AVR - CO2 CAPTURE AND LIQUEFACTION

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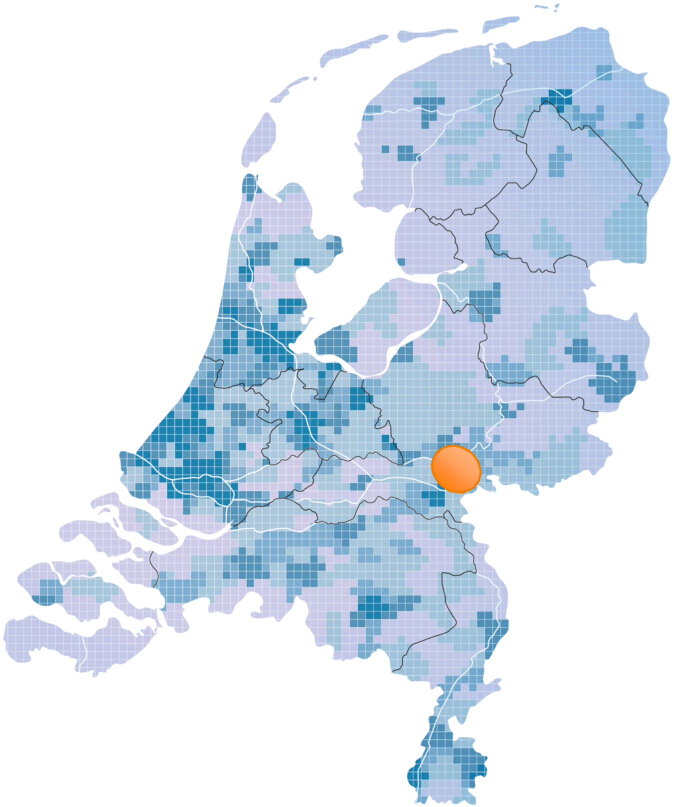
BIO-CCUS PROJECTS

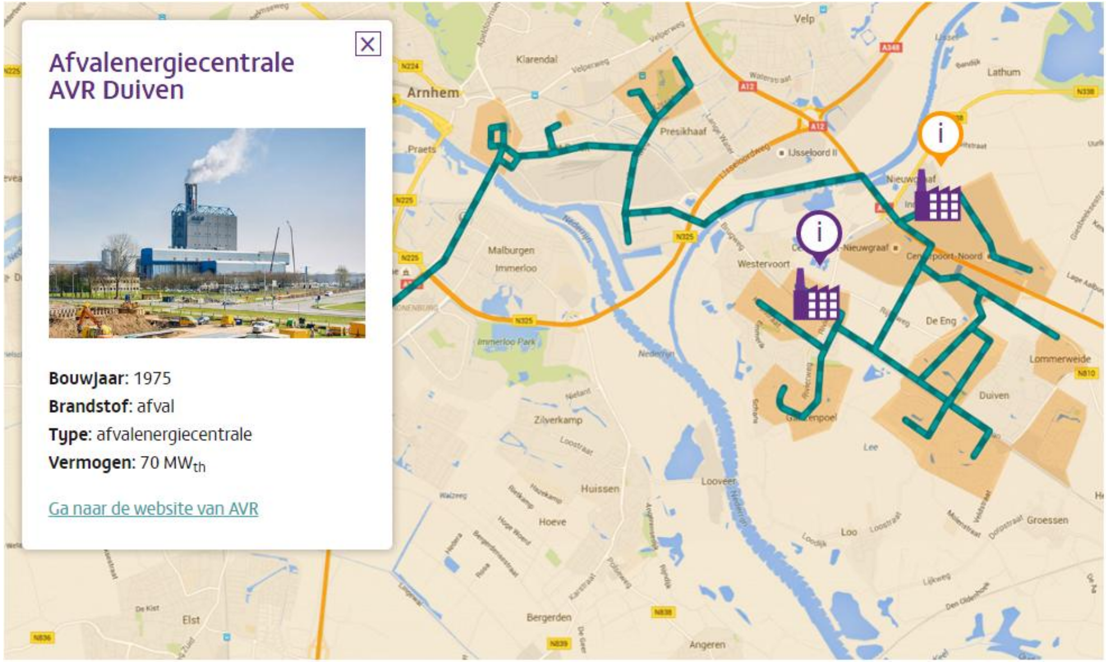
AVR Duiven

- Feasibility study for CO_2 capture from waste to energy plant
- 50,000 tCO_2/yr
- Delivery of CO_2 captured to horticulture by truck



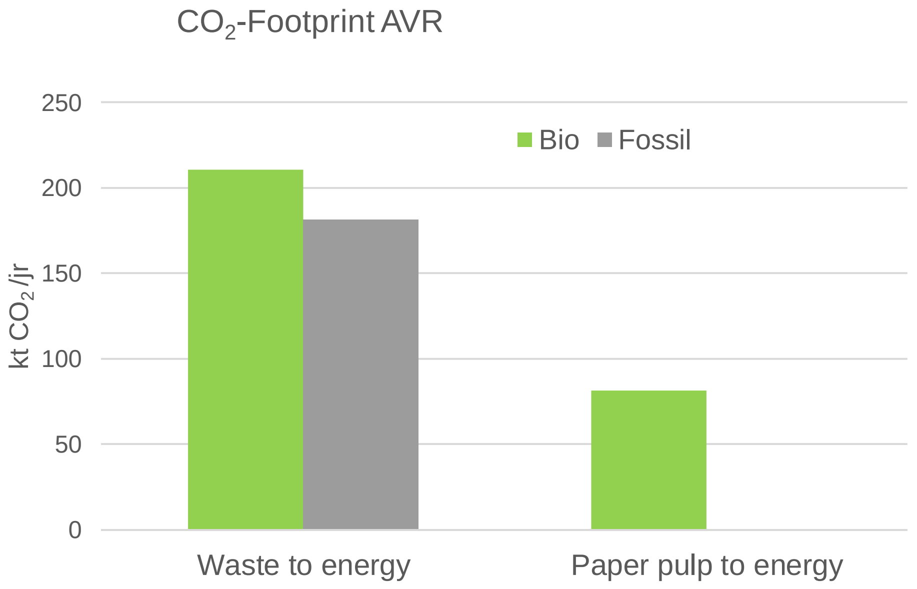
SETTING THE SCENE

- Waste to energy plant AVR Duiven
- Main supplier of district heating network
- 70 MWth
- Waste (54% bio / sustainable)
- Paper pulp residu (100% sustainable)
- Electricity to grid: 125 GWh
- Heat to grid: 880 TJ (14.000 households)



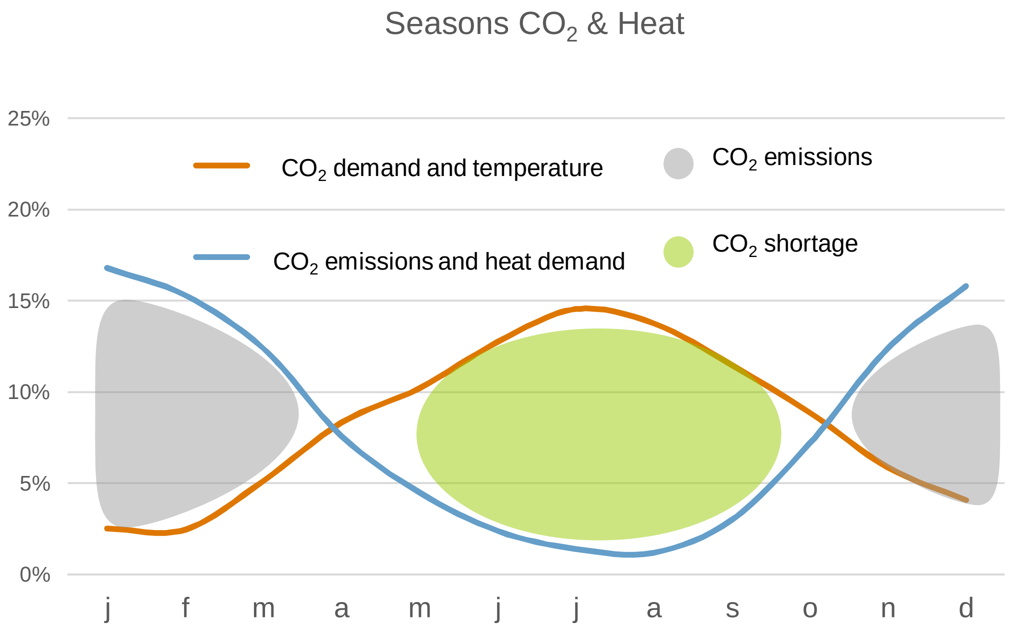
SETTING THE SCENE

- Approximately 0.2 Mtonnes of fossil CO2 / year
- Aim to recover 50,000 tCO2/yr
- Supply the gas to horticulture in the regional market
- Upscaling towards 2030
- Improving overall footprint significantly



SETTING THE SCENE

- Horticulture: local combined heat-and-power stations not economical to produce CO_2 for growth enhancement themselves,
- CO_2 and costs are saved.
- External CO2 supply enables horticulture to make a shift towards renewable energy use for heating,

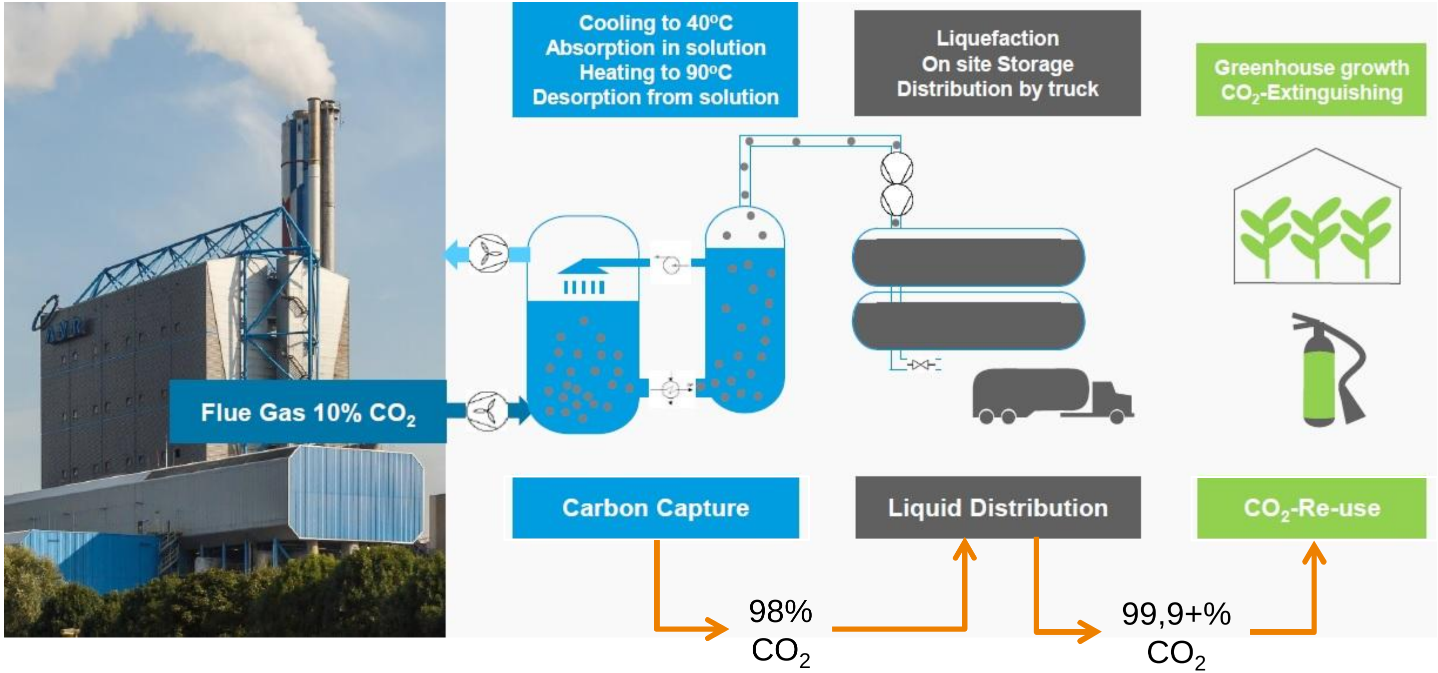


PHASED APPROACH

PHASE 1	**CONCEPTUAL DESIGN**	
WP 1	User requirements	D01. User Requirements Report
WP 2	Conceptual process design • Technology Selection • Process Flow Diagram • Integrated design • Technical/economic evaluation • Implementation roadmap, Risk identification and reporting	D02. Conceptual Design Report including initial Development Plan
PHASE 2	**SMALL SCALE TEST**	
WP 3	Small scale test and validation	D03. Test and validation Report Test results include measurements on solvent degradation, emissions and CO_2-quality.
WP 4	Final reporting – including development plan	D04. Final report - updated D02 report including development plan

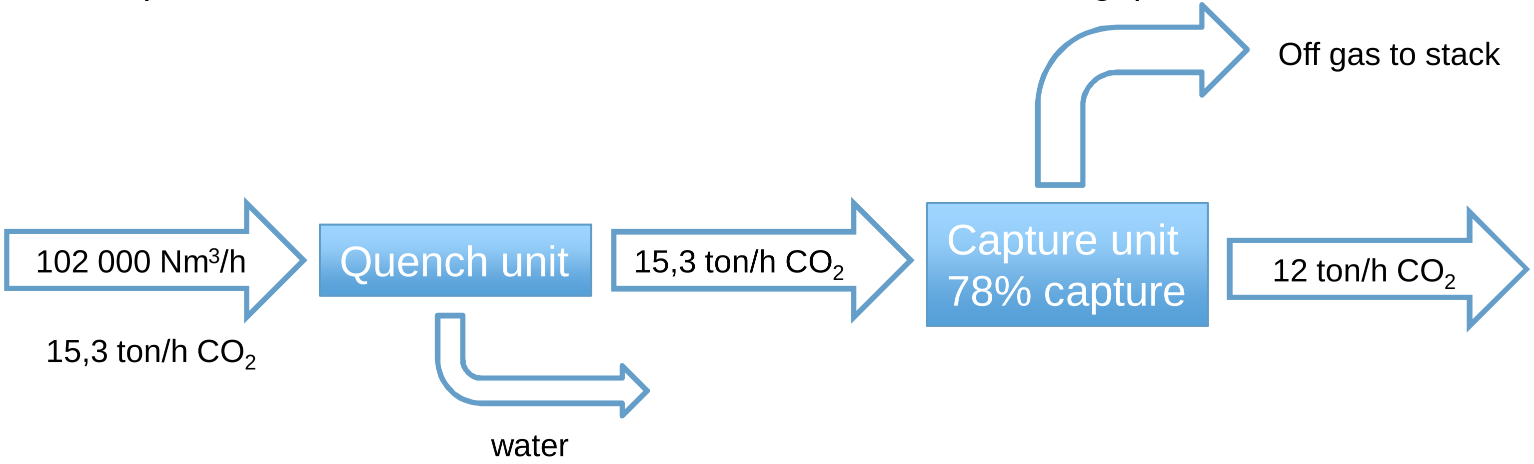
SOME FIRST INSIGTHS

CO_2 CAPTURE AND LIQUEFACTION



FLUE GAS

- 102 000 Nm^3/h
- 10% CO_2 (dry basis) = 7,6% CO_2 (wet basis)
- Design basis: capture 12 ton/h (full load = 78% capture)
  - Flex: Operate at 50% and 80% load + Determine maximum throughput



FLUE GAS CONDITIONING AND CO2 CAPTURE

Flue gas:
- Too hot
- Not enough pressure

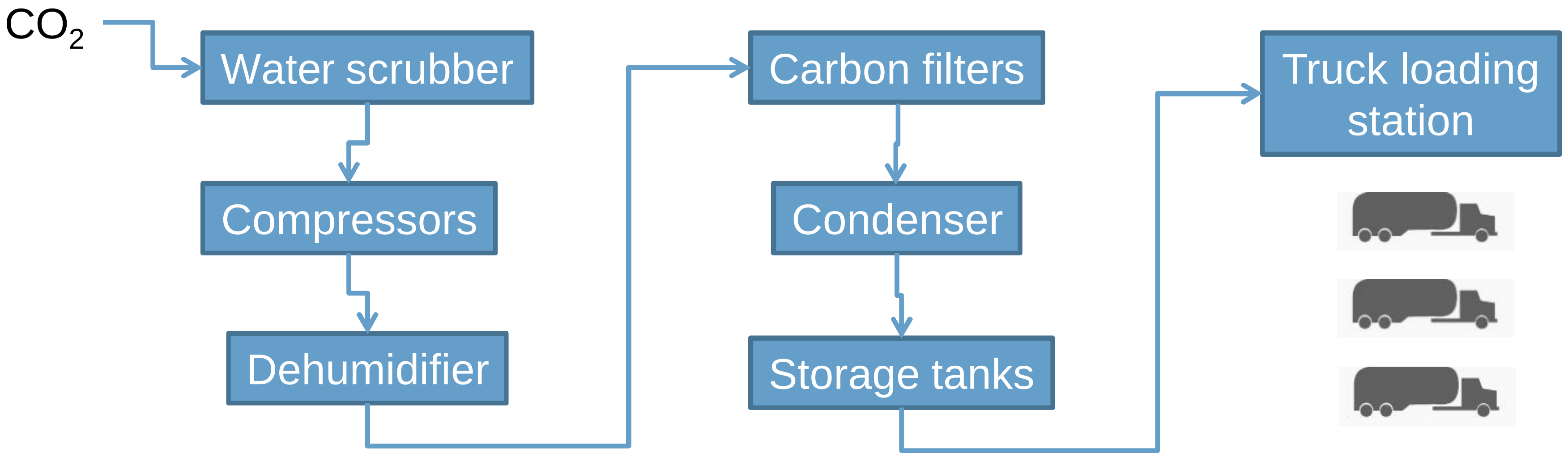
Blower → Quench → Absorber → Stripper → Distillation and flash

- Quench: Cooling water
- Absorber: Offgas to water wash
- Distillation and flash: CO2 to liquefaction

SUMMARY – INDICATIVE NUMBERS

- Flue gas conditioning + CO_2 capture
- Utilities and consumables :
  - Electricity = 17-21 kWh/ton CO_2
  - Cooling water = ~1500-2500 m^3/h
  - Steam = 3-4 GJ/ton CO_2
  - MEA to be determined
- CAPEX: to be determined

CO_2 LIQUEFACTION PLANT



NEXT STEPS

TNO innovation for life

TNO MOBILE PILOT PLANT THIS SUMMER

FINAL REPORT
SEPTEMBER 2016

QUESTIONS?