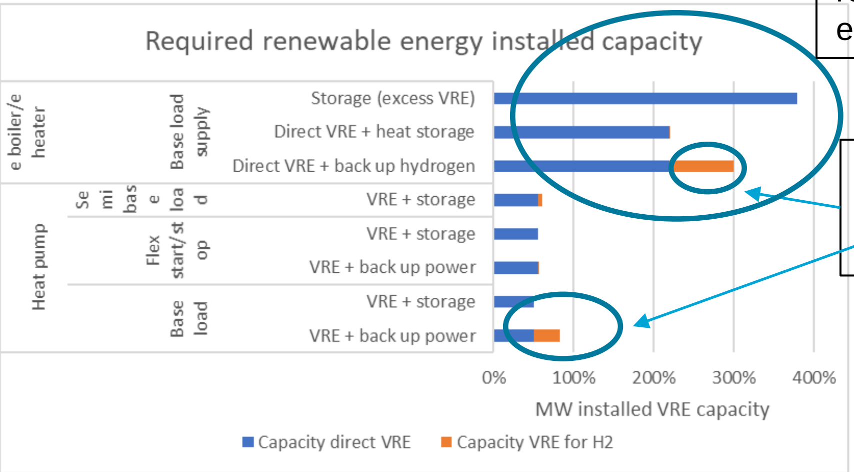
Annual production of 8500 MWh/a heat

E-heat

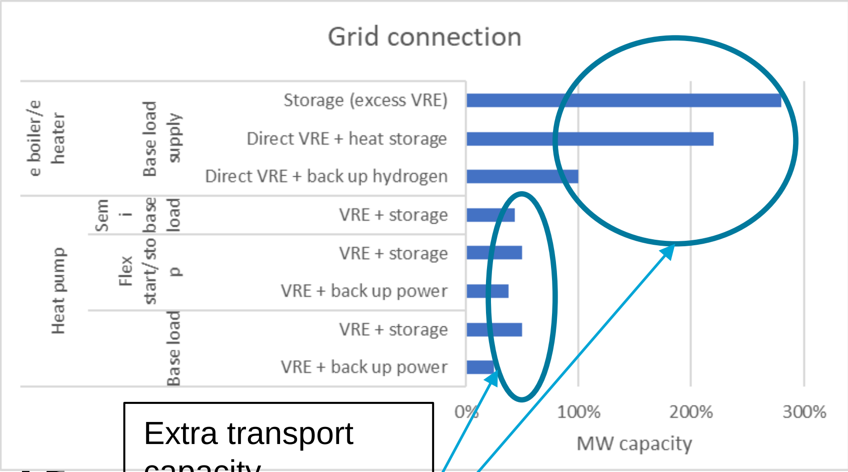
Heat pump

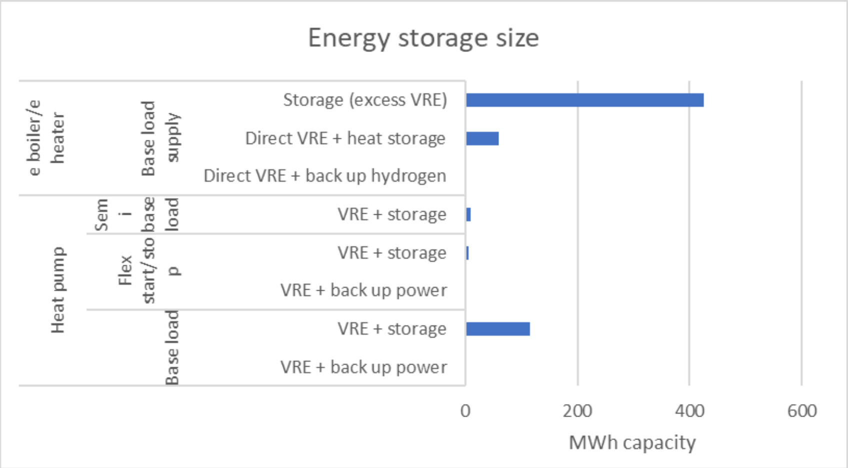




4-5 times as much renewable generation for e-heat options

Renewable generation for hydrogen production for back up energy





Extra transport capacity due to flex and local storage

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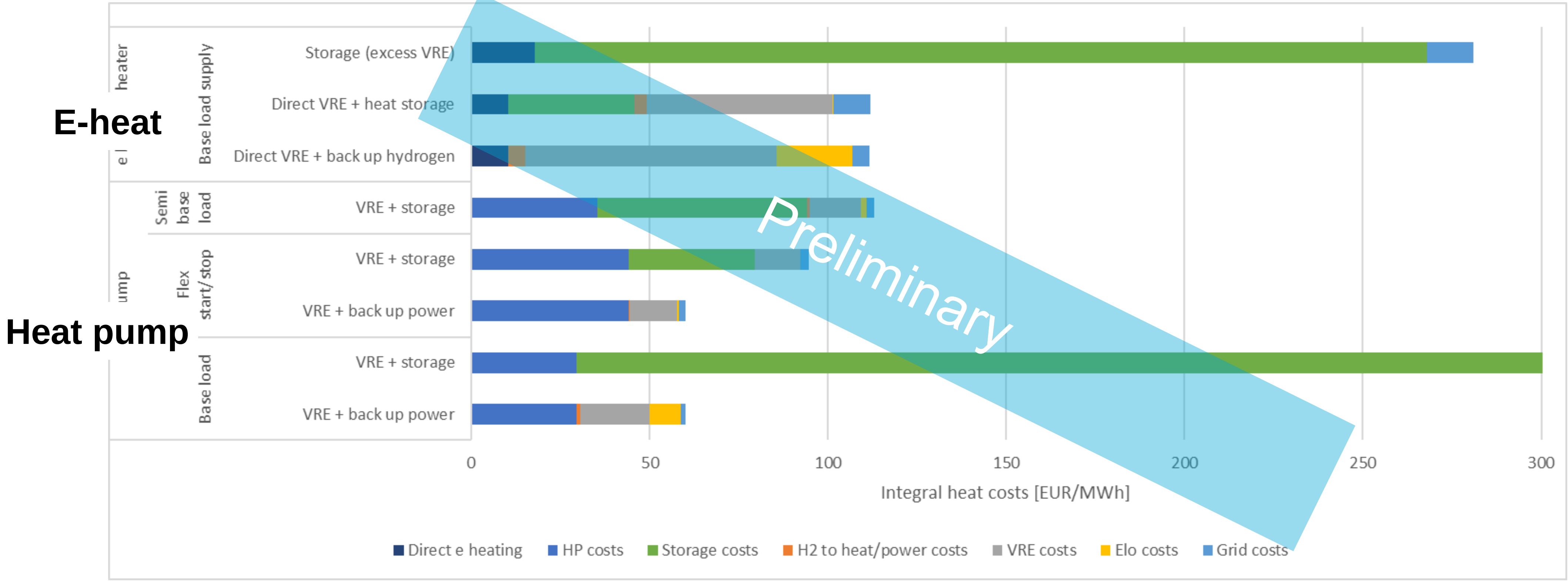
Integral cost level comparison (CAPEX based)
Total Costs of Heat Generation



- VRE: 1000 EUR/kW_{out}
- Heat Pump: 5000 EUR/kW_{e_in} COP=4
- Grid: 200 EUR/kW_e
- H_2toPower (retrofit)/H_2toheat (new): 200 EUR/kW

- Electricity storage: 250 EUR/kWh
- Heat storage: 25 EUR/kWh

- 5 year simple pay back time, no tax

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Observations General

- **Energy efficiency** counts also with renewable energy
  => heat pump solutions (open (MVR) and closed) far better than any e-boiler solution
  (two times as cheap, four times as much industry electrified, four time less transport and renewable electricity generation capacity)

  => System optimum solution does not always coincide with “cheapest” end user solution

- **(Large scale) storage is not cheap**
  => optimum combination of demand side management, storage and back up energy
- **Electricity transportation is not for free**
  => storage as close as possible to ‘problem causing’ entity
- Not all renewable electricity will be used (circa 10% curtailment)

Obstacles for large scale industrial heat pump implementation

BASED ON INPUT FROM DIFFERENT STAKEHOLDERS

- **Business case/Energy exposure**
  - High costs of heat pump and due to integration
  - Still financially exposed to fossil fuels (forward power price closely linked to fossil prices)
- **Technical:**
  - Best (thermodynamic) solution in many cases : Process integrated heat pump
    - Partial redesign of plant
    - More complex operations
  - Availability electrical connection (although 4 times smaller than e-boiler)
- **Knowledge** of and experience with industrial heat pump technology
- **Perception at end users**

Gezamenlijk Actieplan efficiente en flexibele elektrificatie nodig?!

- **Industrie:**
  - Studie om naar 100% CO_2 vrij te gaan op efficiente en toekomstbestendige manier
  - Kijk verder dan (maatschappelijk) kostbare opties (waterstof en e-boiler) met name voor volgende toepassingen: kristallisatie, drogen, scheiding (destillatie), sterilisatie etc.
  - Lange termijn commitment door investeren in installaties
- **Overheid:**
  - (SDE++/NIKI/…) Financiele regeling voor proces geintegreerde warmtepompen
  - Beschikbaar maken nieuwe duurzame elektriciteit op kostprijsniveau aan efficiente elektrificatie (tender voorwaarde nieuwe wind- en zonneparken: levering aan industriele installaties met COP > 3 ?)
  - Er zijn voldoende stokken (ETS, klimaatheffing, energiebelasting, energiebesparingsplicht …) ….
- **Overheid & Industrie**: targets stellen:
  - In 2030: 5 000 000 ton CO_2 besparing door 50% van warmtepomp potentieel in industrie te realiseren
  - Creeer voorsprong positie NL industrie
- **Kennis:** ontwikkeling, opleiding en kennisdeling
- **Innovatie:** flexibele warmtepompen en regelingen, complexe procesintegratie, opslag

CONCEPT IDEE
SUGGESTIES EN
VERBETERINGEN
WELKOM

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WIE ZIET OOK NOODZAAK EN MOGELIJKHEDEN OM EFFICIENTE EN FLEXIBELE ELEKTRIFICATIE TE VERSNELLEN?

VRAGEN/OPMERKINGEN

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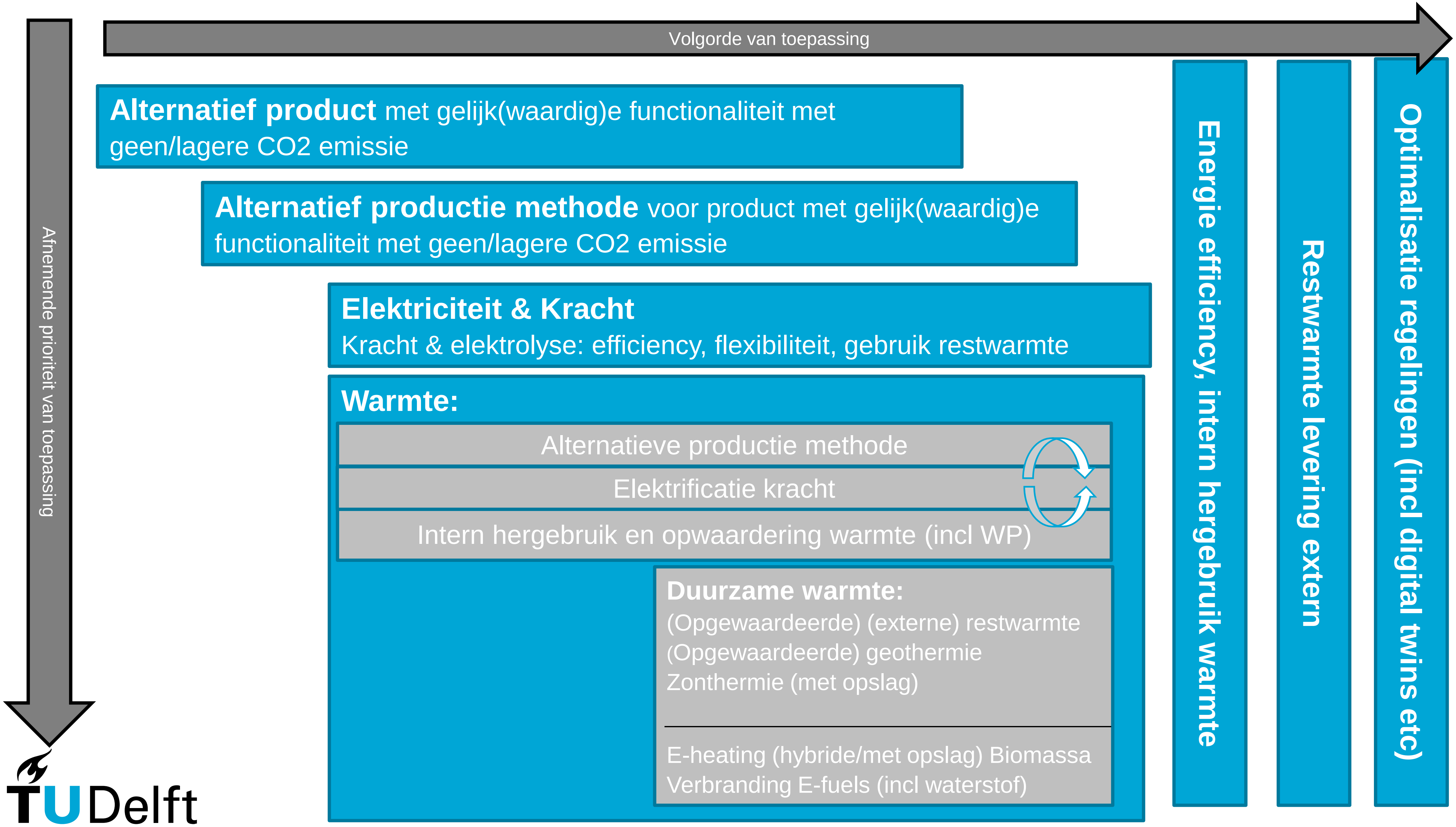

Volgorde van toepassing
Afnemende prioriteit van toepassing
Alternatief product met gelijk(waardig)e functionaliteit met geen/lagere CO2 emissie
Alternatief productie methode voor product met gelijk(waardig)e functionaliteit met geen/lagere CO2 emissie
Elektriciteit & Kracht
Kracht & elektrolyse: efficiency, flexibiliteit, gebruik restwarmte
Warmte:
Alternatieve productie methode
Elektrificatie kracht
Intern hergebruik en opwaardering warmte (incl WP)
Duurzame warmte:
(Opgewaardeerde) (externe) restwarmte
(Opgewaardeerde) geothermie
Zonthermie (met opslag)
E-heating (hybride/met opslag) Biomassa
Verbranding E-fuels (incl waterstof)
Energie efficiency, intern hergebruik warmte
Restwarmte levering extern
Optimalisatie regelingen (incl digital twins etc)
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