



Renewable Power On Demand

**Michael Bartlett, Co-Founder**  
**[michael.bartlett@phoenixbiopower.com](mailto:michael.bartlett@phoenixbiopower.com)**  
**+46 730 405 305**

Development of a high-efficiency power generation system integrated with pressurized biomass gasification

Michael Bartlett, Chunguang Zhou  
(Phoenix BioPower)

Christer Rosén, Eftymios Kantarelis, Ayush Agarwal, Klas Engvall  
(Royal Institute of Technology, Stockholm)

- The WHY: biopower and company outline
- The WHAT: BTC Basics
- The HOW: Development program & Outlook

1.5 °C





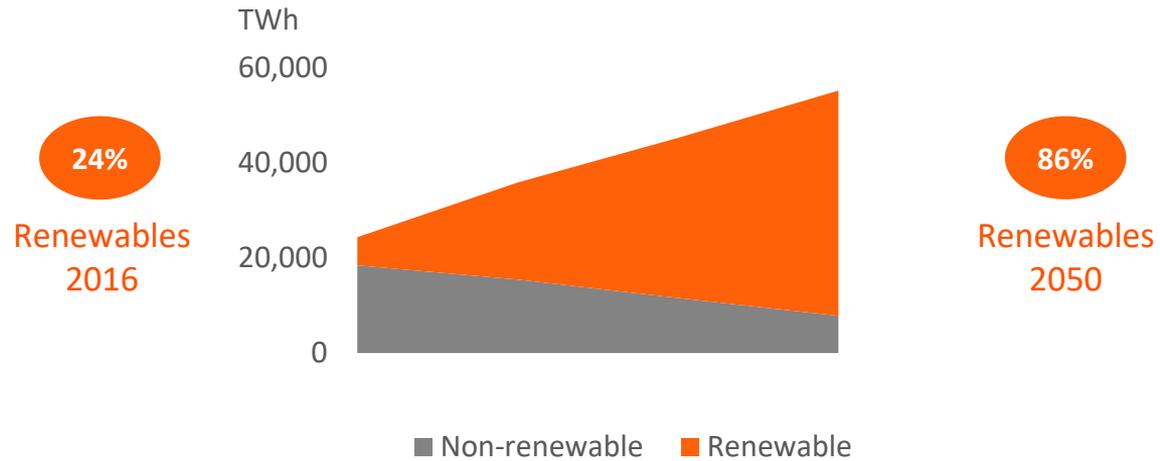
URBANISATION  
AND  
ELECTRIFICATION

A black and white photograph of an industrial welding process. A bright, vertical beam of light from a welding torch is directed at a dark, curved metal component. This interaction produces a massive, dense spray of bright sparks that radiates outwards, filling the lower half of the frame. The background is dark and filled with the structural elements of a factory or workshop, including pipes and machinery. A large white circle is overlaid on the right side of the image, containing the text 'ELECTRIFICATION OF INDUSTRY' in orange.

**ELECTRIFICATION  
OF INDUSTRY**

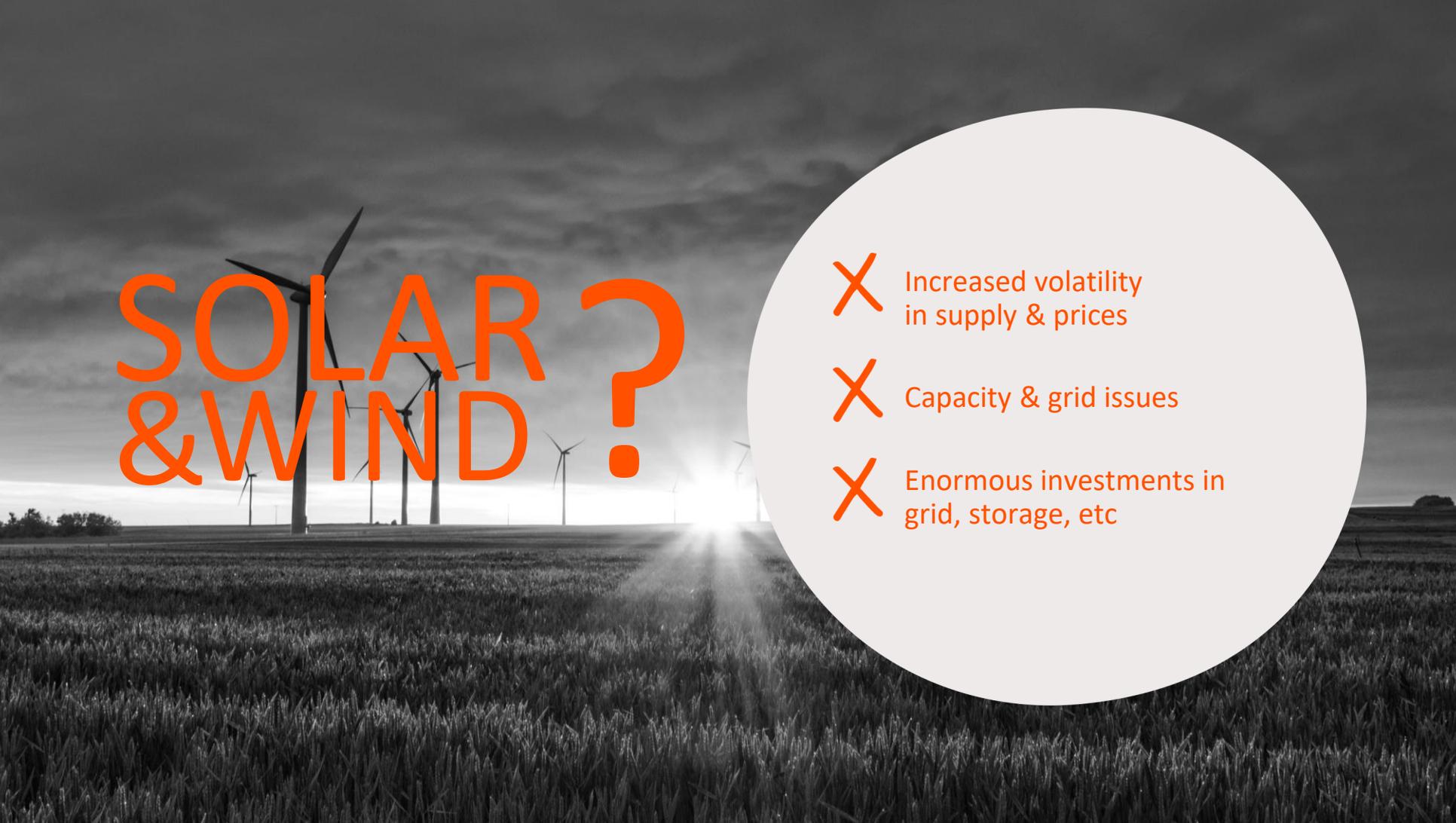
# THE ENERGY TRANSITION: 1,5°C scenario

Electricity Generation. Source, IRENA 2019, REMap 2050



1000 TWh/år growth





# SOLAR & WIND ?

- X Increased volatility in supply & prices
- X Capacity & grid issues
- X Enormous investments in grid, storage, etc

# RENEWABLE POWER ON DEMAND



PHOENIX BIOPOWER  
TRANSFORMING BIOPOWER FOR THE FUTURE



# RENEWABLE POWER ON DEMAND

- ✓ **PLANNABLE**  
Power and heat on-demand.
- ✓ **SCALABLE**  
Cost-effective and highly efficient.
- ✓ **SUSTAINABLE**  
Consume half the biomass.

# ----- TRADITIONAL STEAM CYCLE

25-30%  
ELECTRICAL EFFICIENCY



**BURN FUEL,  
MAKE STEAM,  
DRIVE A GENERATOR**



BIOMASS RESIDUES

# BTC TECHNOLOGY

BTC: Biomass-fired Top Cycle

50-60%  
ELECTRICAL EFFICIENCY



**GASIFY FUEL,  
USE IN TOPCYCLE GAS TURBINE,  
DRIVE THE GENERATOR**

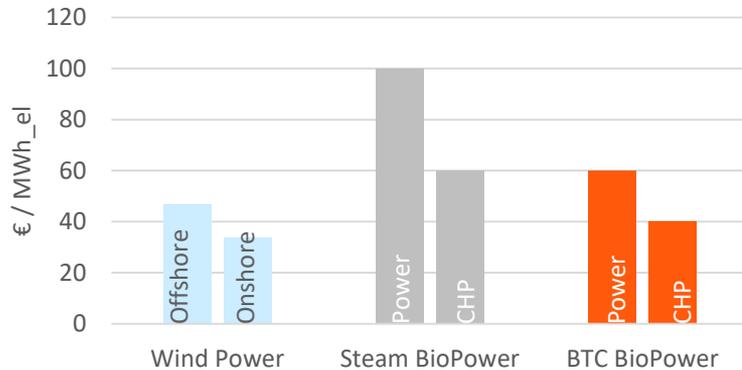


2X

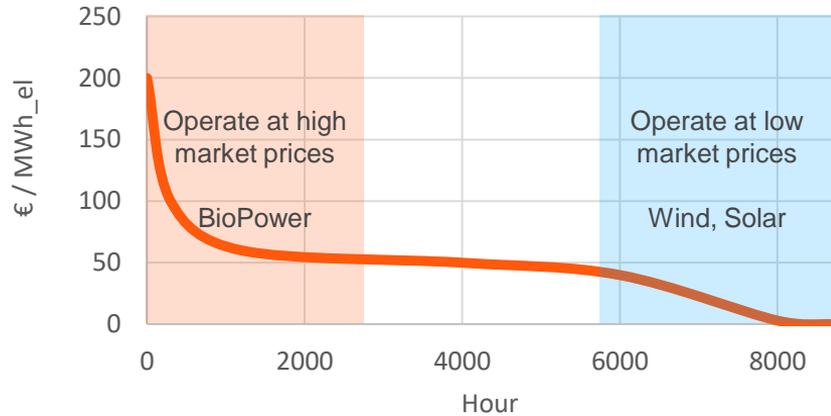
BIOMASS RESIDUES

# ECONOMIC ADVANTAGE

## LEVELISED COST AS WIND POWER



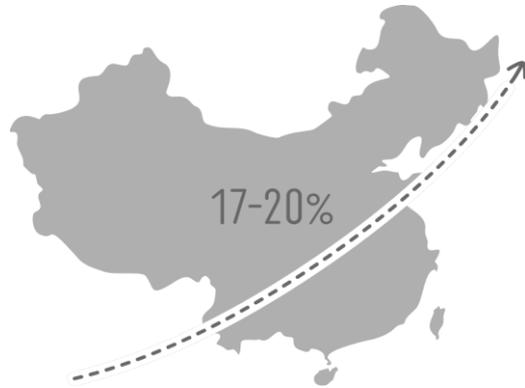
## BUT HARVESTING HIGHER MARKET PRICES



Germany electricity price predicted have standard deviation of 70 €/MWh by 2030

## KEY MARKETS

ANNUAL GROWTH RATE FOR BIOPOWER IN CHINA



- 600 Mton residues per year available
- Up to 1800 TWh electricity



- NREAP plans: 40% of CHP will be biomass-fired by 2050
- 400 TWh of electricity



**MICHAEL BARTLETT**

Co-Founder, CTO

Project Management, R&D  
(GE, Vattenfall, Scania)



**HENRIK BÅGE**

Co-Founder, CEO

Entrepreneur  
(15 years in cleantech)



**OLIVER PASCHEREIT**

Co-Founder, Head of Comb

Prof TU Berlin  
(ABB/Alstom)



**HANS-ERIK HANSSON**

Co-Founder

Entrepreneur & Innovator  
(ABB/Alstom)



**STEFAN JAKÉLIUS**

Chairman

(Industrifonden)



**CATHARINA LAGERSTAM**

Board member

(S.E.C Lux, ICA Bank)



**BIRGITTA RESVIK**

Board member

(Fortum, Svenskt Näringsliv)

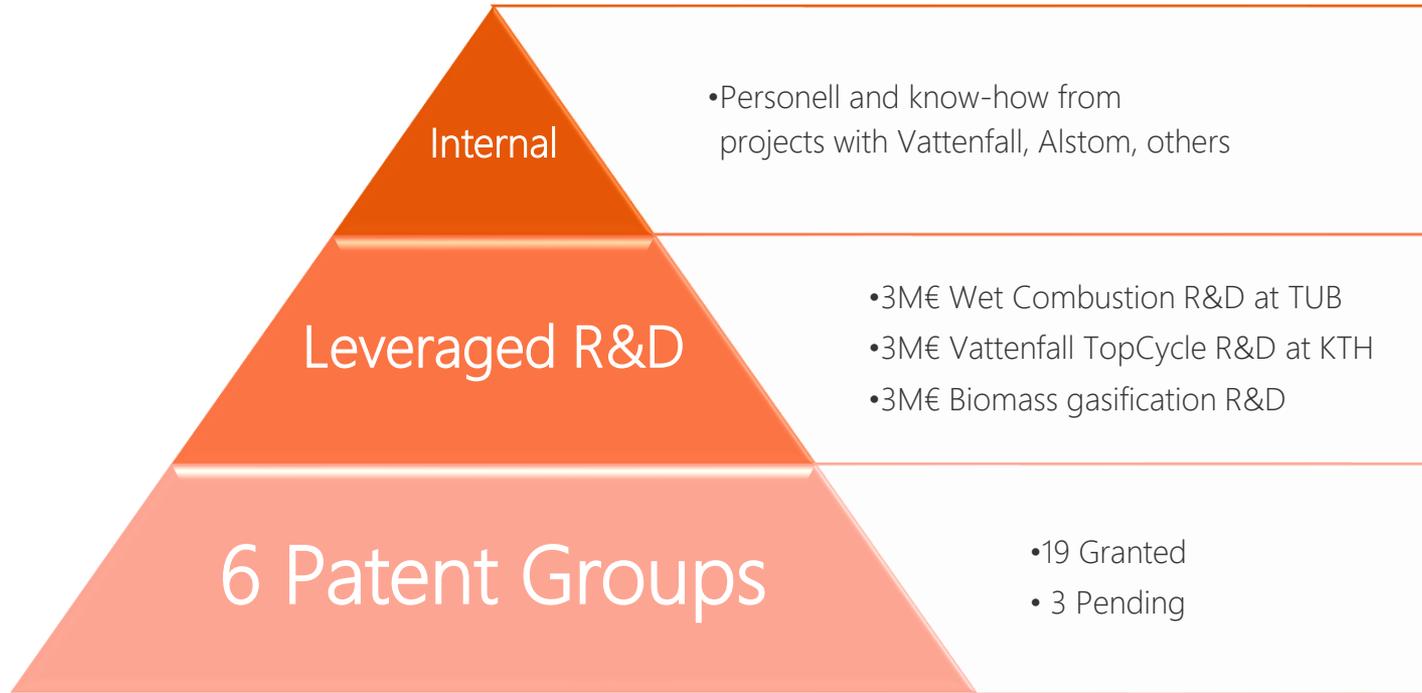


**OLA JOHANSSON**

Board member

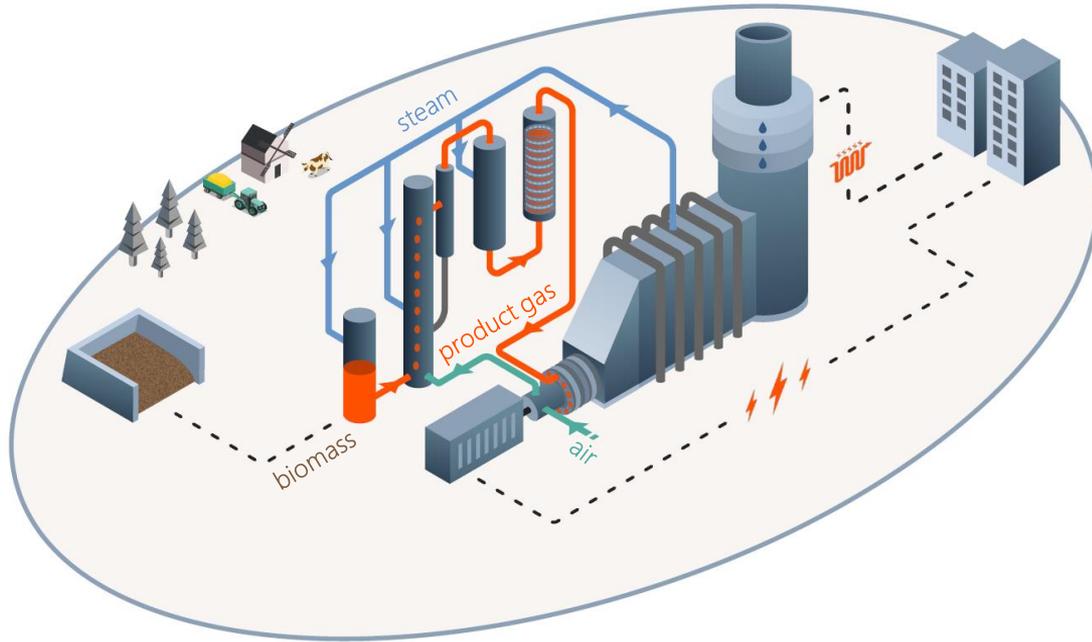
(Siemens, Epishine)

# ----- BUILDING FROM A SOLID IP AND KNOW-HOW FOUNDATION



# THE BTC CONCEPT

# BTC: A NEW POWER CYCLE



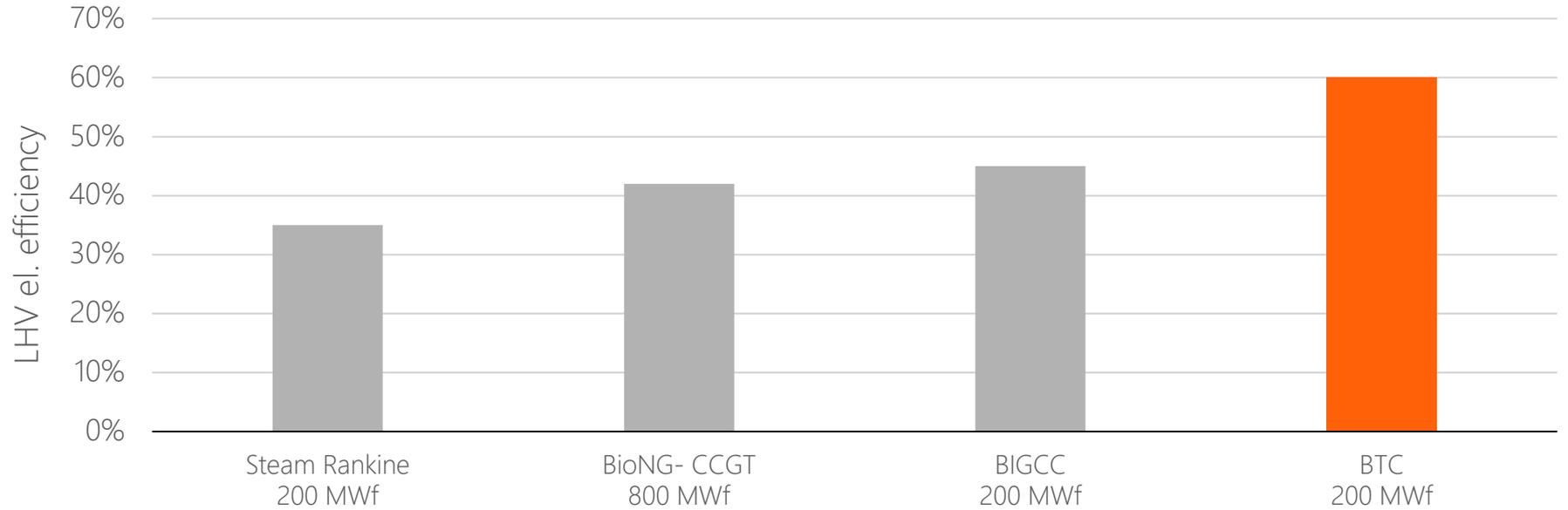
- Steam-injected, high pressure gas turbine
- Near-stoichiometric combustion
- 50% steam in turbine
- Biomass pressurisation, gasifier, cooler all utilise steam
- Water recovered in flue gas condenser

# BIGCC: VÄRNAMO DEMO PLANT

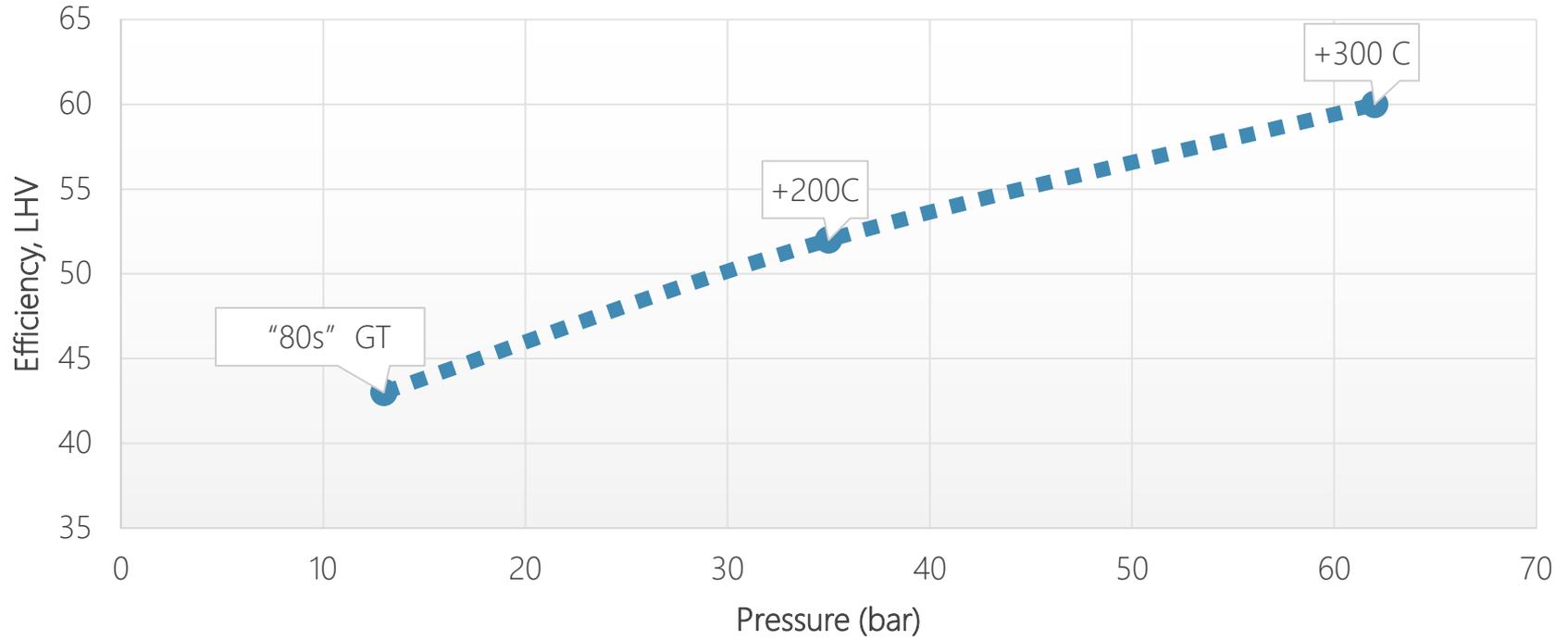


- Pilot to develop technology
- SFW, E.On
  
- 18 MW fuel
- Pressurised CFB gasifier
- Hot gas clean-up
  
- 8500 hours gasifier
- 3500h BIGCC
  
- Fulfilled design spec
- BIGCC abandoned as nuclear fleet kept

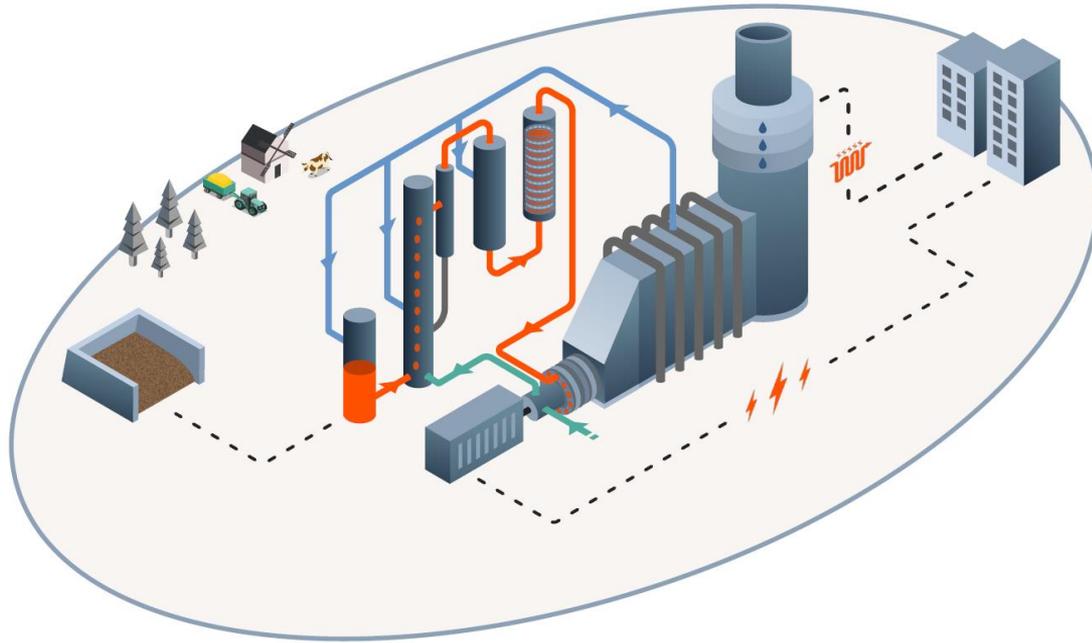
# BIOMASS TO POWER PATHWAYS



# BTC EFFICIENCY CHARACTERISTICS



# BTC: ROLE IN THE ENERGY SYSTEM



- 40% lower operating costs than steam cycle
- 3 times as much power with CHP than steam cycle
- Local production: grid, security of supply,
- Dispatchable renewables
- Extra services: biochar, BECCS, fast start on natural gas

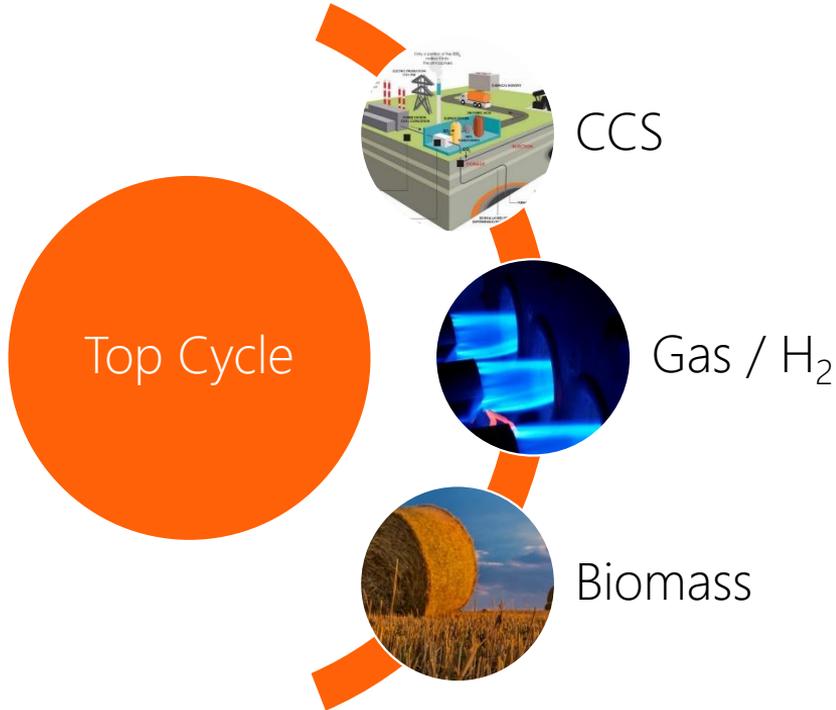
# TOP CYCLE: A PLATFORM TECHNOLOGY

## Advantage vs Combined Cycle

Halve the costs of CO<sub>2</sub> capture, 70% lower power penalty

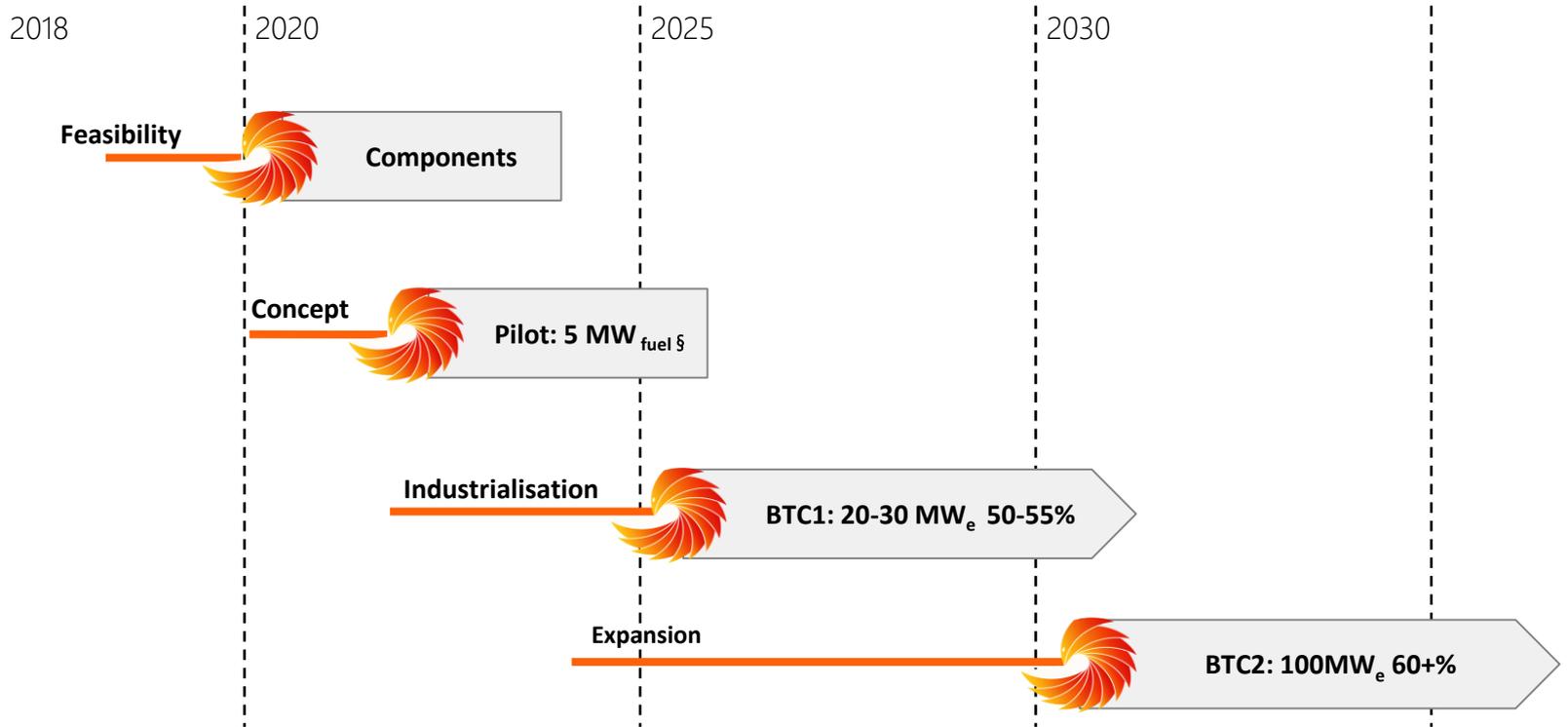
-30 % capital costs. Low NO<sub>x</sub>, no flashback  
+15% pt total efficiency in district heat

+10-15 % pts electrical efficiency



# DEVELOPMENT

# BTC ROADMAP



# AGGRESSIVE DEVELOPMENT UNDERWAY

Invested: 2.5 M€



PRIVATE INVESTORS

Reference Group



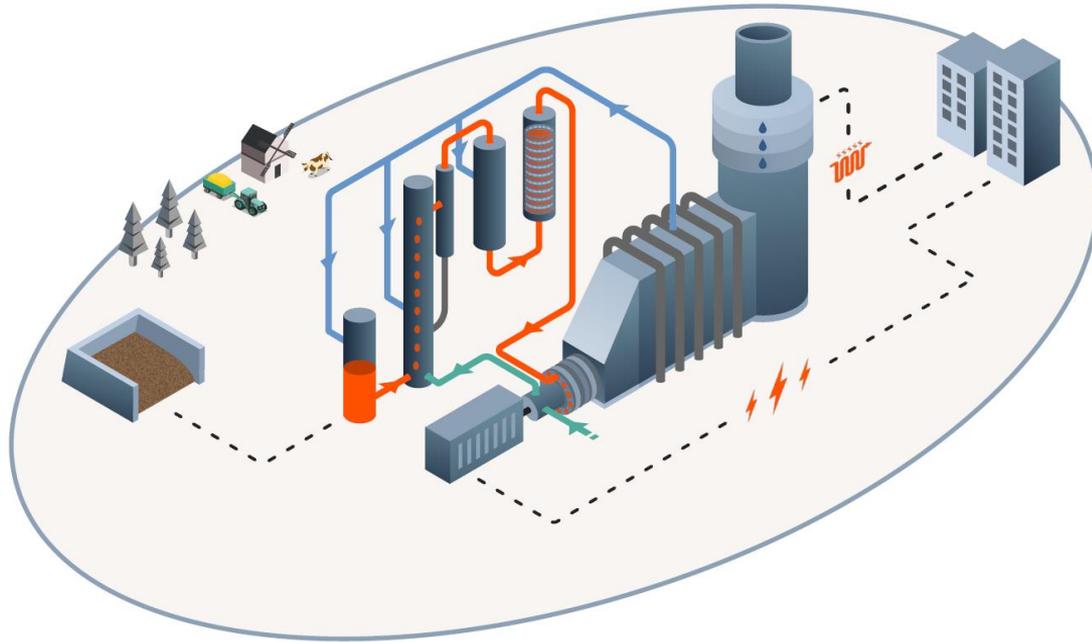
Site



Competence



# BTC: CURRENT DEVELOPMENT WORK



- Reliable fuel conversion
  - Biomass pressurisation and pretreatment
  - Gasification in fluidised bed
  - Gas cooling
  - Hot gas filter
  - Combustion near-stoichiometric
- Materials in new environment
- Initial gas turbine design
- Plant integration and control

# PROGRESS

WORK PACKAGE	SCALE	HIGHLIGHTS / COMMENT	FORECAST
PM	-	New IP identified, Reference Groups meetings	
Plant	-	Optimisations and basic engineering ongoing.	Case studies end Q3
Gas turbine materials	Coupons	Steam environment effects on TBC, bond coat	Lifetime tests finalised Q4.
Feed System	100 kW 45 bar steam	Concept chosen, initial 40 bar tests	Continuous 40 bar tests by Q4
Gasification	50 kW <sub>f</sub>	First gasifier tests over 20 bars	40 bar results by Q4
Combustion	100 kW	First 50 kW tests very successful	Atmospheric, 100kW operating window by Q4



# COMING WORK: PHASE 2

# 4 MW PILOT PLANT



- 2 site candidates
- Operation 2022
- Fuel conversion, can combustor and sector test
- 1 t/h fuel

# EXPANDING OUR PARTNERSHIP

## Reference Group





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