# Electrification and flexibility

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Committed to the Environment

# CE Delft

- Independent research and consultancy since 1978
- Transport, energy and resources
- Know-how on economics, technology and policy issues
- 75 employees, based in Delft, the Netherlands
- Not-for-profit

## Clients

Industries
(Small and medium size enterprises, transport, energy and trade associations)

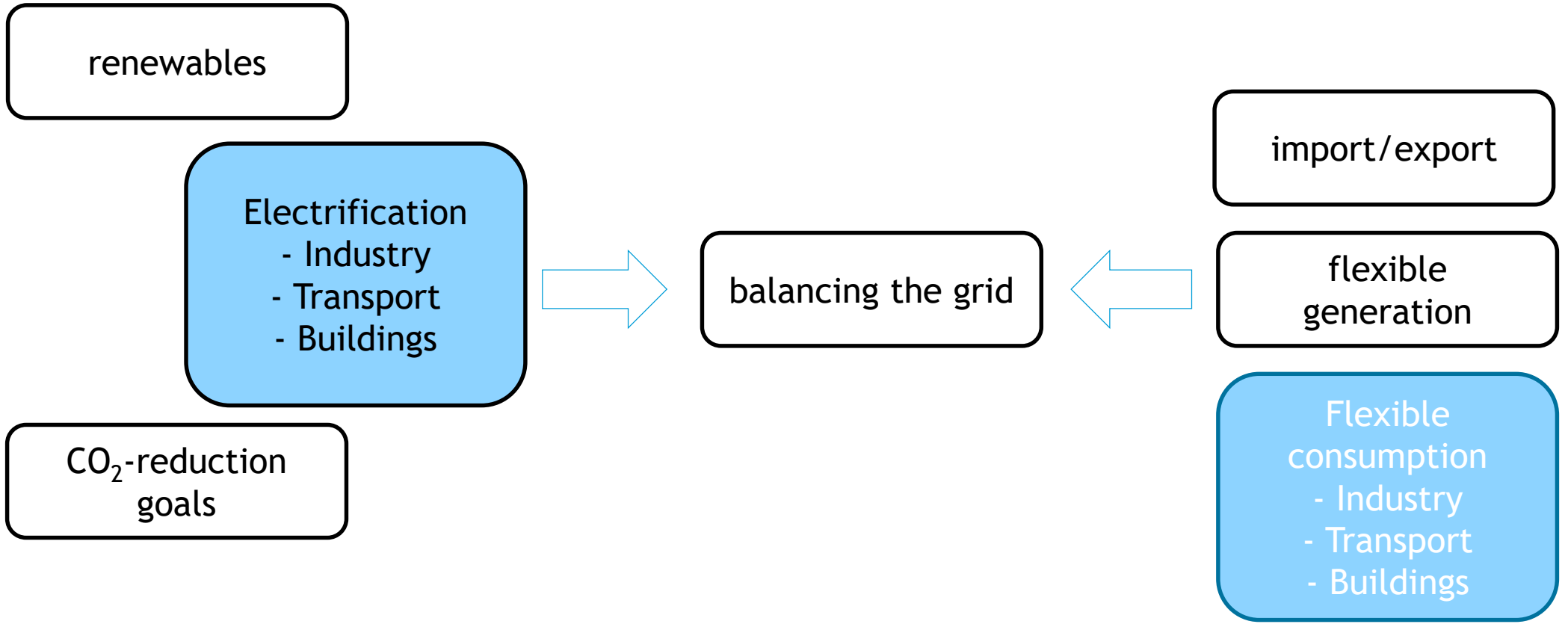
Governments
(European Commission, European Parliament, regional and local governments)

NGOs

# Content

- Study for TenneT (the Dutch Elia)
  - 2030: Current demand + electrification options in industry, transport en buildings
  - Effect on demand pattern
  - Flex options
- What kind of flex options?
- Technologies and potential
- We didn’t do a study for Elia or the Belgium situation, so
  - Figures based on Dutch situation 2030
    - Demand 120 TWh
    - Production 6 GW wind onshore, 11 GW wind offshore, 27 GW solar
  - Belgium: B ~75% NL
    - Demand 90 TWh
    - Production 4 GW wind onshore, 4 GW wind offshore, 11 GW solar

# Content in schematic manner



# Flex options?

Total electricity demand >>

(minus)

Renewables (solar/wind) >> Production 88 TWh

(minus)

Must run production >>

= Surplus 12 TWh

Residual demand >> Shortage 40 TWh

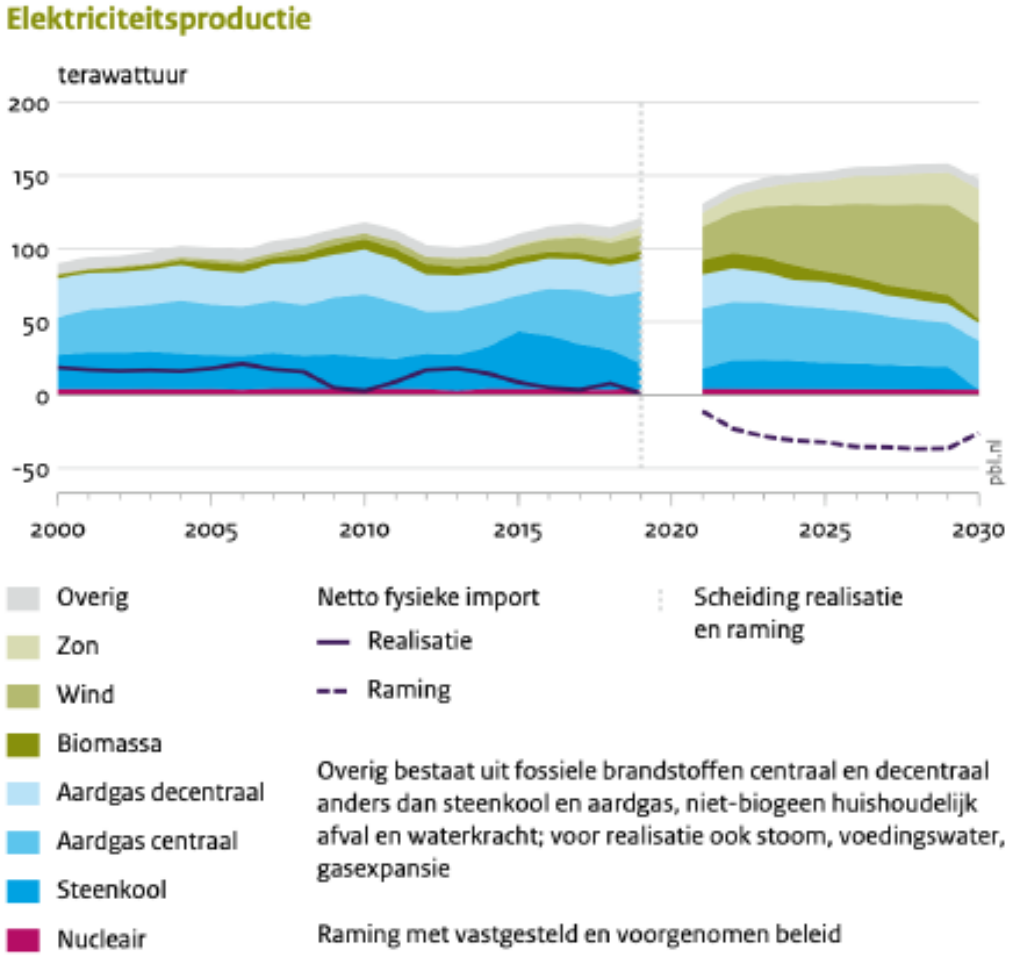
# 2030: New situation for Flex options

Traditional:

- Thermal power plants (natural gas, coal, nuclear)
- Interconnection

Future:

- More variable renewable sources (solar and wind)
- Putting surpluses to good use for more renewable energy
- Price difference peak/offpeak increases
- Accomodating extra Solar + Wind increasingly difficult
- Flexible demand can help



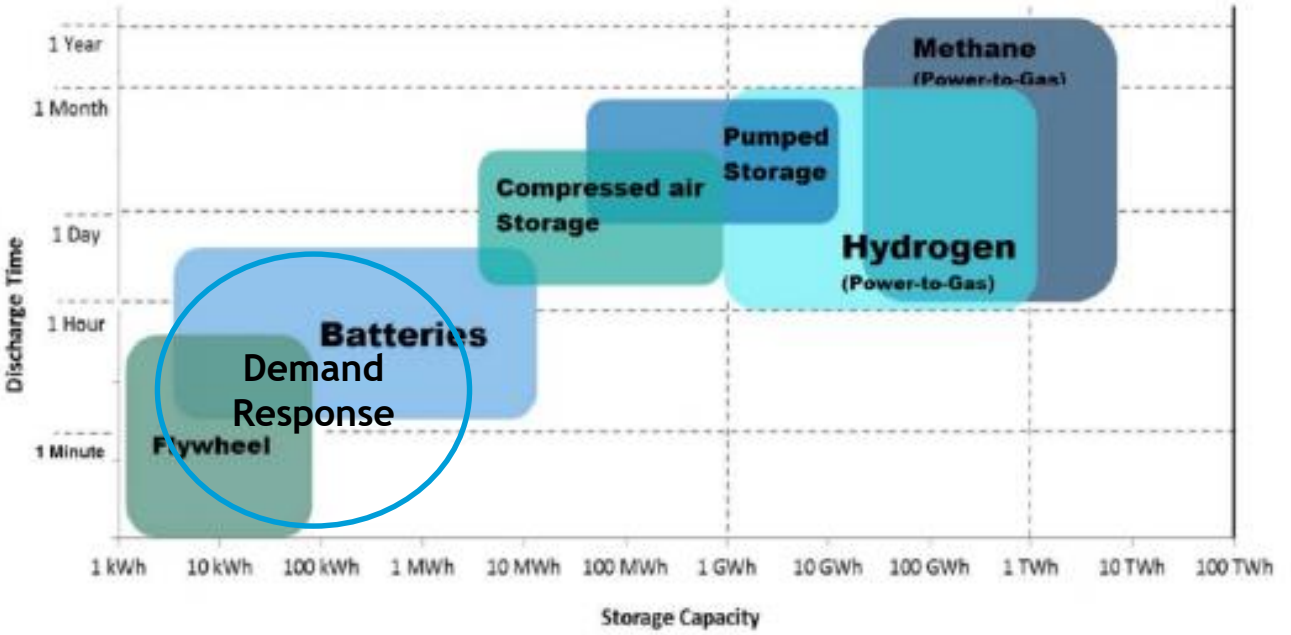
# Which flex options are possible?

- Very short term (minutes, both surpluses/shortages and infrastructure)
- **Short term (day, both surpluses/shortages and infrastructure)**
- **Medium term (week, surpluses/shortages)**
- Long term (season, surpluses/shortages)

- Now: flexible thermal power stations + a bit of demand respons + a bit of batteries + interconnection
- Soon: ?

# Which flex options?

| Flex options | Surplus | Shortage |
|---|---|---|
| Short term<br><br>Day | Batteries<br>Power to heat | Batteries<br>Demand Respons<br>$H_2$-powerplants |
| Mid term<br><br>Week | Compressed air<br>Pumped storage<br>Power to gas | Compressed air<br>Pumped storage<br>$H_2$-powerplants |
| Long term<br><br>Season | Power to gas | $H_2$-powerplants<br>Substitution > gas |




*Source: School of Engineering, RMIT University (2015)*

# Short term storage - Batteries

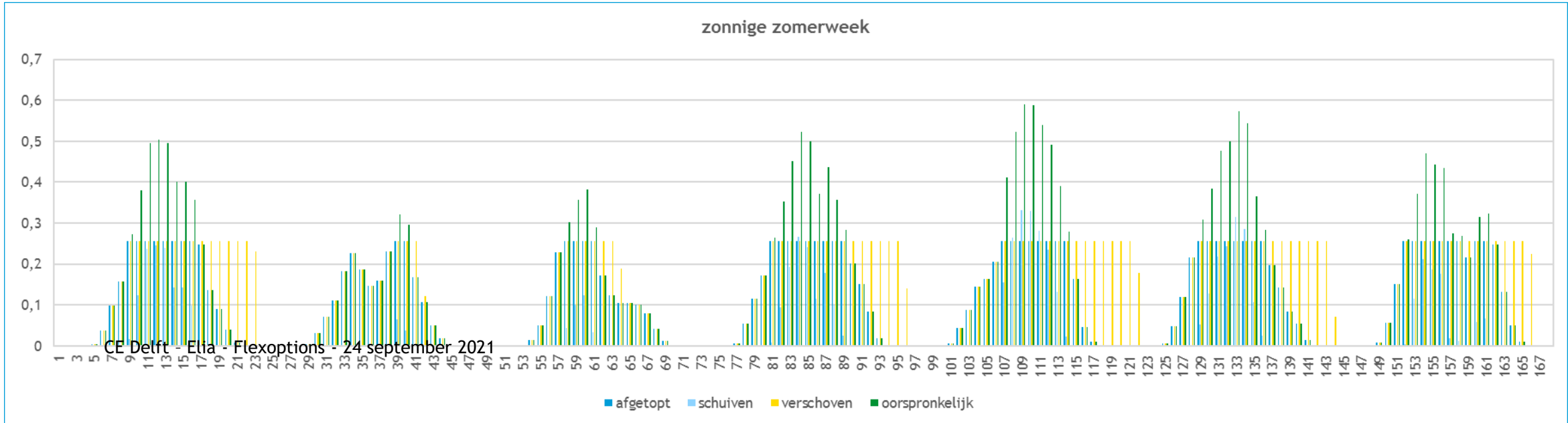
- Techniques:
  - Li-ion, flow, salt water
- Flexible, short time only, rapid respons
- Shortage and surplus
- Multiple services:
  - Balancing, intraday, day ahead, congestion
- Business case?
  - price of the battery >> rapid cost reduction
  - price difference electricity >> Now: too little volatility
  - Efficiency: high
- Coming years expanding


# Short term - Demand Response

- Theoretical potential huge, but a lot of barriers
  - Helping end-users important
  - Lack of standardization
- Transport: Smart charging
  - Tariff incentives needed
  - Electricity suppliers are crucial
- Buildings: heating and cooling
  - Difficult to switch electrical heat pump
  - Interesting: substitution to hybrid heat pump
  - Power to heat for domestic heating systems
- Industry: the process is dominant
  - Power to heat, external investor needed

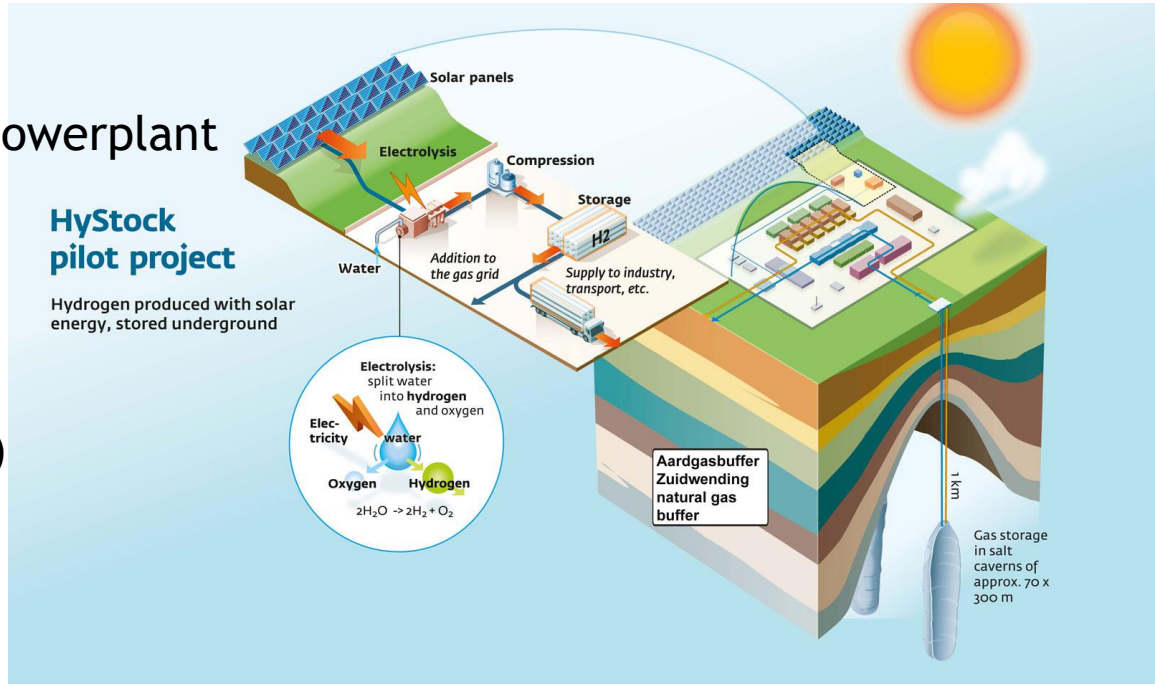
# Infrastructure

- Short term congestion
  - Mostly extra capacity cheapest option
  - Demand respons
  - Local storage (batteries) for peakshaving
- Smart connection: half peak power + batteries
- Incentives needed for maximum utilization of the infrastructure



# Long term storage - Hydrogen

- Seasonal storage and mid term surplus:
  - Surplus: Solar in the summer
  - Shortage: Electricity in the winter > thermal $H_2$ powerplant
- Little bit production in Belgium, too little surplus
- Import from The Middle East, Africa, South Europe
- Rapid cost reduction electrolysers
- Interesting development of fuel cell (bi-directional)
- Business case?
  - Green $H_2$ more expensive than natural gas & fossil $H_2$
- More in presentation Fluxys



# Industry

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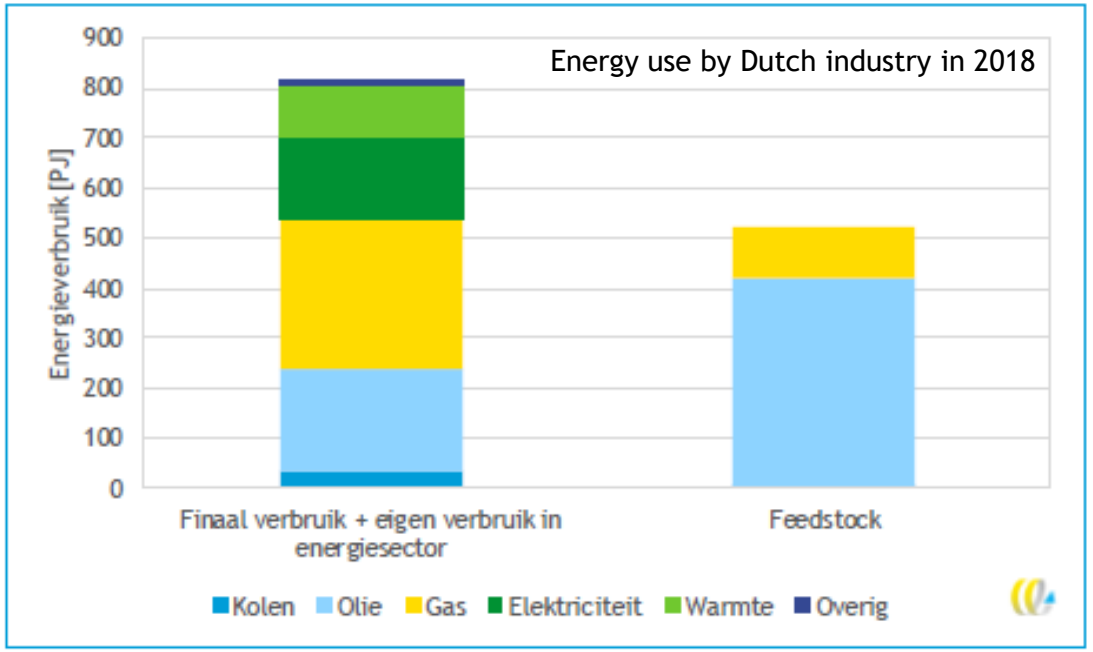
# Electrification in the industry (NL)

- Production sectors (+7,7 to +55 TWh/j)
  - See next sheets
- Agriculture - greenhouses (-1,1 to +2,7 TWh/j)
  - Lighting (-1,1 to + 2,1 TWh/j)
  - Heating (+0,1 to +0,5 TWh/j)
- Datacenters (+1,2 to +19 TWh/j)
  - Extra demand in the coming years
- Feedstock (+1,0 to +7,3 TWh/j)
  - Production of hydrogen



# Electrification of heat - Barriers

The most important barriers:

1. Marginal costs fossil vs electricity: as long as the marginal costs are higher, there is no reason to invest.
2. Investment costs: the business case must be good even with lower marginal costs.
3. Infrastructure: before electrification is possible, it must be ensured that the infrastructure will be available

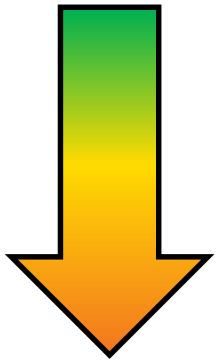
Industrial Heatpump
https://industrialheatpumps.nl/en/applications/

# Industrial flex options

- Demand response
- Hybrid boilers
- Thermal storage

# Industrial flex - Demand response

- Different degrees of flexibility
  - Fully flexible electrified process
  - Stepwise flexible production process
  - Time delay in batch production
  - Plant shutdown



Minimum activation duration
Activation price
Notice period

# Industrial flex - Demand response

- Activation prices can be (very) high
  - Energy cost in most industries less than margin on production
  - Customer contracts can have fines on failed delivery
  - Installations can take hours/days/weeks to restart

- Demand response is low on list of industry drivers:
  1. Safety
  2. Quality
  3. Reliability
  4. Efficiency/energy

- Role for external all-in service party

# Industrial flex – Demand response

Bottom-up analysis 2020 NL:

- Currently ~700 MW participating
- Max economical activation 1,9 GW
- Total demand response potential 3,4 GW
- Max NL electricity demand ca. 20 GW

- Significant share of industrial demand response at
  - Long durations (>1 day); and/or
  - Lond notice periods (>1 day); and/or
  - High activation price (>1000 €/MWh)


DNV-GL (2020) - De mogelijke bijdrage van industriële vraagrespons aan leveringszekerheid

# Industrial flex - Hybrid boilers

- Integration of electric boiler with existing gas-fired boiler
- Total potential ~2,5 GW in NL
- Full load hours dependent on prices
- Industry specific incentives/pricing can increase use beyond hours of excess electricity generation
- Long term potential uncertain: switch to full electric or hybrid hydrogen?

# Industrial flex - Thermal storage

- Electric storage = expensive,
  thermal storage = cheap!
- Simple and mature technology
- Easy to scale to GWh scale

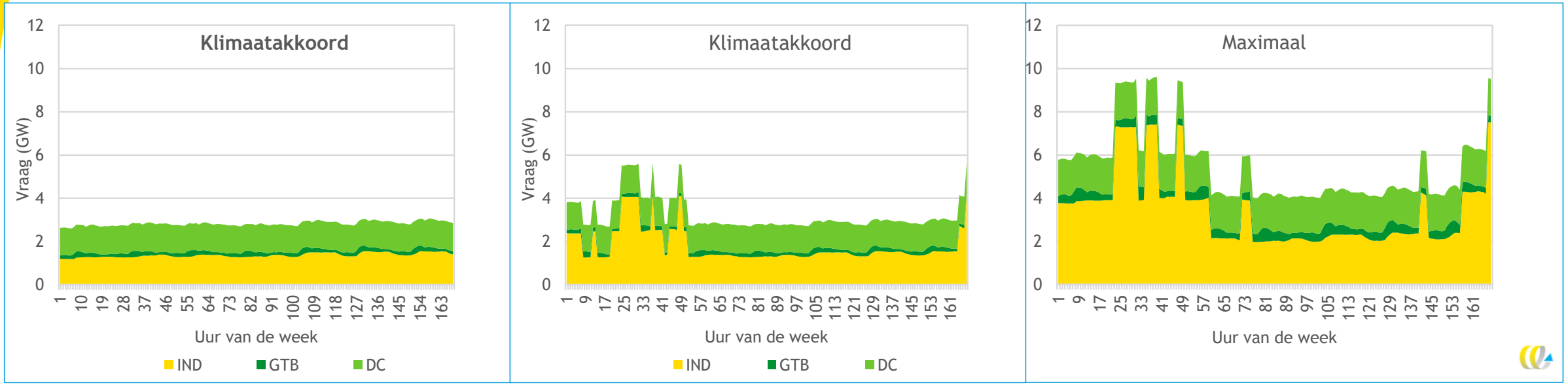
- Intermittency required
  - Constant demand + oversized grid connection
  - Fluctuating demand

- Potential for application yet unknown


Siemens ETES in Hamburg: 1000 t rock, 6 $MW_{th}$/130 $MWh_{th}$ or 1,5 $MW_e$/30 $MWh_e$ from steam turbine

# Industry - Total demand

Week 1, weerjaar 2015




Electrification, no flex

Electrification, with flex

Max electrification 2030, with flex

- Demand pattern of industry is essentially flat
- Demand peaks by electric boilers and electrolysers
- Extra flexibility by demand response possible (not shown here)

IND = Industry

GTB = Greenhouses

DC = Datacentres

# Transport

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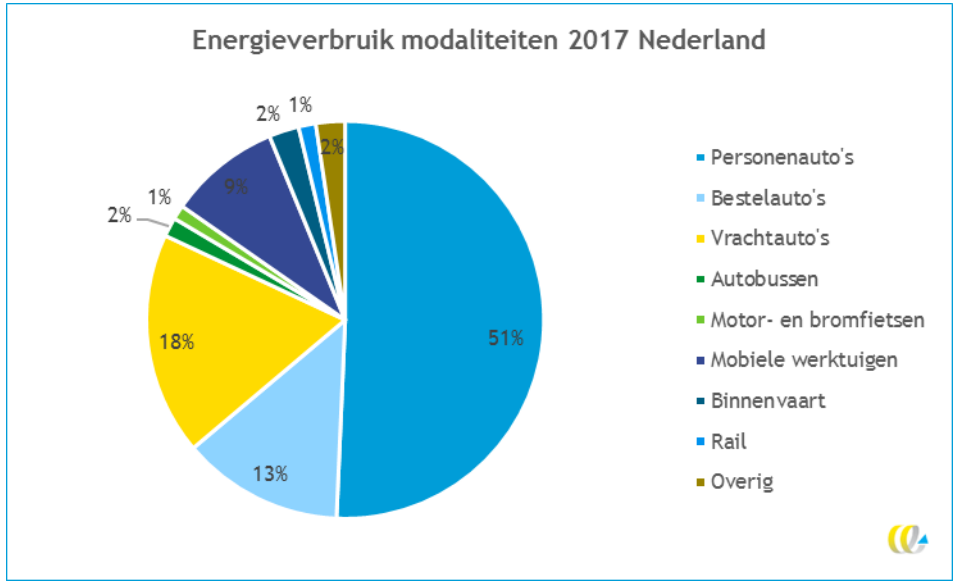
# Transport – Current demand

- Total energy demand mobility 500 PJ (142 TWh) per year (petrol/diesel)
- Electricity demand 1,9 TWh/year, mainly rail (1,4% of total demand transport)



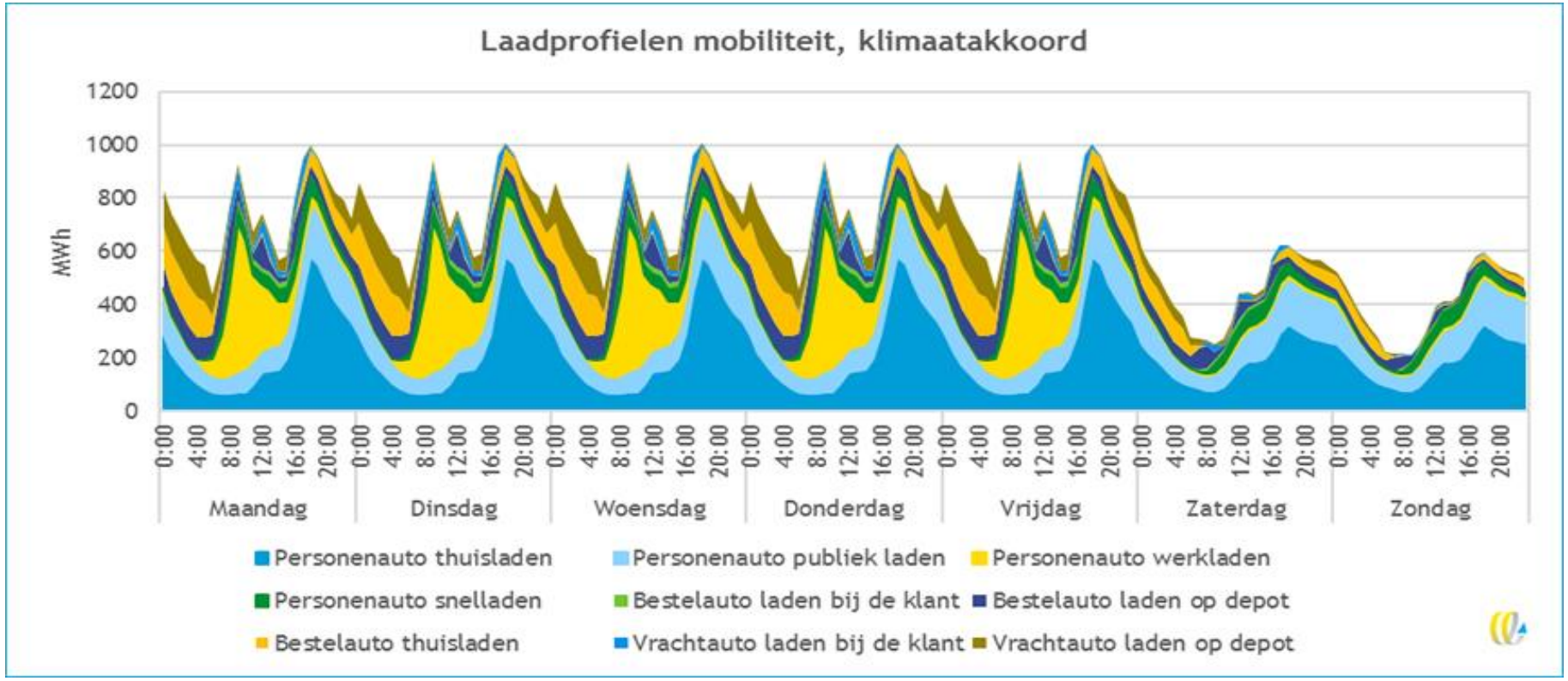
# Number of ZE (zero-emission, batteries) vehicles

| | Baseline 2030 | 2030 - extra incentives |
|---|---|---|
| Passenger vehicles | 0,5 mln | 1,9 – 2,25 mln |
| Vans | 50.000 | 115.000 – 420.000 |
| Trucks (city logistics) | 2.200 | 10.000 – 30.000 |
| Busses | 4.500 | 4.500 |
| Machinery | - | 10% - 20% ZE in building sector |


- Continuous acceleration of electrification in transport sector!
- Total electricity demand in 2030 3 - 6 times higher (7 - 12 TWh/j) than existing demand (1,9 TWh/j)
- Energy demand is not only determined by number of vehicles but also annual milage and energy efficiency
- Electrification is necessay for flex options in this sector

# Transport – Demand pattern 2030

- Peaks at the beginning and end of working days
- Charging demand for passenger cars dominant in peaks



# Transport – Flex options

- Demand pattern shift: smart charging
  - Spreading passenger car workloads over the day
  - Spreading home charging of passenger cars and delivery vans over the evening and night
  - Spreading the depot loading of buses and delivery vans and trucks over the evening and night
  - Logistics & heavy duty: possibilities very limited
    - Charging combined with rest period
  - “Charge me now” possibility important for public acceptance

# Transport – Flex options

- Temporary storage surpluses: V2G vehicle to grid
  - Charge the vehicle when there is a surplus, discharge when there is a shortage on the grid
  - Vehicle must be technically suitable (current offer is limited)
  - Incentives needed for vehicle owners


# Buildings

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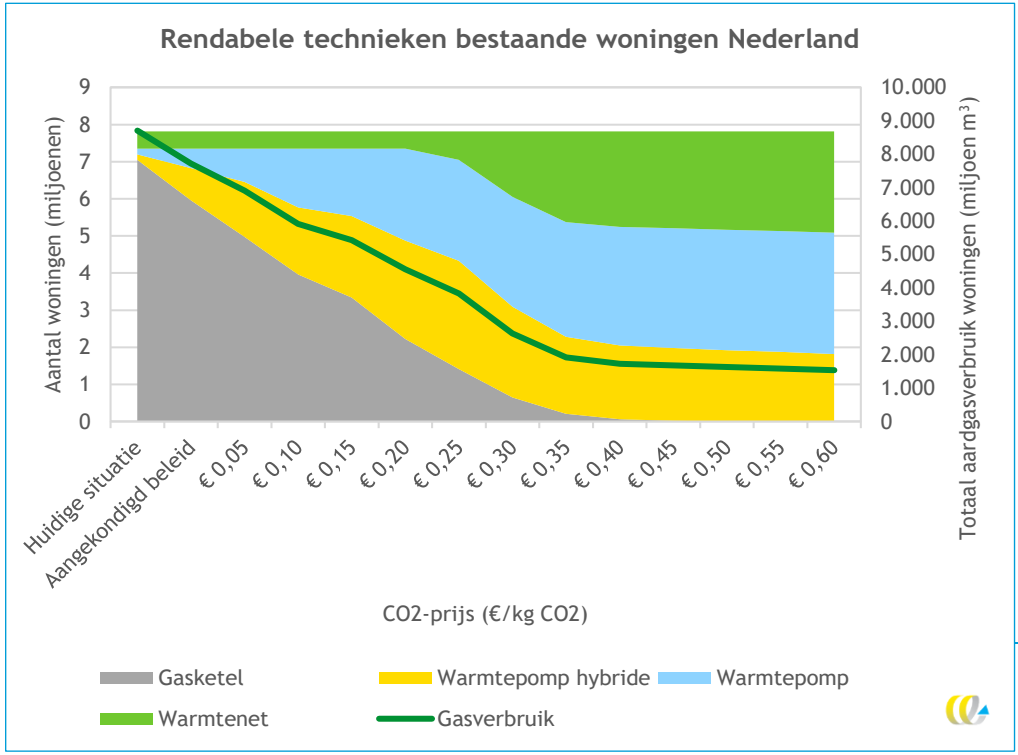
# $CO_2$-reduction >> electrification

- NL 2020: 90% natural gas
- Electrification depends on:
  - Local policy
    - Municipal heat plans
    - Subsidies
  - National policy
    - Laws and regulations
    - Subsidies, taxes and $CO_2$-pricing
- General resistance in society to change away from gas-based heating

# Buildings - Techniques and potential

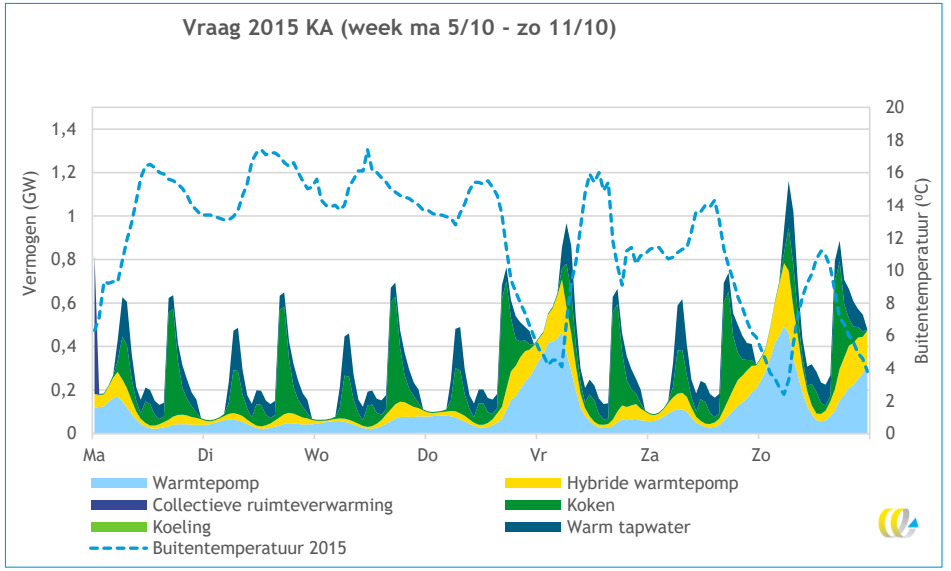
- $CO_2$-free: >> several options
  - 35% district heating
  - 40% electric heat pump
  - 25% hybrid heat pump




| Function | Techniques<br>Heating and cooling | Flexible? |
|---|---|---|
| Individual<br>space heating | Electric heatpump | Yes, technically<br>Difficult in behavior |
| | Hybrid heatpump | Yes, technically<br>Difficult in behavior<br>fewer problems compared with all electric heat pump |
| District heating | LT heating system | Heat buffer<br>Power to Heat |
| Warm water | Heat pump boiler | Yes, short term |
| | Electric boiler | Yes, short term |
| Cooling | Air conditioning | Synchronized with solar |
| Cooking | Induction | No, high power for short time only (battery?) |
| Divers | Washing machine<br>Dishwasher | Yes, short term |

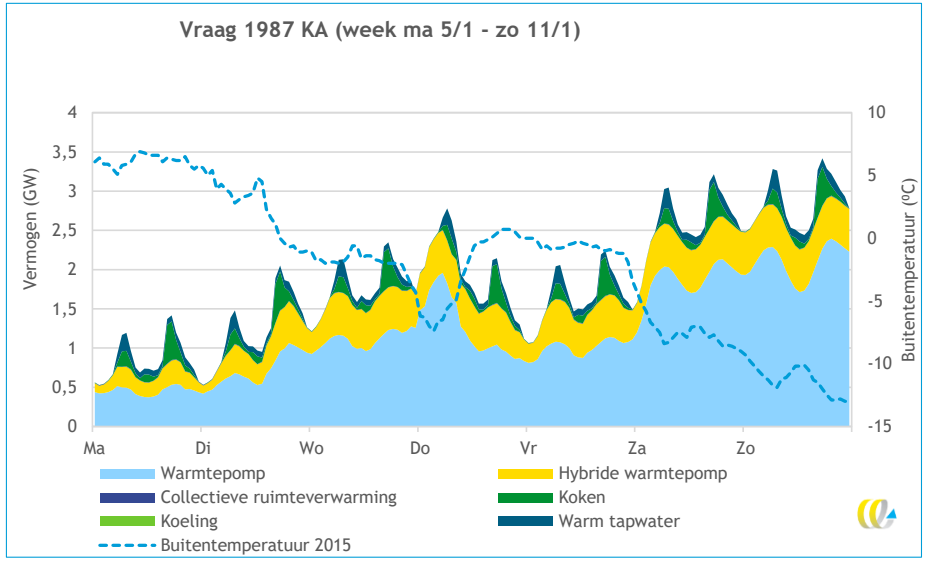
# Buildings – Additional demand pattern

- Average week in the main scenario
- Heat pumps largest energy demand
- Hybrid heat pumps do not have high peaks due to gas boiler
- Cooking and hot water cause peaks

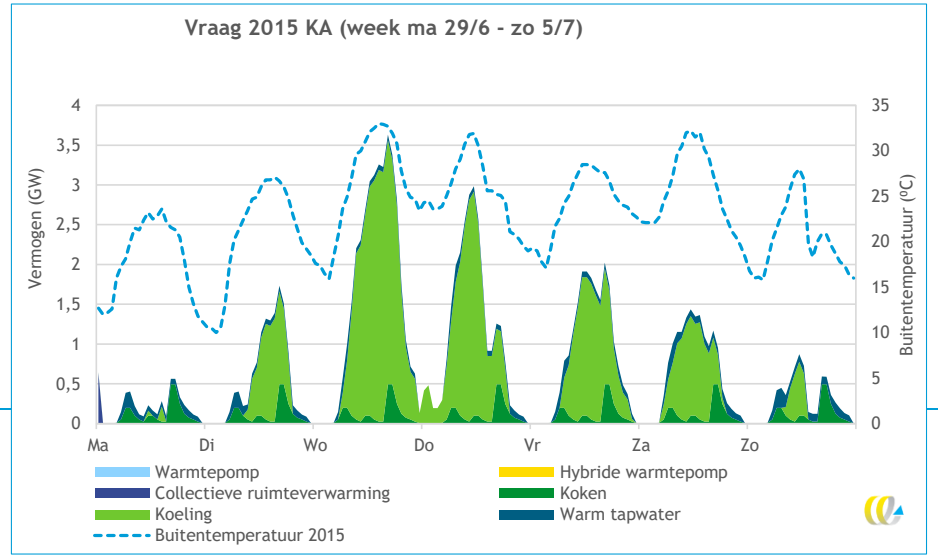


# Buildings – Additional demand pattern, extreme weeks

- Cold winter week
  - Heating is dominant
  - 0,5 – 3 GW

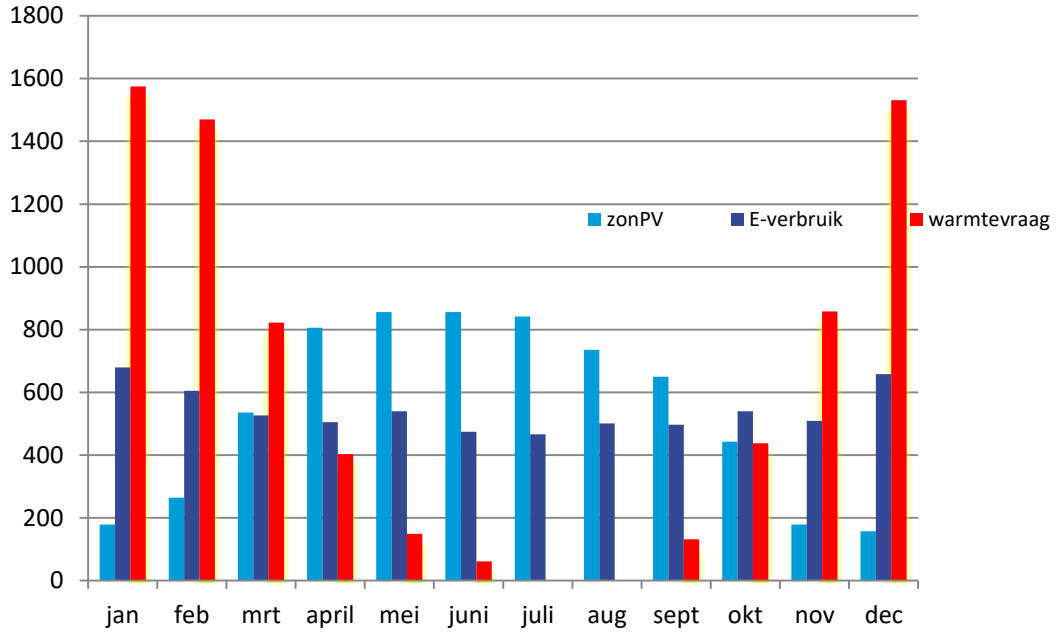


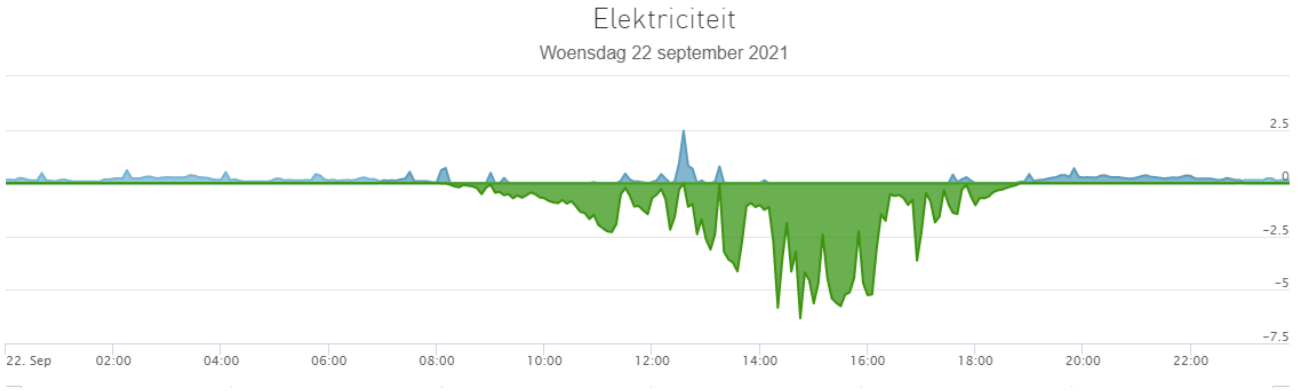

- Hot summer week
  - Cooling is dominant
  - 0-3,5 GW



# Home battery

- For solar systems
  - High price volatility >> also day/night
- Expensive at this moment
  - Rapid cost reduction
- Only useful for short term




# 2030: conclusions (NL)

- More need of flexibility
  - By introduction a lot of solar and wind
- A lot of flex options are available
  - For all time spans
  - Surpluses and shortages can be reduced
  - Surpluses decrease sharply in time by batteries (autonomous)
- Only policy can ensure that in the next 15 years
  - natural gas plants are being replaced by
  - storage, demand management and $H_2$ power plants
- Possible policies:
  - Strong lowering of ETS emissions cap (EU Green Deal)
  - Standard: max $CO_2$/kWh

# Thanks for your attention

**More information:**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