CIRCULAR ENERGY BV

Circular Energy Slidepack

23 January 2018

Arnold Groot

Circular Energy is…

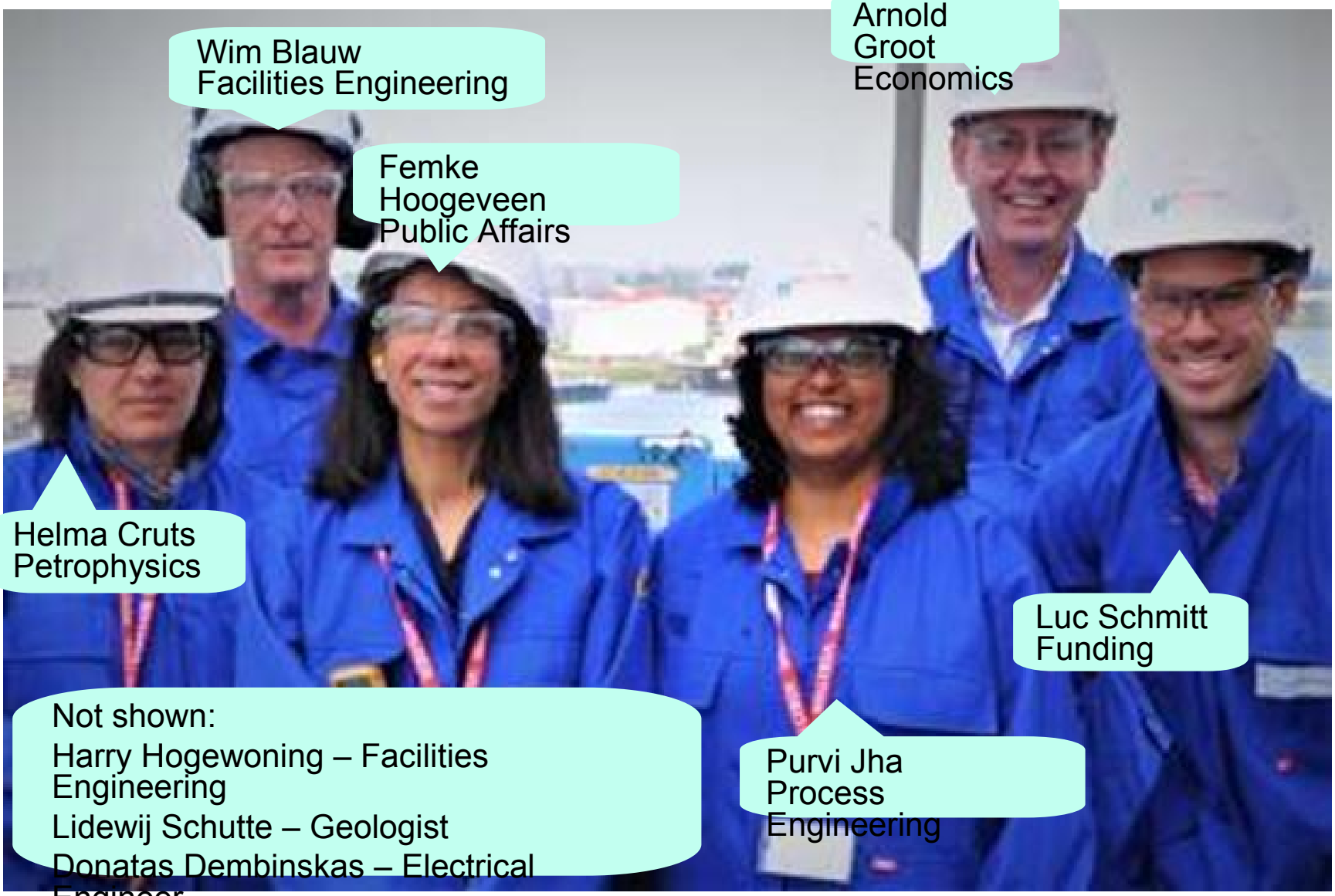
Circular Energy is

- A start-up company based in The Netherlands
- Targeting small offshore gas discoveries
- Producing power offshore
- Capturing and injecting CO_2
- Selling 100% CO_2-free power

Circular Energy does not

- Apply new technology
- Take Exploration risk

Who is on board?



Not shown:

Harry Hogewoning – Facilities Engineering

Lidewij Schutte – Geologist

Donatas Dembinskas – Electrical Engineer

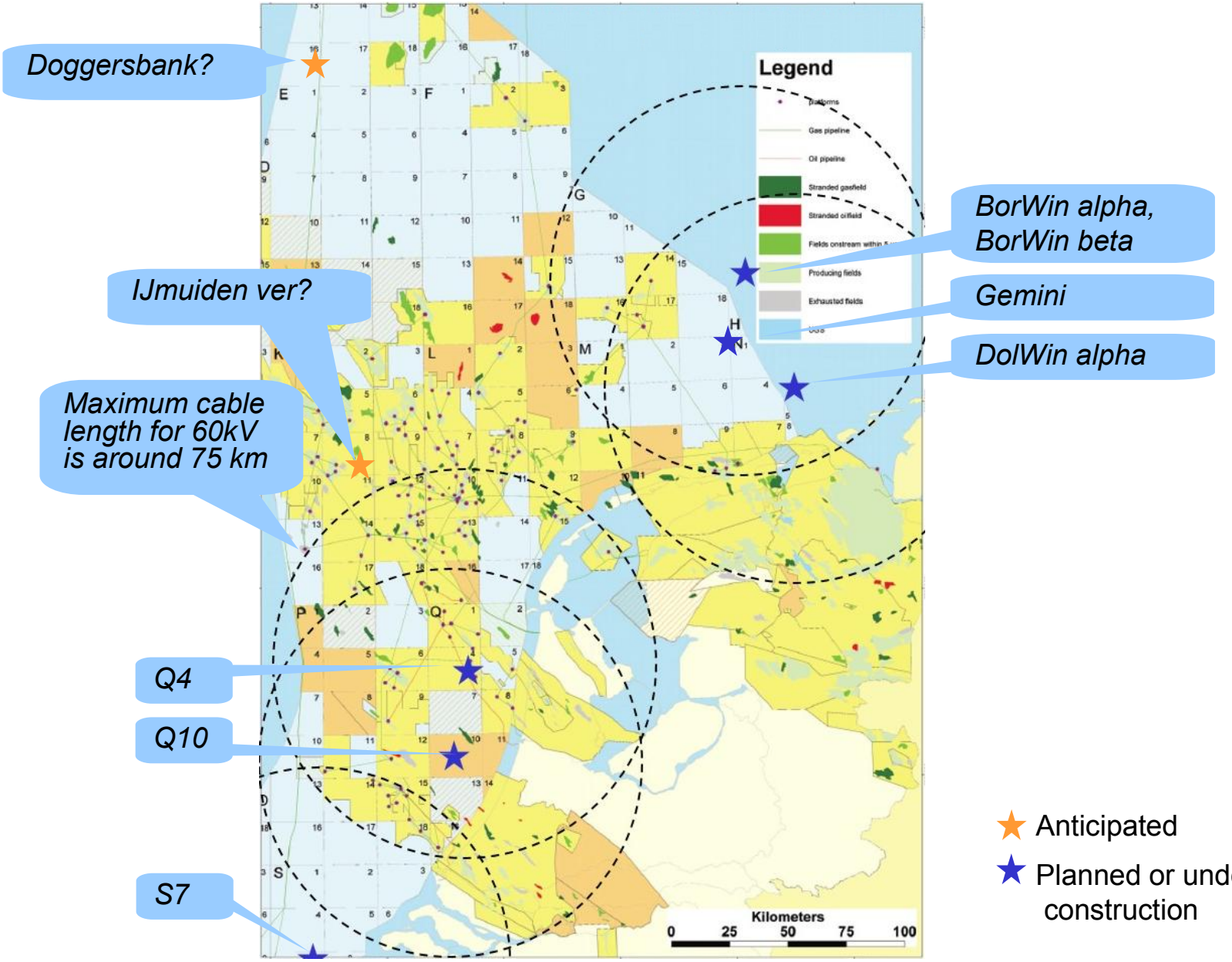
Who else is on board?

CIRCULAR ENERGY BV

Non-Executives

- Ir Rene Peters PhD, director Gas Technology TNO
- Drs Kim Smit, formerly VP Finance C&P at Shell
- Bart Cornelissen MSc MBA, partner Strategy at Deloitte
- Drs Ruut Schalij, partner at eRisk
- Drs Anne-Mette Jørgenson, partner Eco-effective Strategies

Opportunities for offshore Powergen



Reservoir pressure decline is counteracted

Ambient air comprises typically of 21% oxygen and 79% nitrogen

The processing of Nitrogen is a major source of inefficiencies for power plants

$$CH_4 + 2\,O_2 + 7.5\,N_2 \longrightarrow CO_2 + 7.5\,N_2 + 2\,H_2O$$

Natural gas comprises typically of:

93.00% C1
2.85% C2
0.35% C3
1.70% CO_2
1.90% N_2

For every mole of CH_4 produced one mole of CO_2 is injected, assuming perfect capture effectiveness.

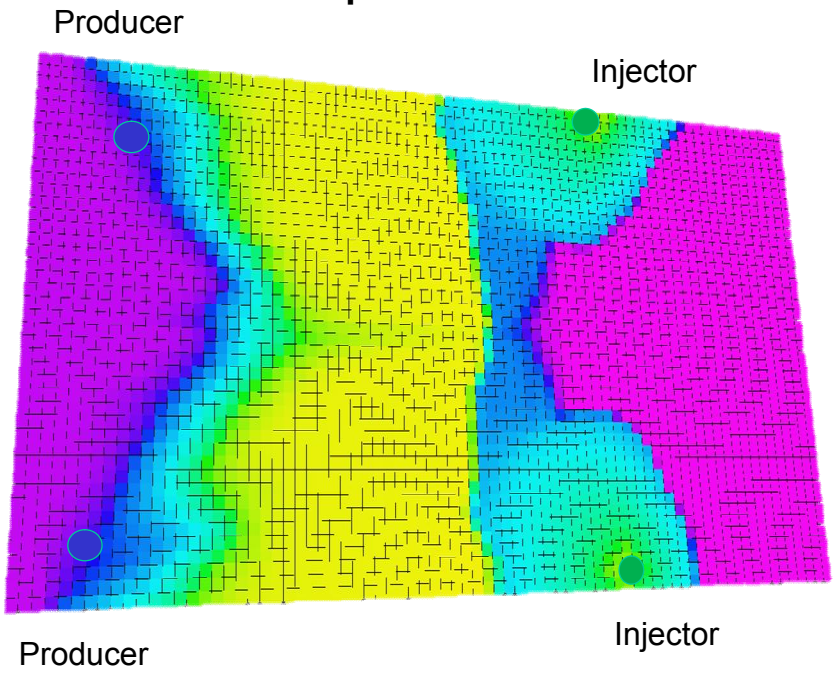
The reservoir receives a similar volume of CO_2 as the volume of natural gas produced from it.

Propagation of CO_2 through the reservoir can be managed

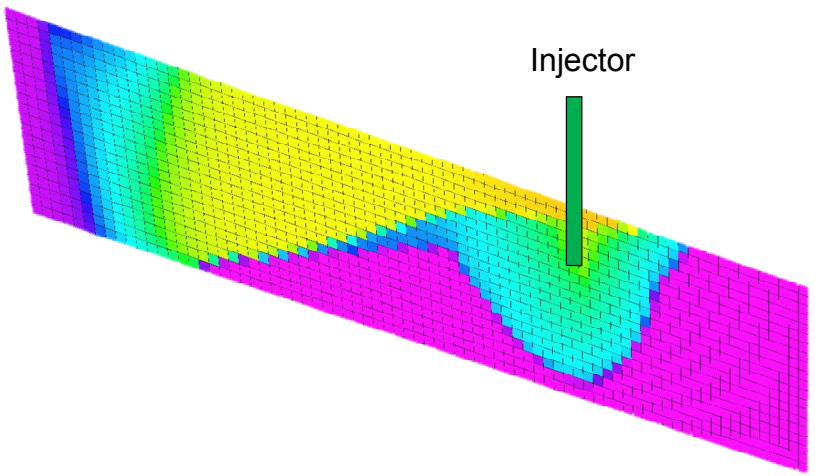
CIRCULAR ENERGY BV

TNO innovation for life

Top view



Side view



CO_2 concentration after 10 years:

Propagation depends on
- Rock properties
- Well spacing
- Well design
- Pressure & temperature

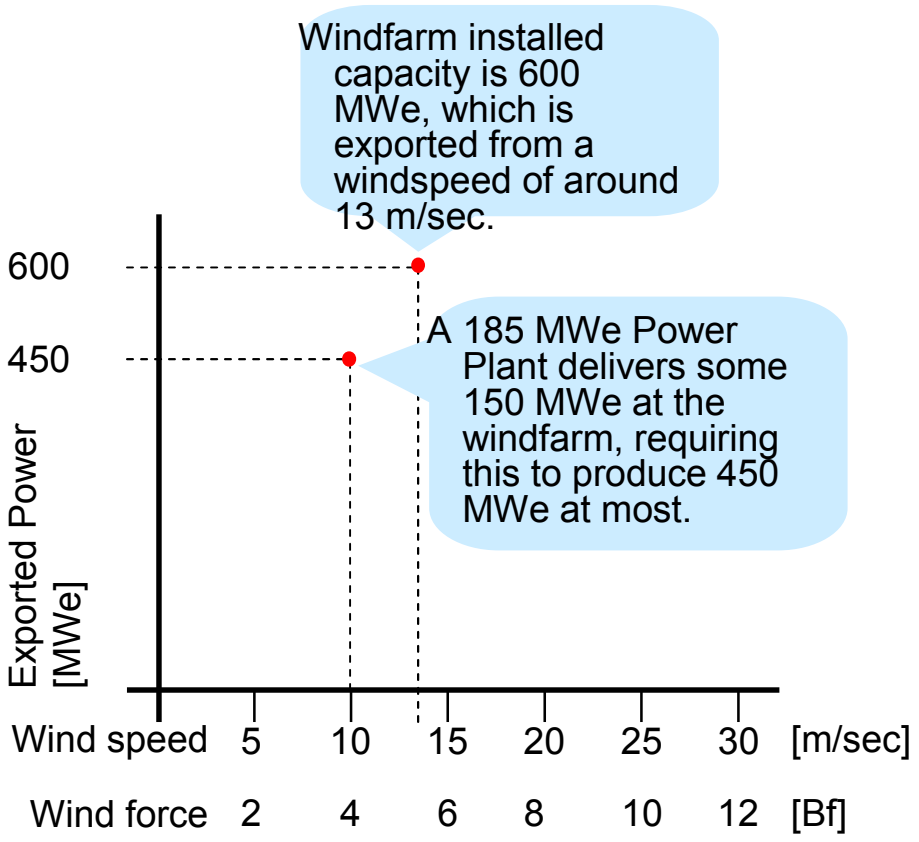
The export route determines the sizing

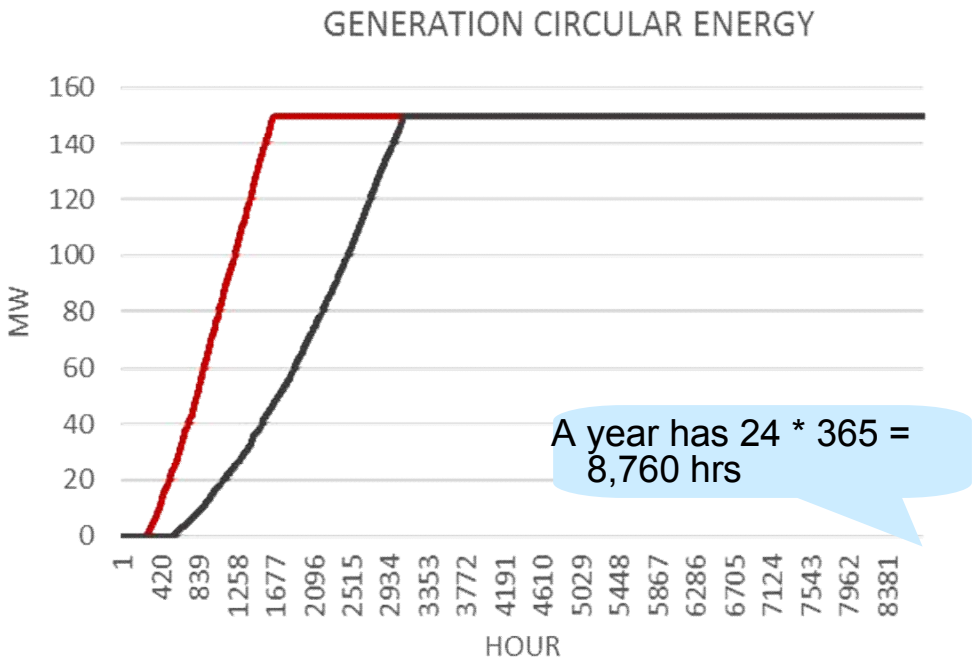
*Power **produced** is given by R/P ratio, number of wells, production rate and powergen efficiency*

*Power **transported** is given by available export cable capacity from windfarm to shore*

Average "Time Online" is given by:
- *Nameplate capacity of the windfarm*
- *Capacity of export cable*
- *Power fed into cable by Circular Energy*
- *Probability distribution of wind speeds*

Exporting power through a windfarm





High wind — Low wind

Loadhours Circular	6.750	7.771	hr
Capacity	150	150	MW
Output per year	1.012	1.166	GWh

6,750 loadhours correspond to 77% “uptime” or “time online”

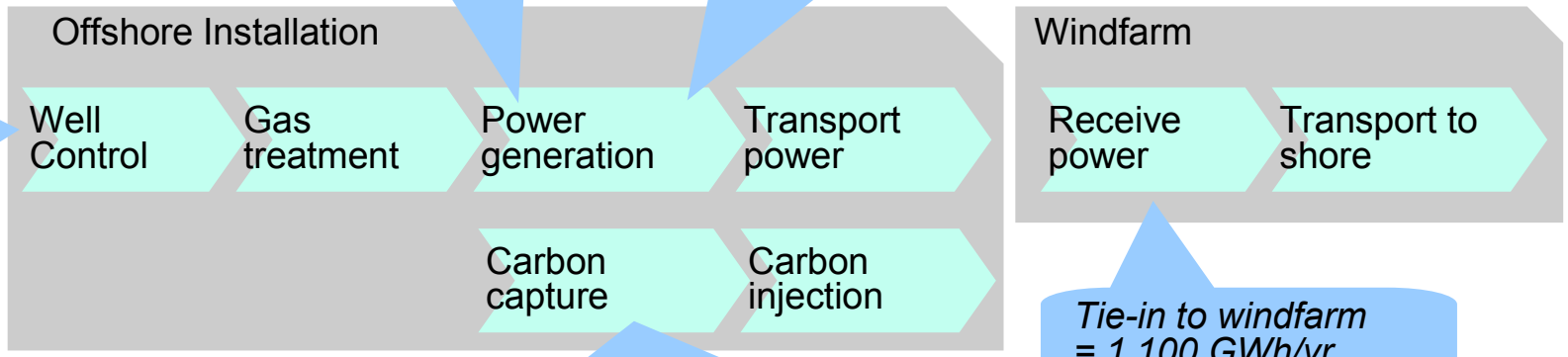
A 185 MWe Zero Emission Power Plant

CIRCULAR ENERGY BV

Average "time online" is 73%

2 GT + 2 HRSG
+ 1 Steam Turbine
= 1,200 GWh/yr
= 135 MWe average
= 185 MWe peak

Power produced
= 292 MMnm³/yr avg gas prod'n
** 8.46 kWh/nm³ energy content*
** 48% PowerGen efficiency*
= 1,200 GWh/yr



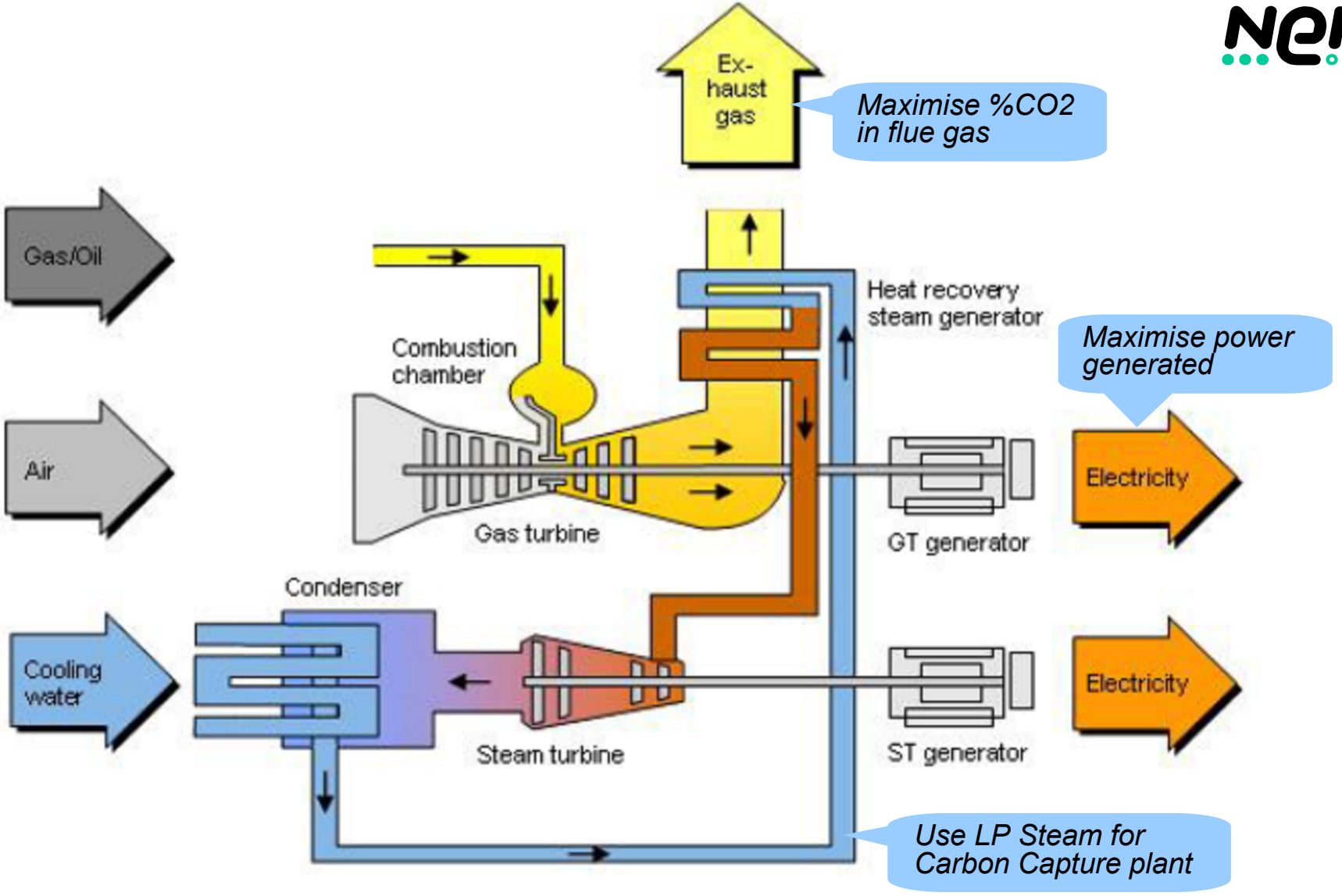
***Average** daily gas production*
= 800 knm³/d
= 292 MMnm³/yr
from 4 wells

***Peak** daily gas production*
= 800 / 0.73
= 1,100 knm³/d

Tie-in to windfarm
= 1,100 GWh/yr

Amine based capture plant producing
292 MMnm³/yr avg gas production
** 2.2 kg/nm³ from combustion*
= 642 ktonne/yr CO_2

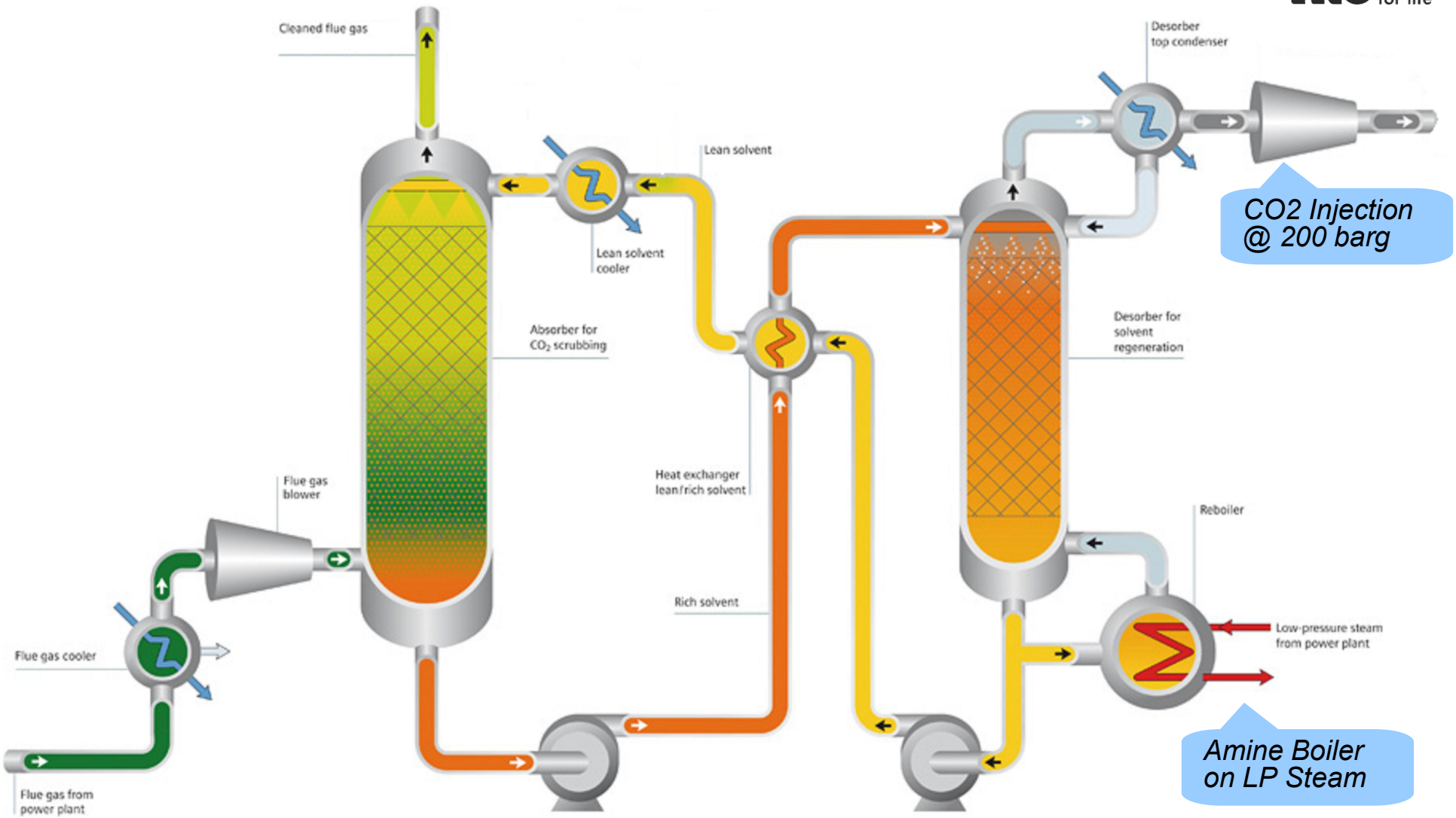
Power Generation plant



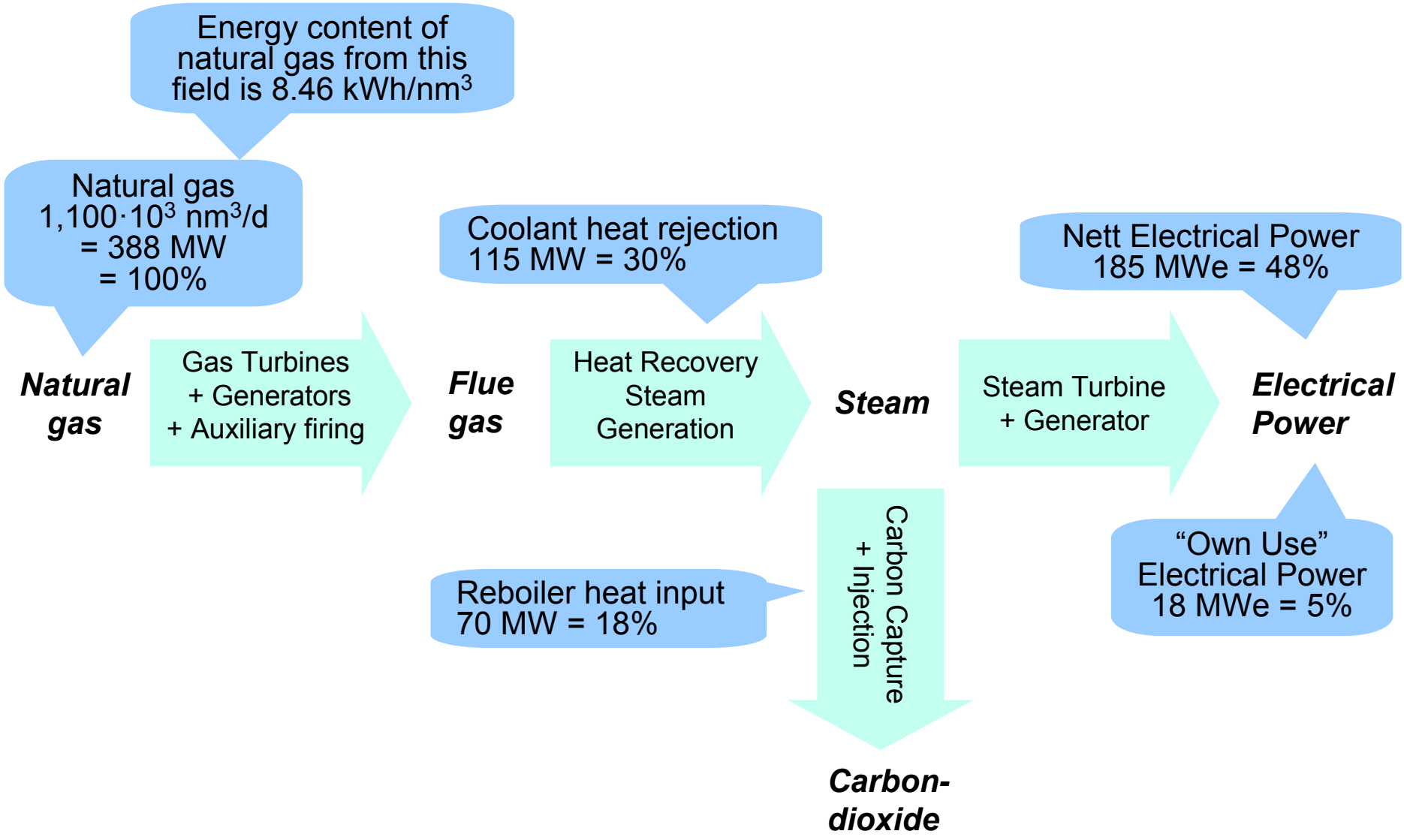
Carbon Capture Plant

CIRCULAR ENERGY BV

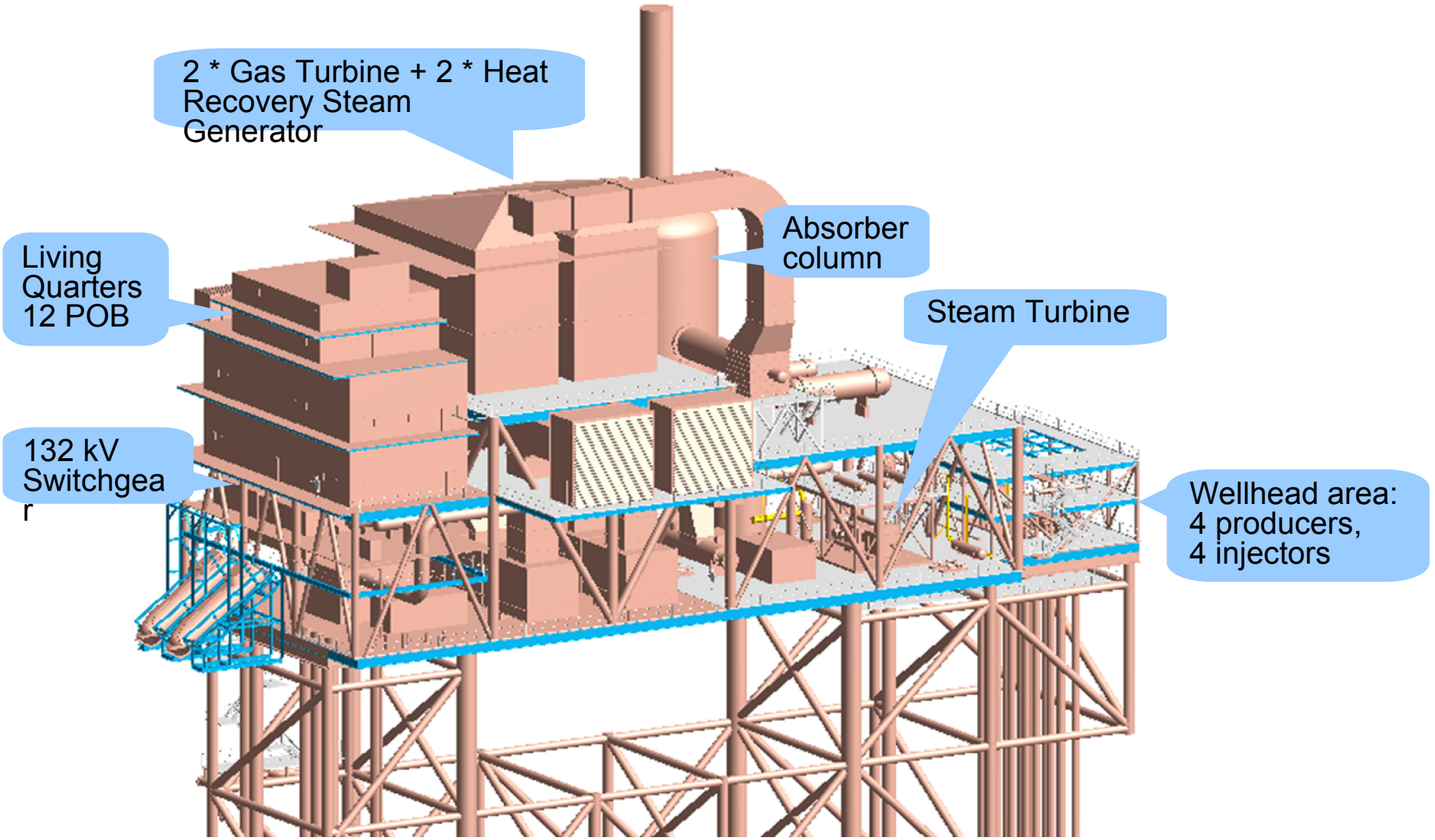
TNO innovation for life



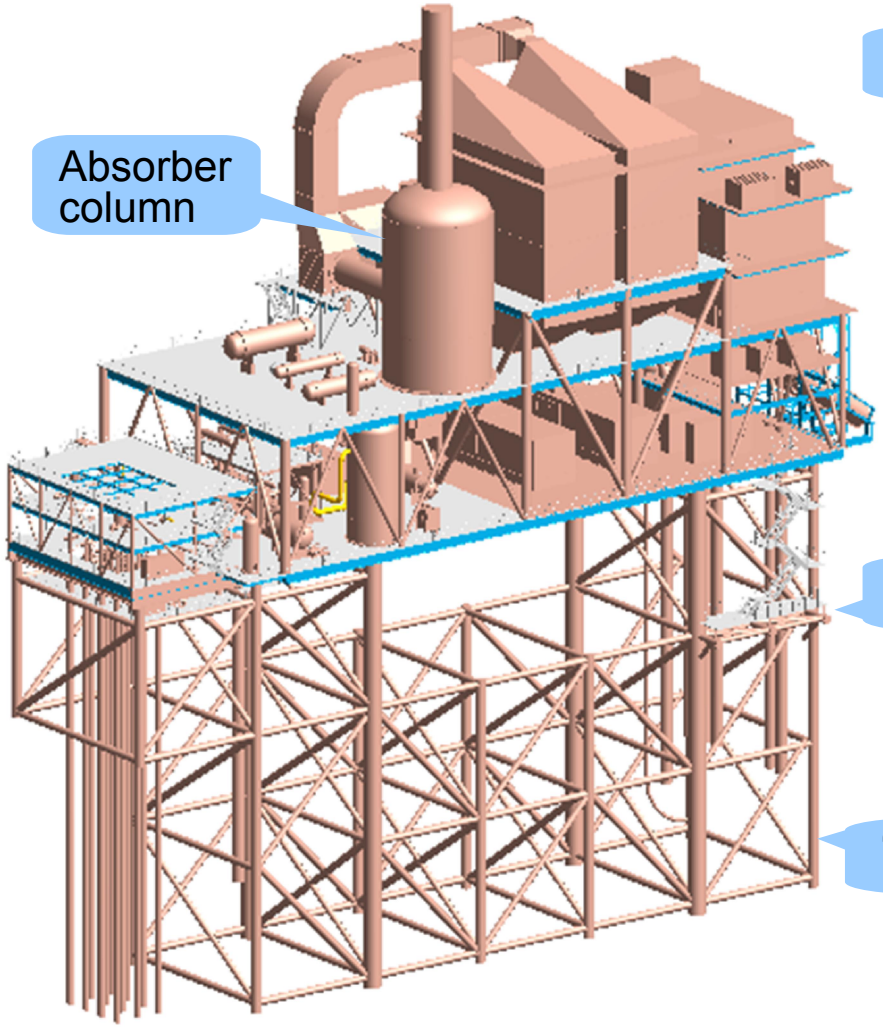
Heat Integration is key to success



Topsides to be optimised



Topsides to be optimised



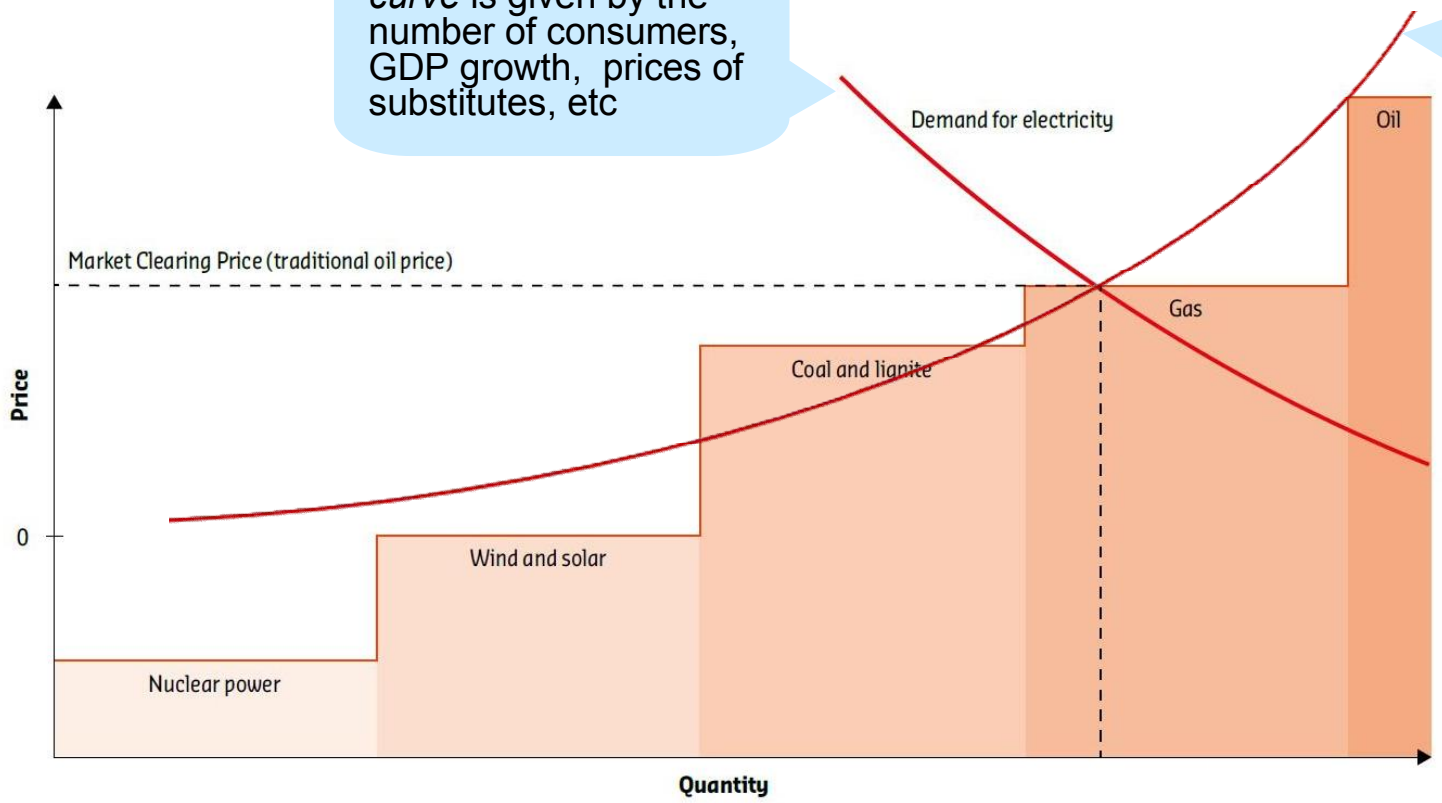
Self Installing Platform

CIRCULAR ENERGY BV

The Merit Order

The collective *demand curve* is given by the number of consumers, GDP growth, prices of substitutes, etc

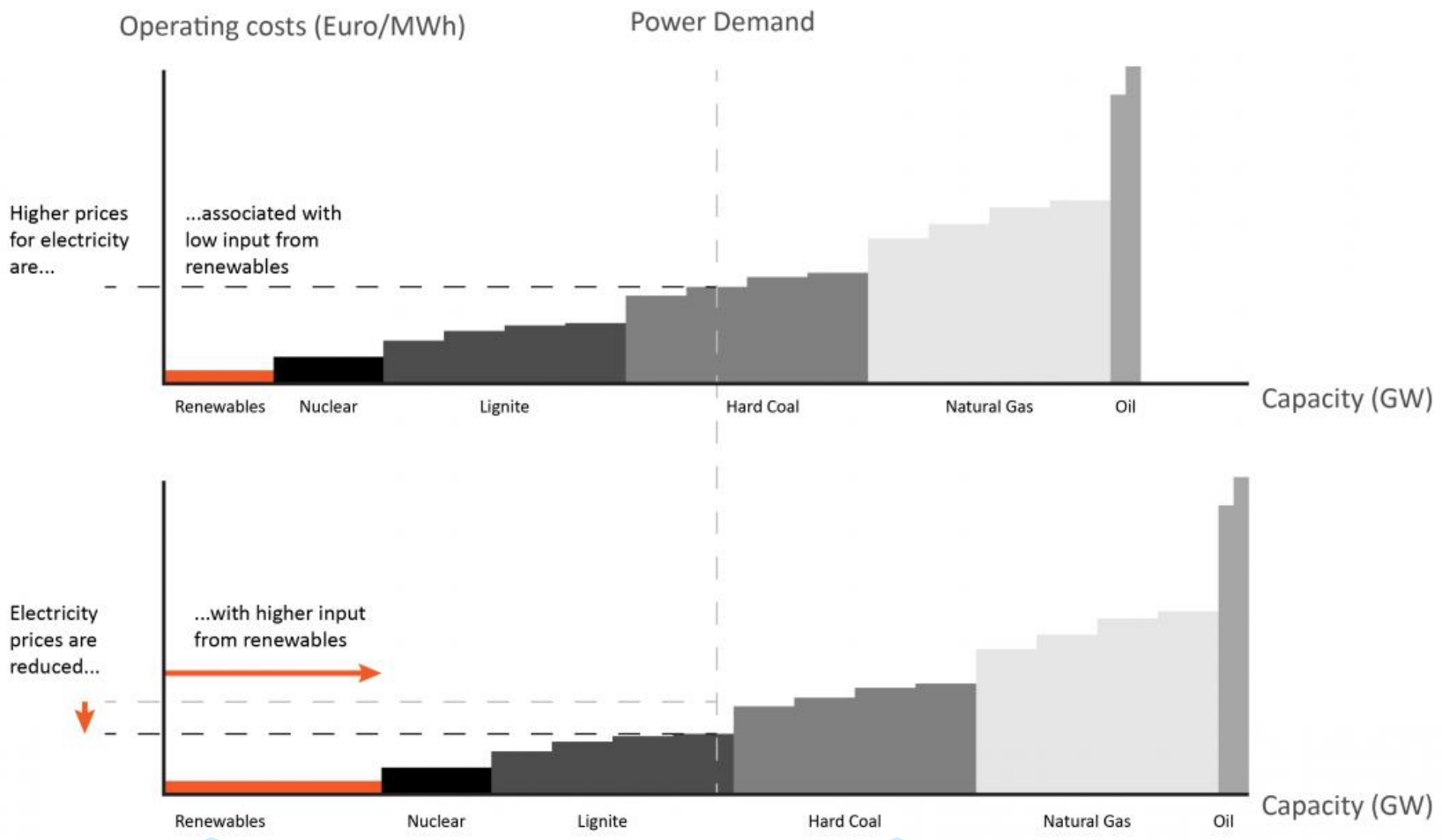
The collective *supply curve* is given by the combined cost structure of all suppliers



When the market clears, the price is set by the *highest marginal cost* producer. All producers with a lower MC make a profit. Producers with a higher MC are not producing.

The *Merit Order* describes the sequence in which additional capacity is brought online when the demand curve moves to the right.

Price volatility resulting from growth in Renewables



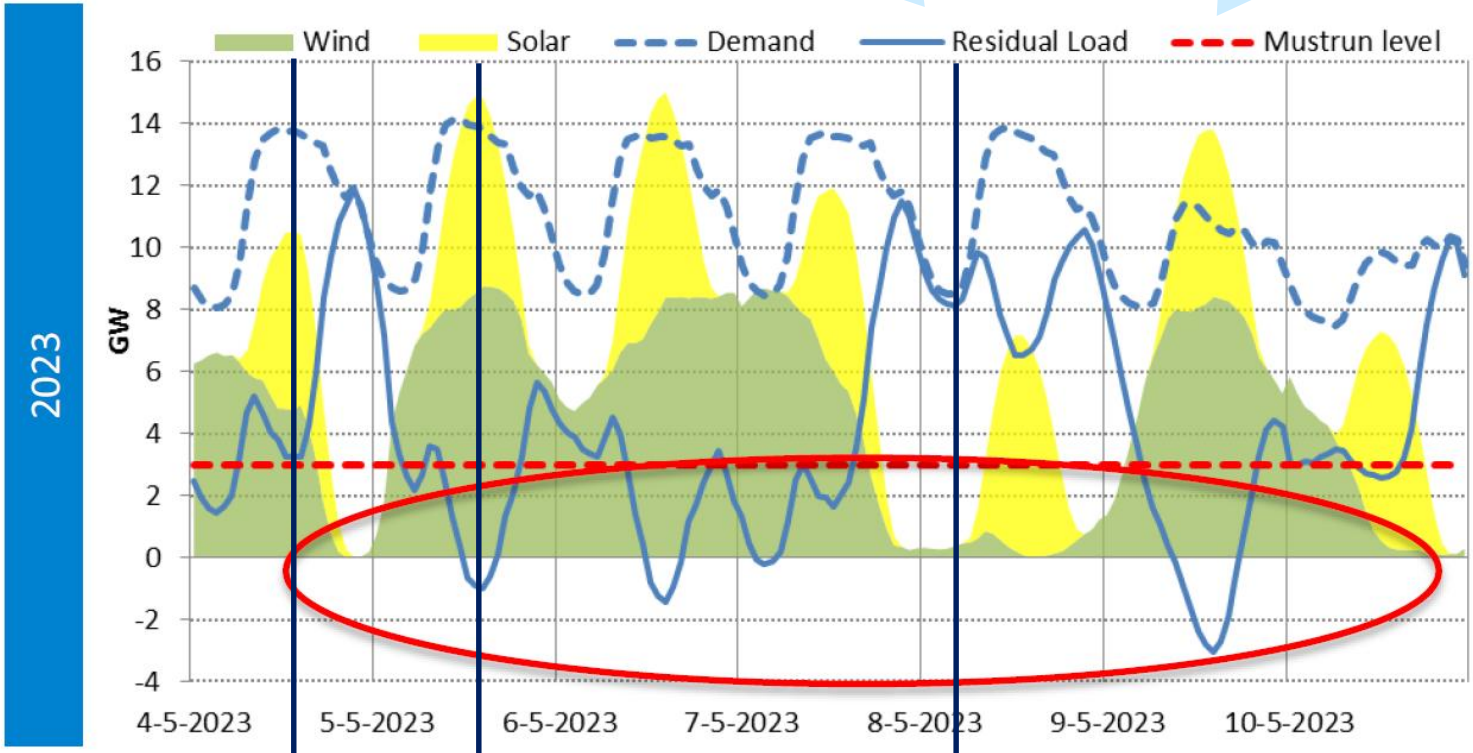
Renewables typically have high *Fixed Costs* but low *Variable Costs* and therefore produce at low Marginal Cost

Thermal Power Plants typically have high *Variable Costs* (fuel) and therefore high Marginal Cost

A day in The Netherlands in 2023

Residual Demand = Demand -/- Wind -/- Solar

MustRun = lowest available capacity, i.e. nuclear or CHP with a heat demand



Residual -/- MustRun = 0, prices are likely to be low

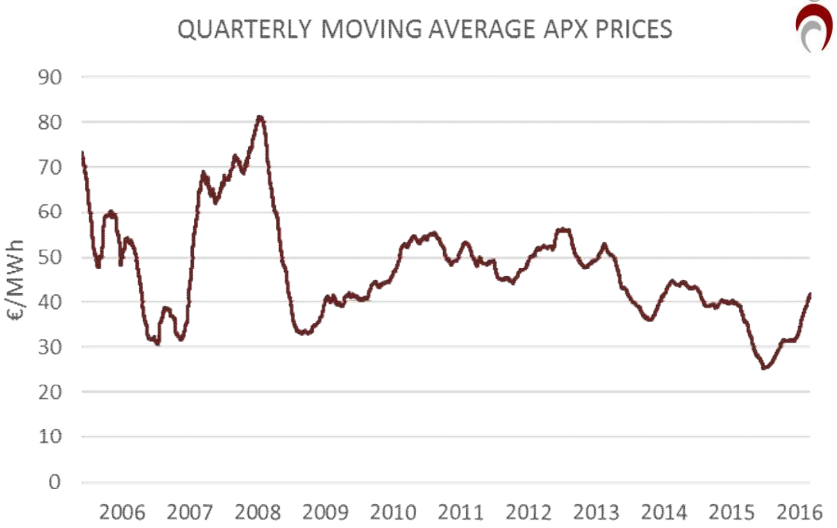
Residual -/- MustRun < 0, negative prices

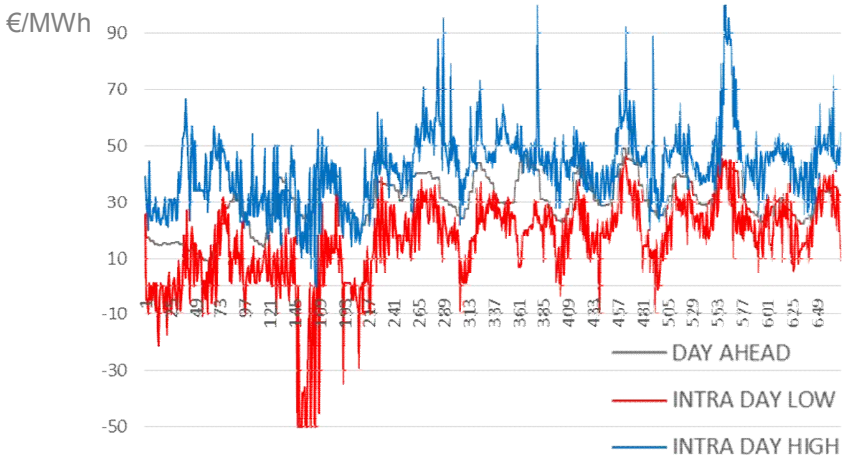
Residual -/- MustRun > 0, prices are likely to be high

How to sell it

Option – sell it on the power markets

On the *day-ahead* market (APX spot market) power is traded for the next day. A *forward* market is provided by ENDEX





Option – long term PPA

Prices are hedged for a long period of time, reducing price risk and reducing upside

Option – Sell it on the Offbalance market

Capture high prices if power plant is responsive

Option – Sell it to the Windfarm

Windfarm can add security of supply, commanding a premium over other renewables

Option – Sell it to End Users

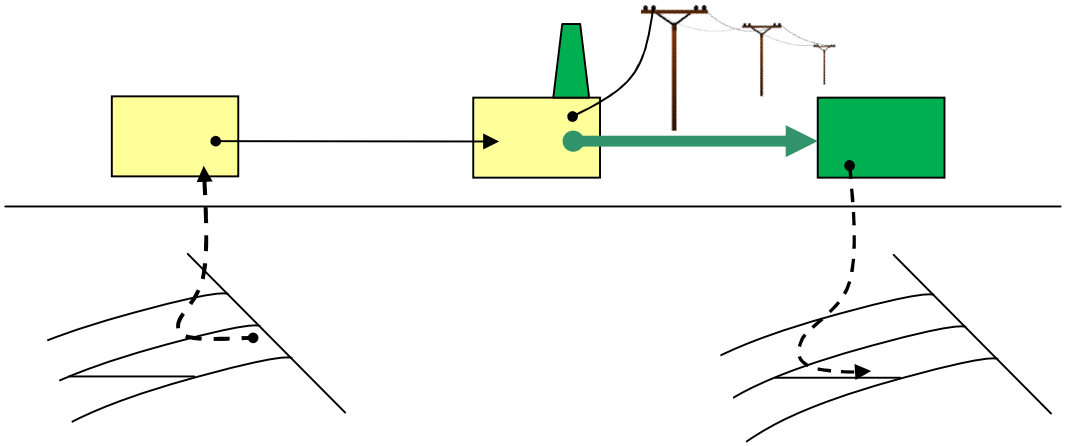
New trading platforms such as Vandebron allow for price differentiation

How is this “circular”?

Circular economy basics	Circular Energy
Sell the service, not the product	We prevent waste by selling the “service”, electric power and not the “product”, natural gas
Collect and re-use/ refurbish/ recycle products to prevent waste	We collect and recycle the energy carrier (natural gas)
Forward integration towards market may be required	We build a Power Plant in order to be able to capture the waste (CO_2) ourselves
Minimise use of raw materials	Efficiency is key in plant design

How come Circular Energy can do something others can't?

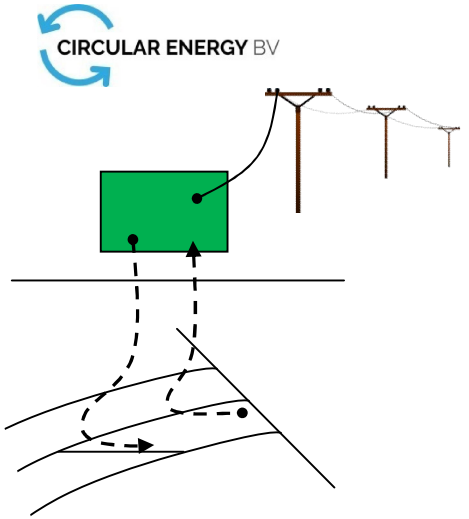
End-of-pipe solution



Additional Capex: Capture Plant + Flowline to existing offshore installation + Wells

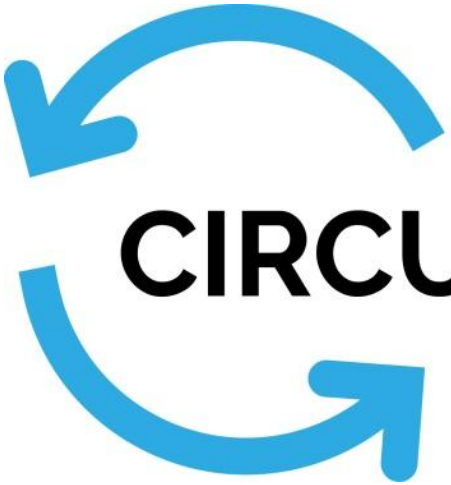
Additional Revenues: none

Integrated solution



Capex: Power Plant + Capture Plant + Wells

Revenues: Sales from gas field that would otherwise not be developed



CIRCULAR ENERGY BV