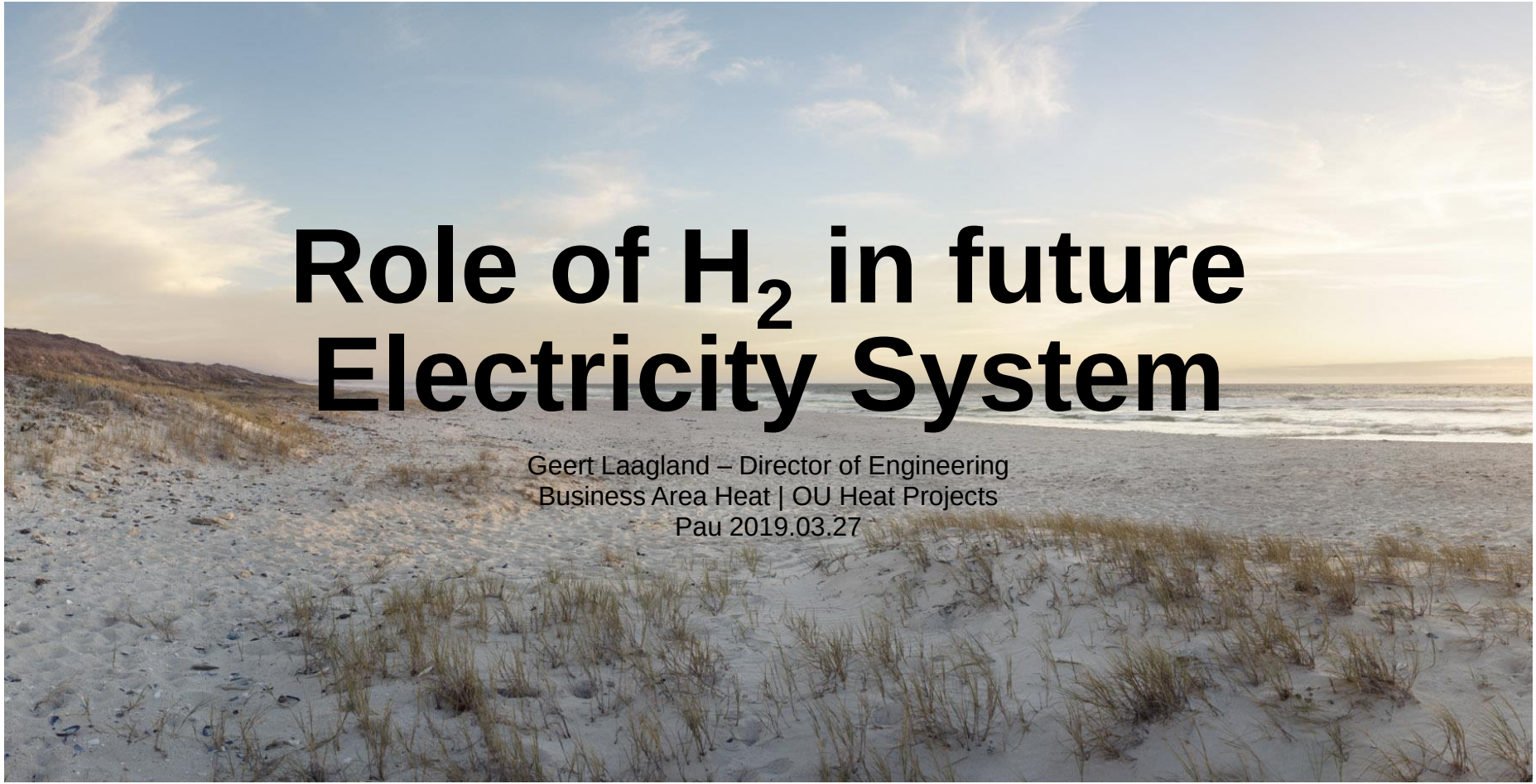


Role of H_2 in future Electricity System

Geert Laagland – Director of Engineering
Business Area Heat | OU Heat Projects
Pau 2019.03.27

VATTENFALL

Vattenfall’s value chain

Production

Production from
- Hydro
- Nuclear
- Coal
- Natural gas
- Wind
- Solar
- Biomass
- Waste

Actively phasing out fossil-based production

Electricity distribution

- Guarantees secure supply via well-functioning distribution networks and smart network solutions
- Enables customers to feed self-generated electricity into the grid (“prosumers”)

Sales of electricity, heat and gas

- Sells electricity, heat and gas to consumers and business customers
- Focuses on various price and service models, and gives customers the opportunity to reduce their environmental impact

District heating

- Drives the transformation towards fossil-free heating and cooling solutions together with cities and regions
- One of Europe’s largest producers and distributors of district heating

Energy services & decentralised generation

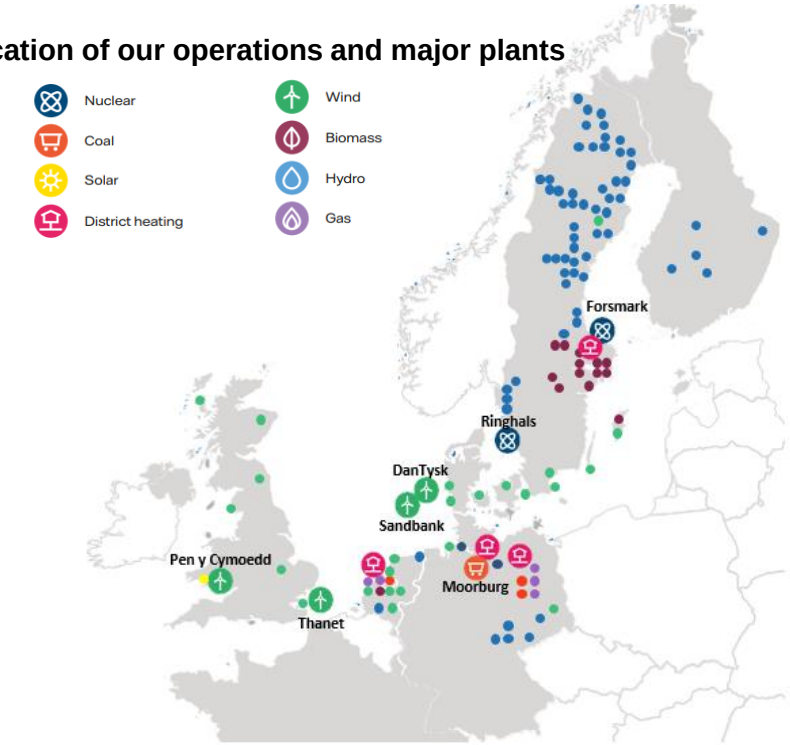
Offers energy services
- Heat pumps
- Solar panels
- Charging solutions for electric vehicles
- Battery storage
- Network services
- Smart meters

Provides marketplaces and access to marketplaces where customers can buy and sell electricity

Introduction to operating segments

- ***Customers & Solutions*** - Responsible for sales of electricity, gas and energy services in all of Vattenfall's markets
- ***Power Generation*** - comprises the Generation and Markets Business Areas. The segment includes Vattenfall's hydro and nuclear power operations, maintenance services business, and optimisation and trading operations
- ***Wind*** - Responsible for development and operation of Vattenfall's wind farms as well as large-scale and decentralized solar power and batteries
- ***Heat*** - Responsible for Vattenfall's heat operations including sales, and gas and coal-fired condensing
- ***Distribution*** - Responsible for Vattenfall's electricity distribution operations in Sweden and in Berlin, Germany

Location of our operations and major plants



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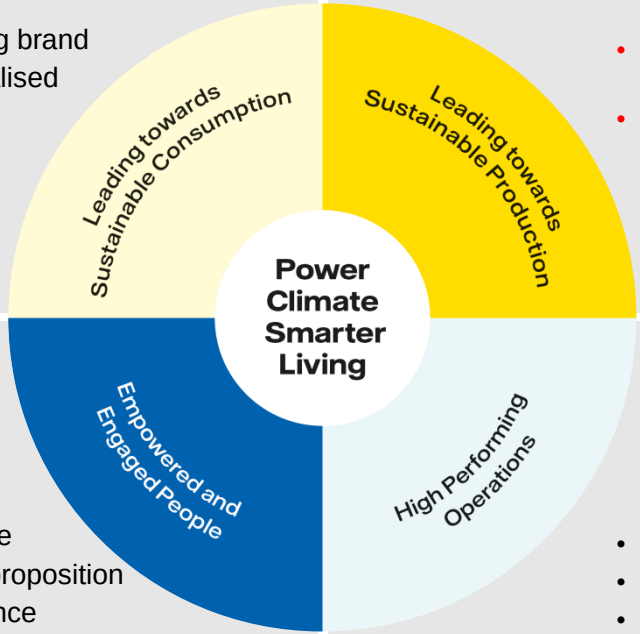
Strategy and strategic targets

- Customer centric and strong brand
- Sizable position in decentralised energy
- Driver of electrification and climate smart society

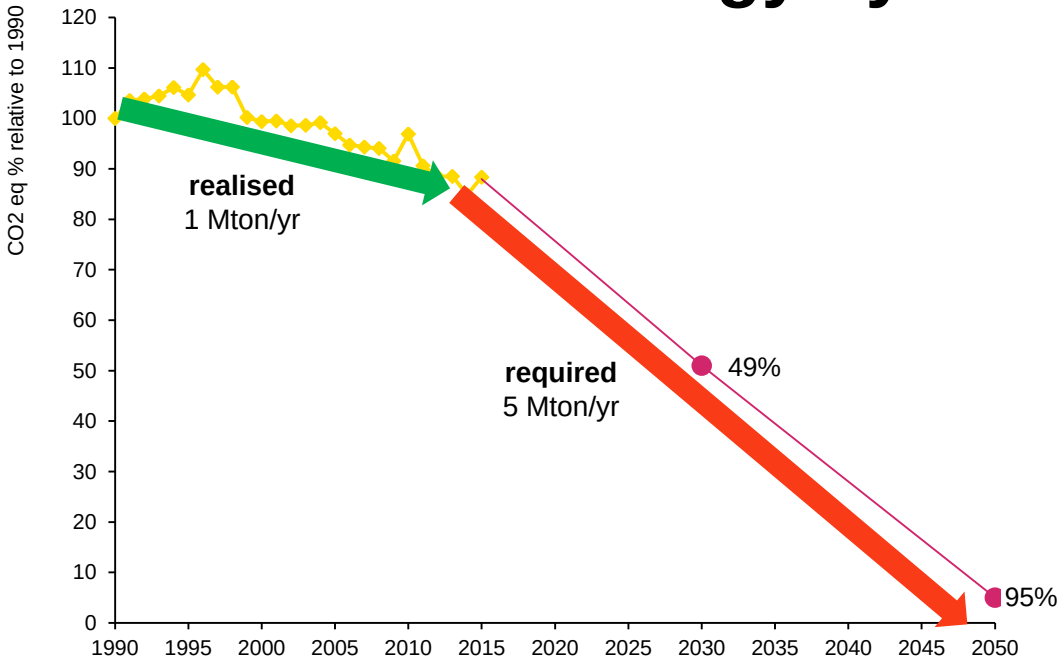


- **Leading producer of renewable energy**
- **Fossil-free within one generation**

- Clear and engaging purpose
- Attractive employee value proposition
- Right and diverse competence

- First quartile in cost efficiency
- Digital utility
- Sustainable value chain

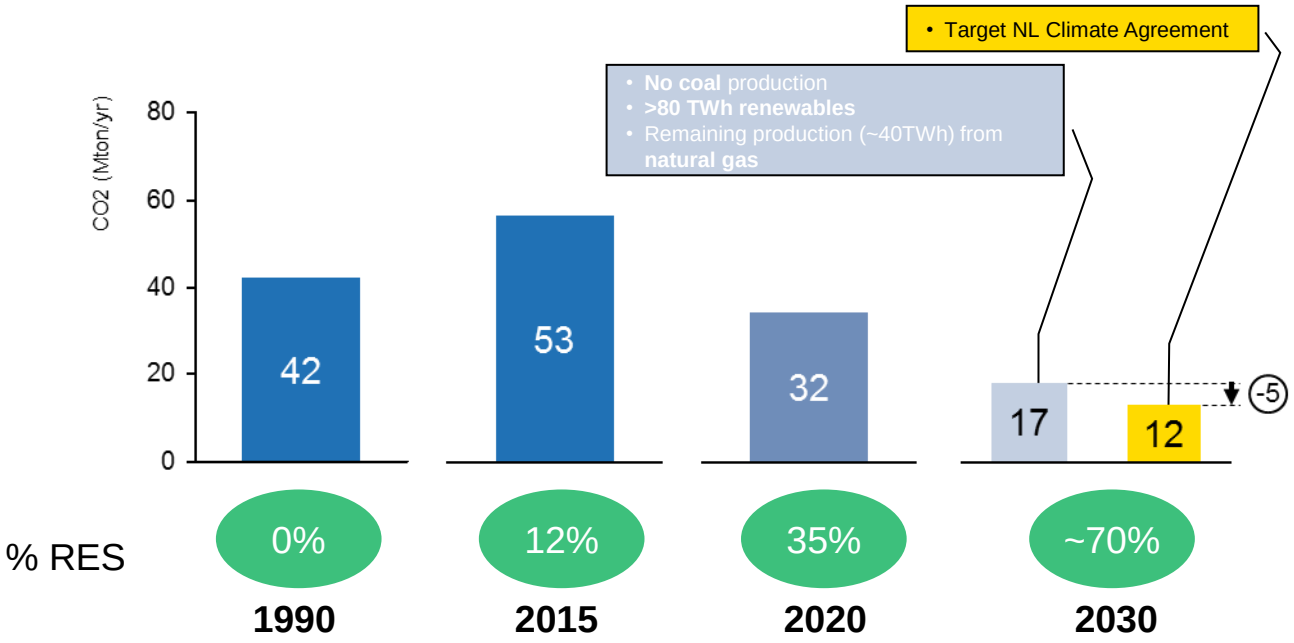
Towards a CO_2-free and reliable energy system in NL



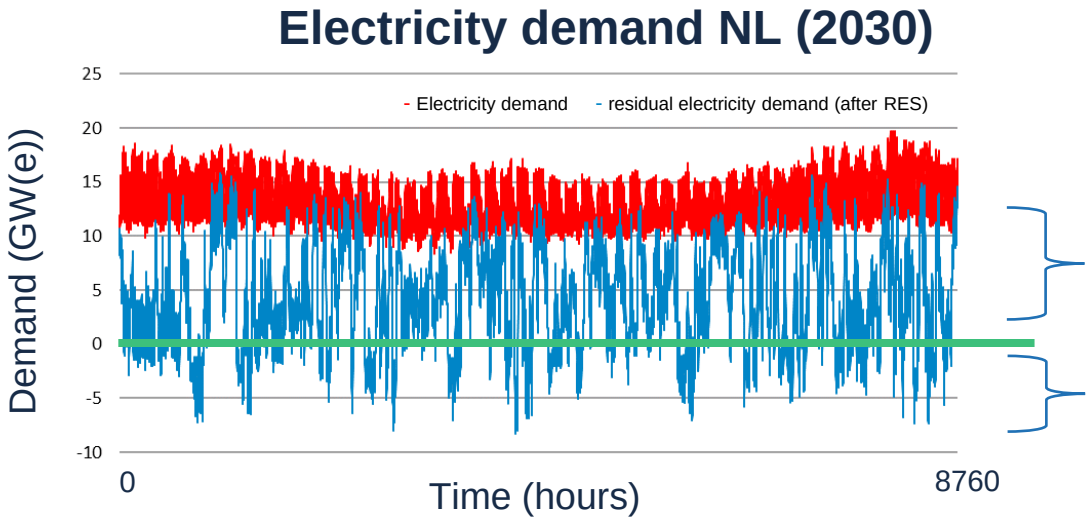
Our main challenges:

- Achieve deep CO_2 reduction
- Accelerate
- Keep the energy system stable

Approximately 30% of CCGTs need to be decarbonized to realize the 2030 20 Mton reduction target for the NL power sector



NL CCGTs will provide flexible capacity to balance VRES, but need to be CO_2 free



Too little production from wind/ solar: **flexible capacity needed** to fullfill demand

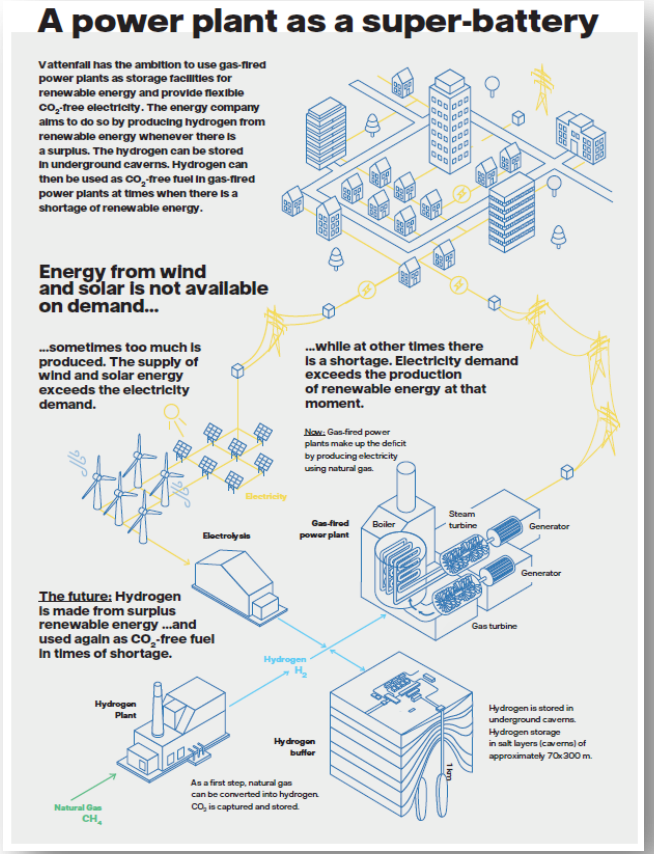
Too much production from wind/ solar: **Possible curtailment** of useful energy

Decarbonization options for controllable flexible power are few
Use of H_2 in CCGTs is preferred option for Vattenfall

- Options to deliver CO_2-free controllable flexible power are few:
  - Post-combustion CCS on (existing or new) CCGTs
  - Biomass in new plants or existing coal plants, which can not fire coal after 2030 anymore
  - Use of CO_2-neutral H_2 (blue/ green) in CCGTs

- Use of H_2 in CCGTs:
  - Decarbonizes Vattenfall's generation portfolio
  - Provides long-term value to the Dutch energy system

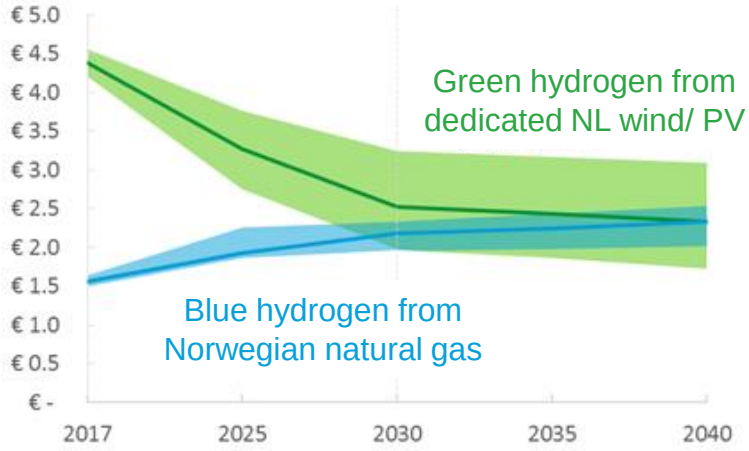
- H_2 can be an important element in future Dutch energy system, with multiple applications.
  - Green H_2 from excess electricity is only limitedly available until after 2030[1]
  - Blue hydrogen can kick-start a hydrogen economy, enabling realisation of a hydrogen infrastructure



[1]in addition, there may be cases where H_2 is generated offshore and the wind energy is transported in the form of molecules rather than electricity

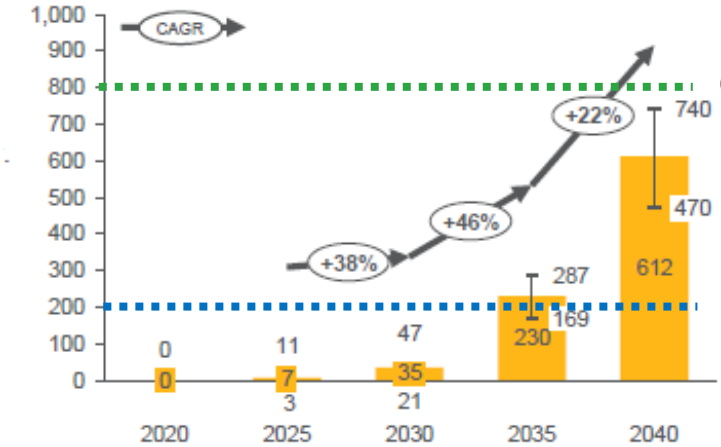
100% green H_2 not yet feasible on short to medium term

Integrated costs



From: CE Delft "Waterstofroutes Nederland - Waterstof ketens voor blauwe en groene en import"

Hydrogen production potential from "excess electricity"



From: Navigant study (proprietary) into development of excess electricity in The Netherlands; (NL with interconnection; basispakket 49% scenario)


THANK YOU FOR YOUR ATTENTION!
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