

# DOUBLING THE EFFICIENCY OF POWER FROM BIOMASS

## **The 60-30 Mission**

Michael Bartlett

# PROBLEM DESCRIPTION

## DRIVER

Global need for CO2 reductions

Transition to renewable energy

Phase-out of Nuclear

## RESULTING IN

Massive growth in intermittent power

Lack of plannable power

Collapse of traditional business models

## NEED

Plannable & profitable  
renewable power  
production

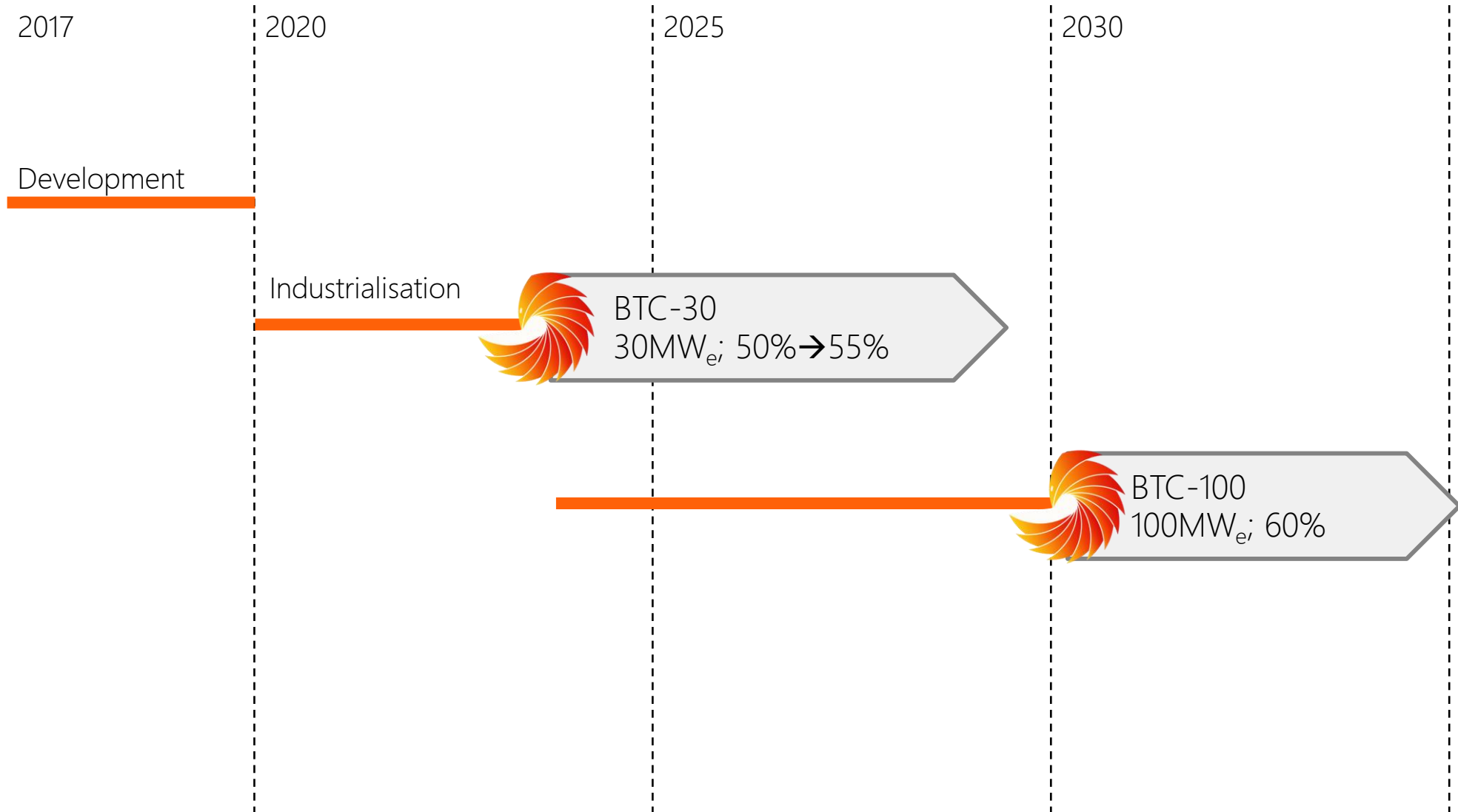
PHOENIX VISION – Highly efficient, cost-effective and plannable power from biomass

# THE 60-30 MISSION:

60% ELECTRICAL EFFICIENCY BY 2030 FOR  
BIOMASS-FIRED POWER PLANTS



# 60-30 ROADMAP



# TEAM

## Hans-Erik Hansson



- Co-Founder
- Inventor
- Initiator
- 30+ years experience with development in the energy industry

## Michael Bartlett



- Co-Founder
- Head of R&D
- Project management and R&D background Scania, Vattenfall, GE
- PhD in Humidified Gas Turbines

## Henrik Båge



- Co-Founder
- Head of Business Development
- 13 years in Cleantech
- Background in Finance industry

# PHOENIX BIOPOWER BACKGROUND & IP

- IP stems from Euroturbine AB
  - Natural gas-fired, steam-injected gas turbine
  - Development project with Vattenfall 2009-2012
  - Biomass-fired TopCycle patent application 2011
- Phoenix BioPower formed end 2016 with new leadership team & biomass focus
  - KIC InnoEnergy 2017
  - Development started

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## Protection mechanism

## Background IP in Partners

Patents

- 5 patents: 3 gas turbine, 2 gasification + gas turbine
- 16 applications in EP, US, CN, JP, RU
- 8 granted, 8 pending
- Process and plant configurations

Know-how

- Personnel, results, models, reports etc from 3M€ project with Vattenfall
  - Leveraging : 3 M€ wet combustion R&D at TU Berlin, 3 M€ biomass gasification R&D at RISE ETC
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# INTRODUCING THE BTC PLANT

The Biomass-fired TopCycle Plant

# THE BTC TECHNOLOGY – BASIC PRINCIPLES

Biomass gasification at high pressure integrated with a steam-injected gas turbine.

Features:

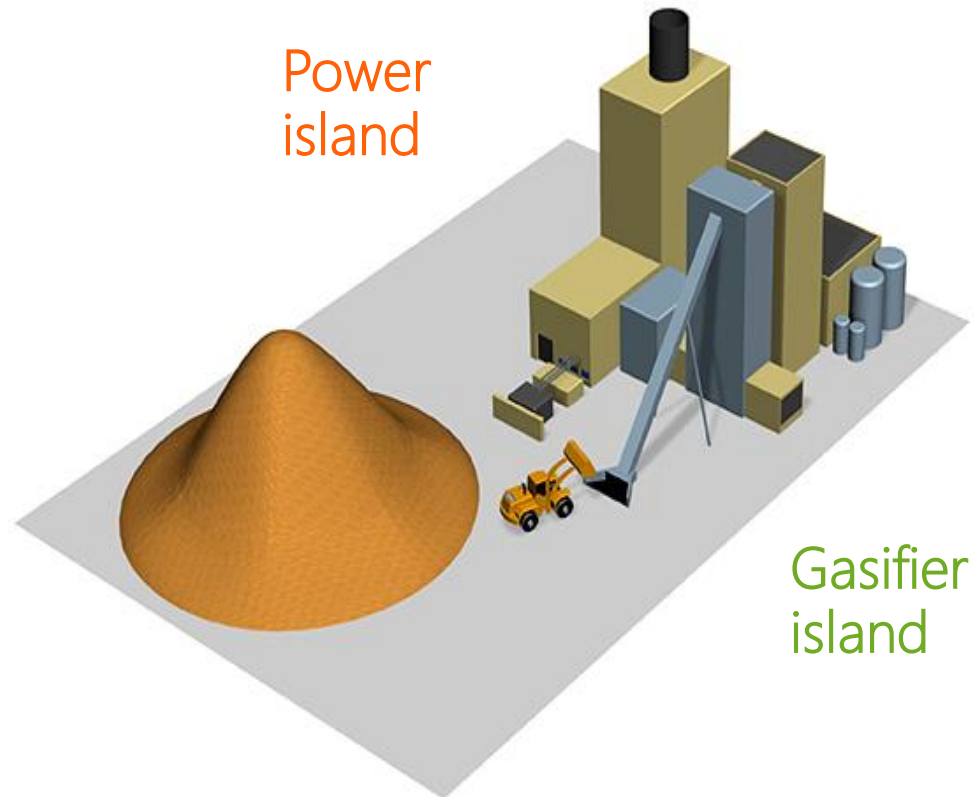
- High pressure operation
- Massive steam injection
- TopCycle gas turbine
- BTC heat integration



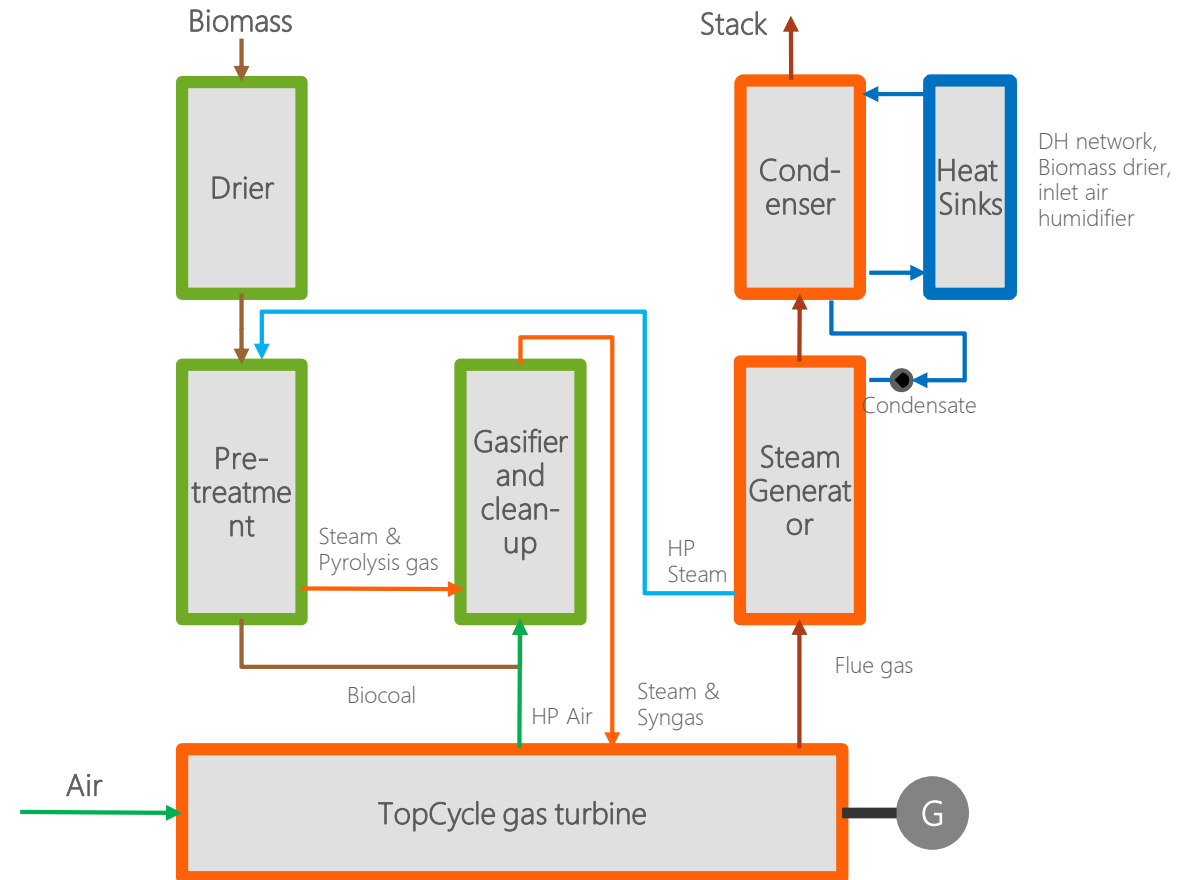


# THE BTC PLANT FOR CHP AND POWER GENERATION MARKETS

## Plant sketch



## Process



# HOW DOES THE BTC GENERATE VALUE?

# BTC TARGETS

60%

electrical efficiency  
at 100 MWe

110%

total efficiency with  
district heat

40%

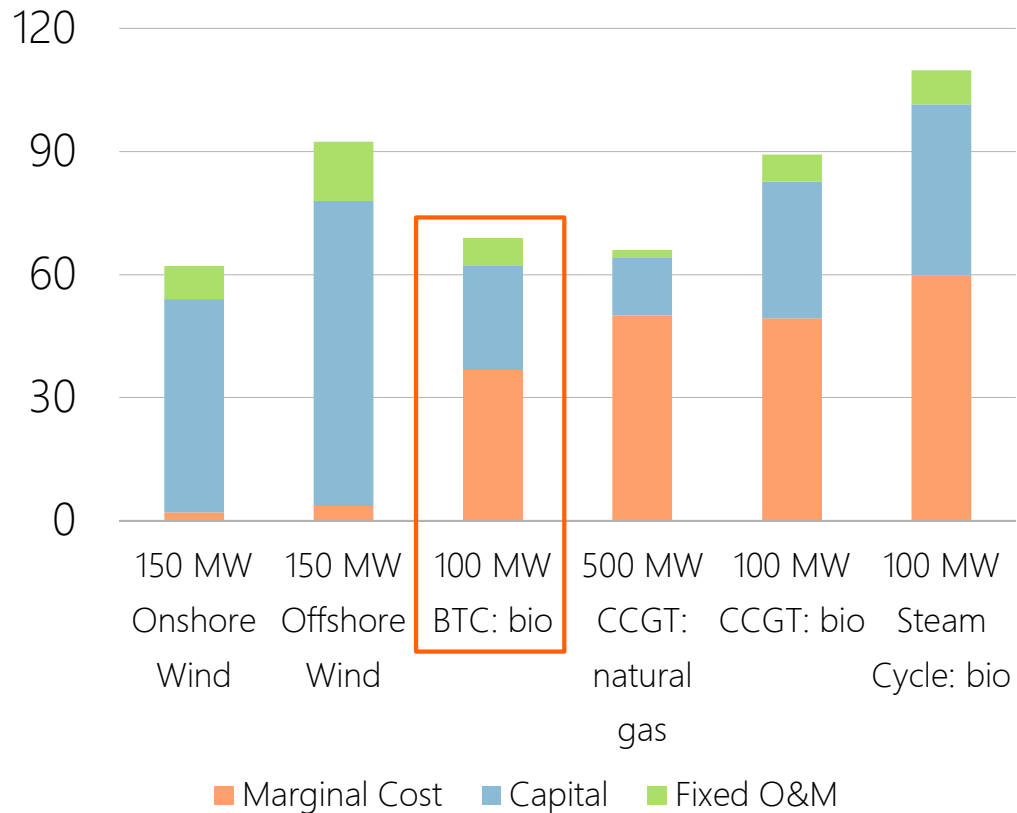
lower marginal  
cost in powergen

40%

lower LCOE in  
CHP

# BTC OPPORTUNITY FOR POWER GENERATION (1.)

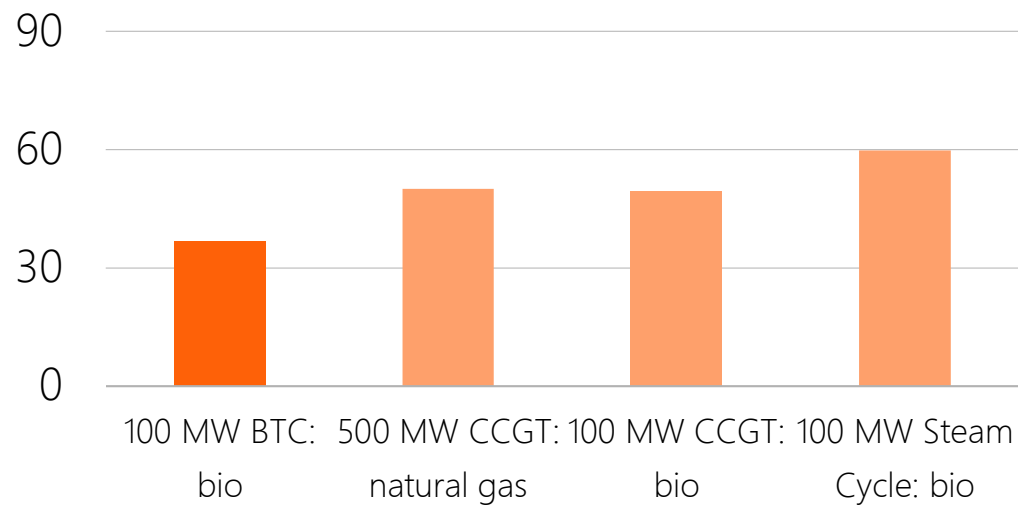
2030 Levelised Cost of Electricity, €/MWh<sup>1</sup>  
No taxes, subsidies, heat income



- “Conventional” LCOE at wind-parity
- Market value of BTC power will be higher
  - Wind = 40-85% average annual power price
  - Bio = 100-120%<sup>2</sup>
- Grid services potential for further income

# BTC OPPORTUNITY FOR POWER GENERATION (2.)

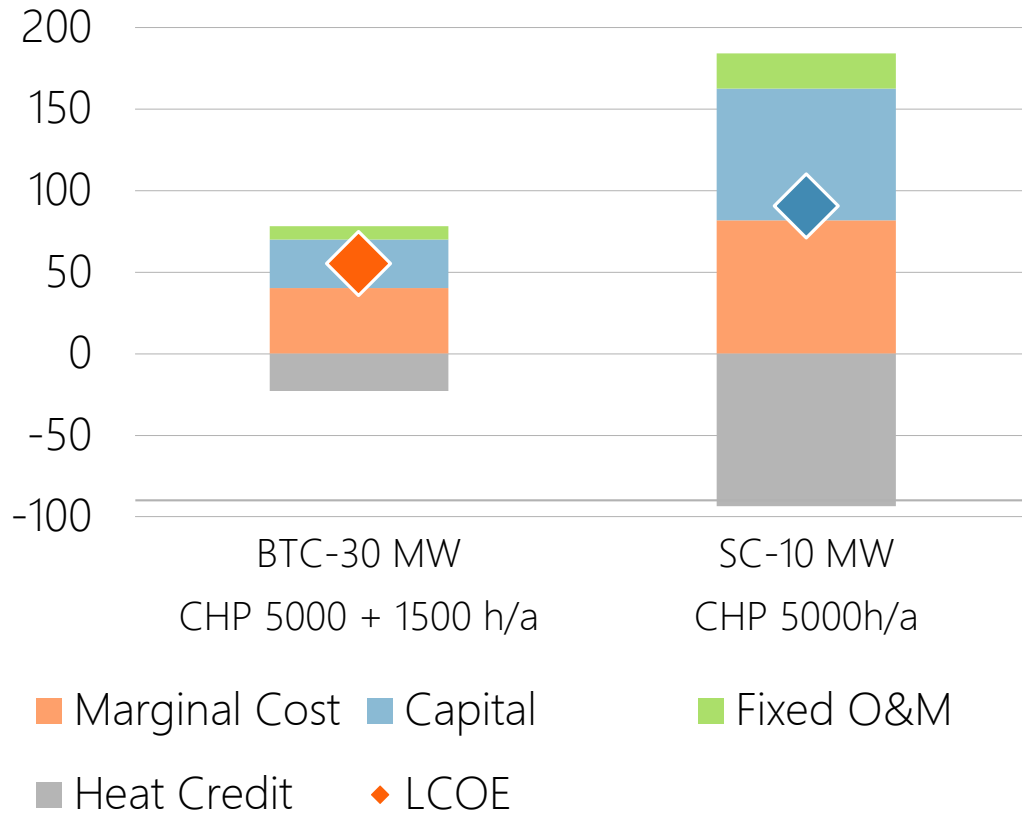
2030 Short-run Marginal Cost of Electricity, €/MWh<sup>1</sup>  
No taxes, subsidies, heat income



- Operating hours will be higher
  - BTC lowest marginal cost of plannable power
  - Marginal cost 40 €/MWh, no subsidies
  - NG will have carbon dioxide penalties

# HIGH-VALUE BTC OPERATION WITH CHP

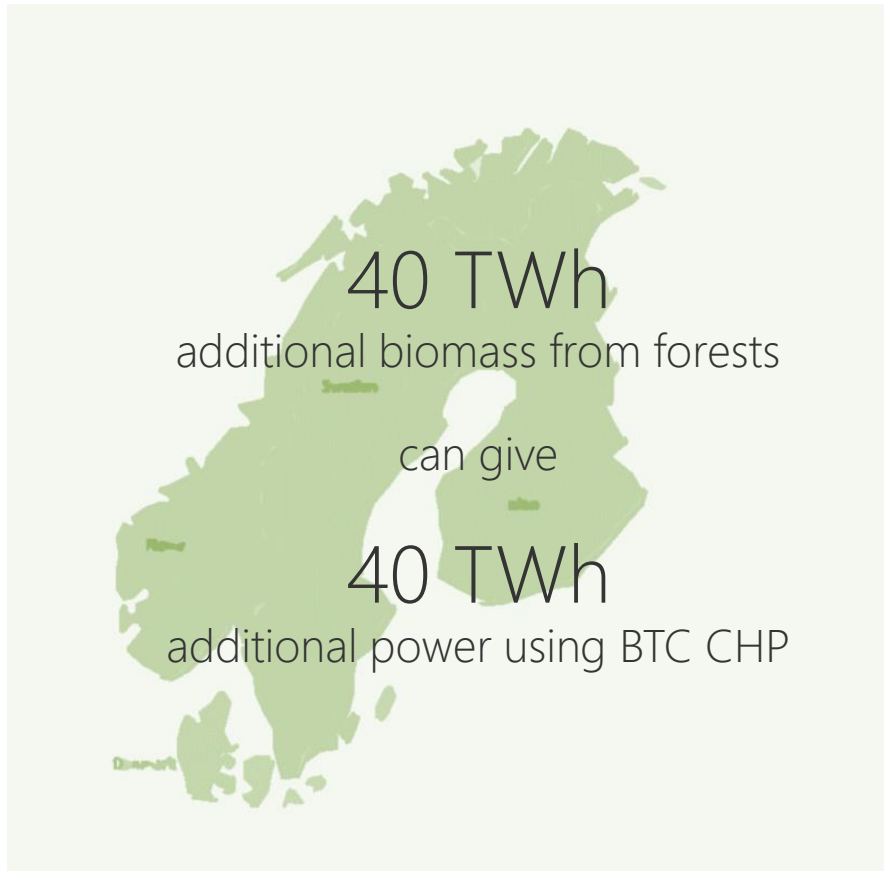
2030 Levelised Cost of Electricity, €/MWh<sup>1</sup>  
 27 MW heat delivery. No taxes, subsidies



- 3 times as much power delivered
- 40% lower LCOE → 56€/MWh no subsidies
- Marginal cost halved ~40€/MWh no subsidies
- Capital costs halved
  - Scaling effects (10 vs 30 MW)
  - High efficiency

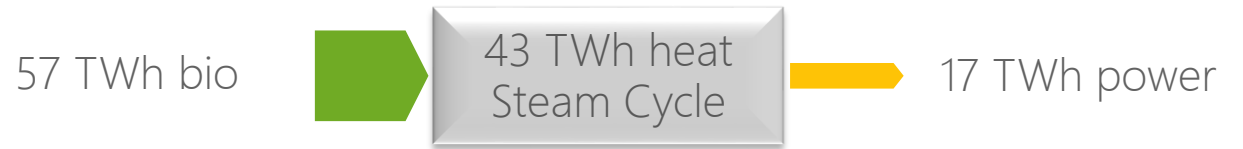
1. 32 €/MWh heat credit, 5000h/a steam cycle. 6500 h/a BTC due to low marginal cost. BTC with 5000/h gives 60 €/MWh

# 100% MARGINAL EFFICIENCY FROM SCARCE BIOMASS



Potential for sustainable increase in forest harvest = 60-240 TWh/a

Baseline: conventional CHP  
30% el. / 105% total. 5000 h/a



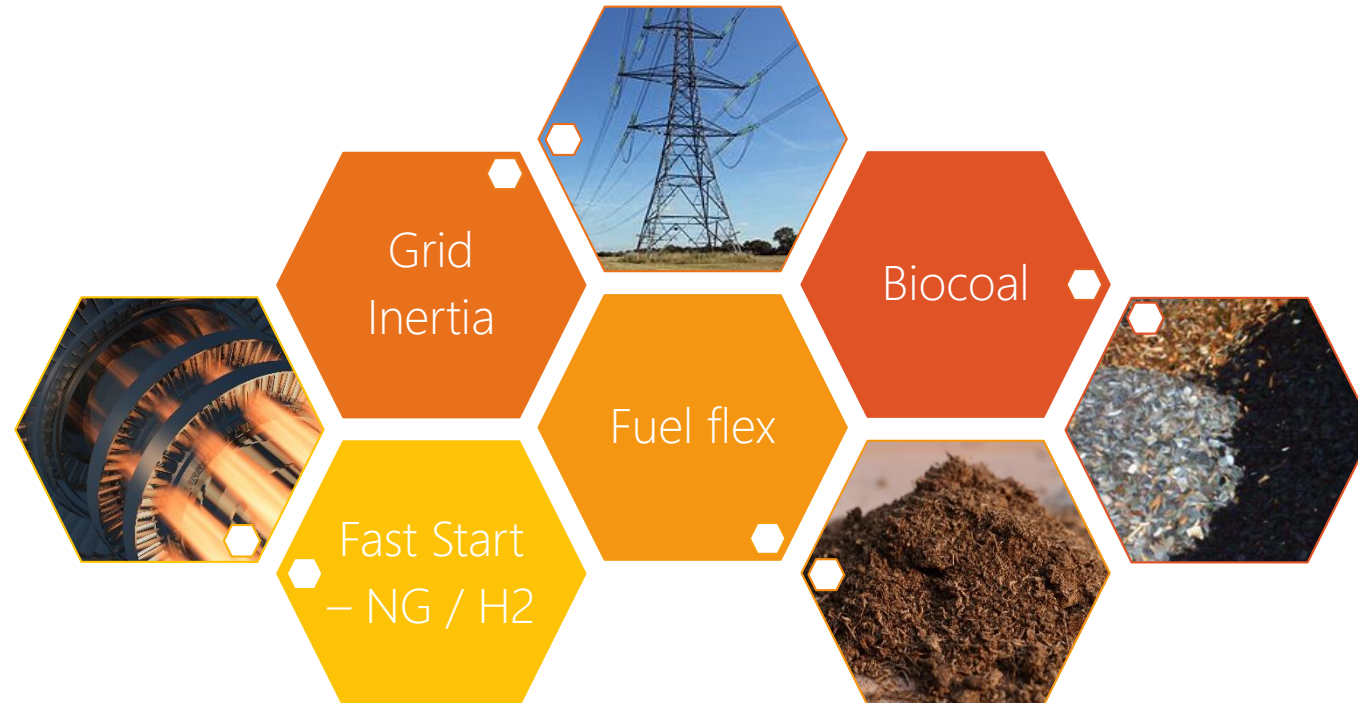
Case 1: BTC CHP  
60% el. / 105% total, 5000 h/a



Case 2: BTC CHP + Condense  
60% el. / 100% total, 6500 h/a



# ADDITIONAL SERVICES





# BTC DEVELOPMENT PROGRAM

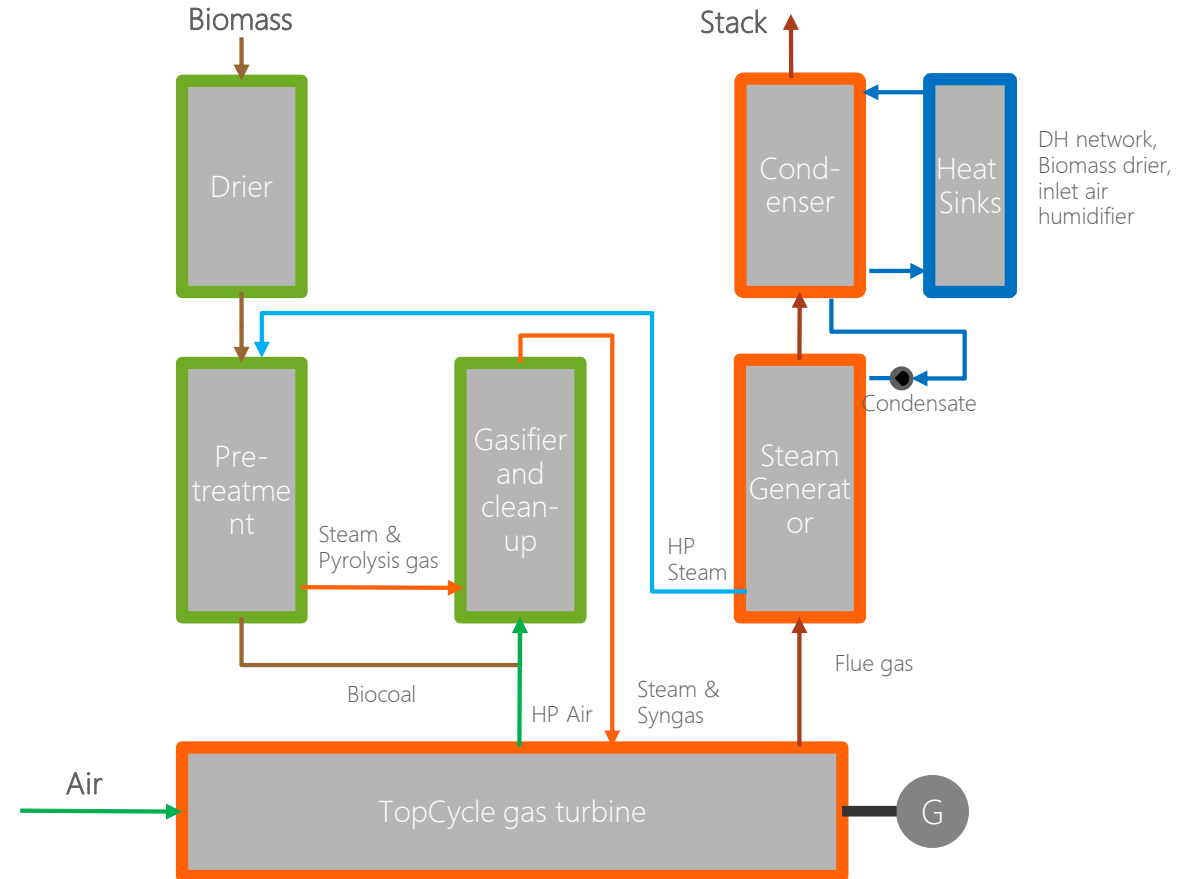
# KEY DEVELOPMENT AREAS

Phoenix  
&  
Partners

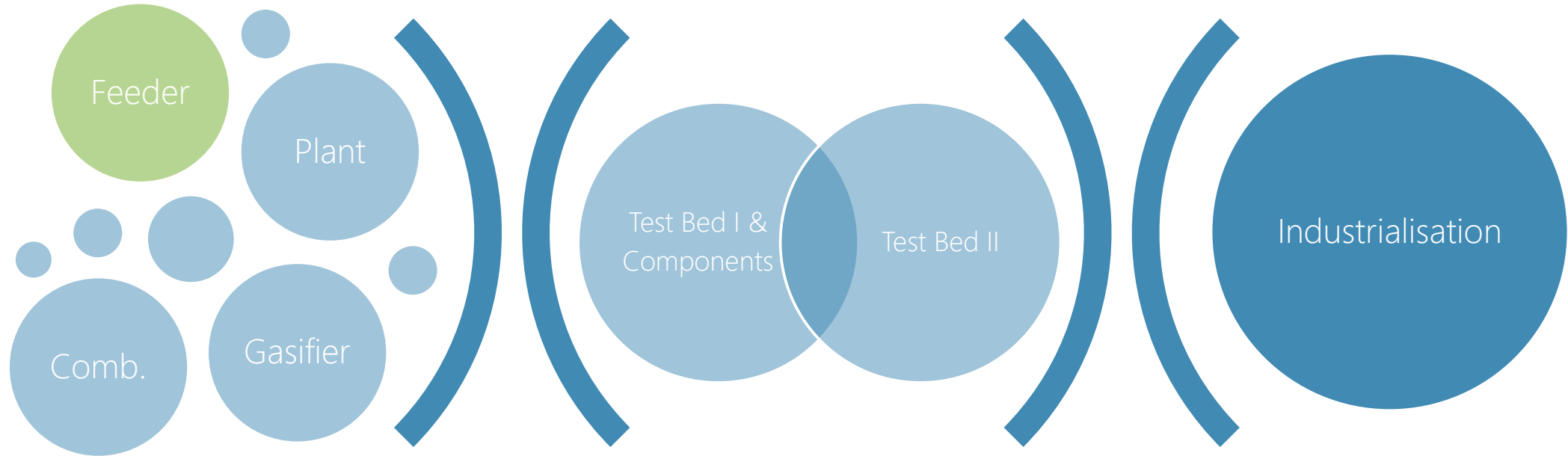
- Biomass pre-treatment
- Gasification with partial quench
- Gas turbine combustor
- Plant and integration

Partners

- High pressure GT expander
- GT integration & packaging



# PROGRAMME OUTLINE



Phase 1: Feasibility  
2017-2018

Phase 2: Development  
2018-2020

Phase 3: Industrialisation  
2021-2023

Component development 2017-2020

Prototypes Atm <-> Pressurised 1/200 scale

Rigs at TU Berlin, RISE Piteå, Phoenix Finspång

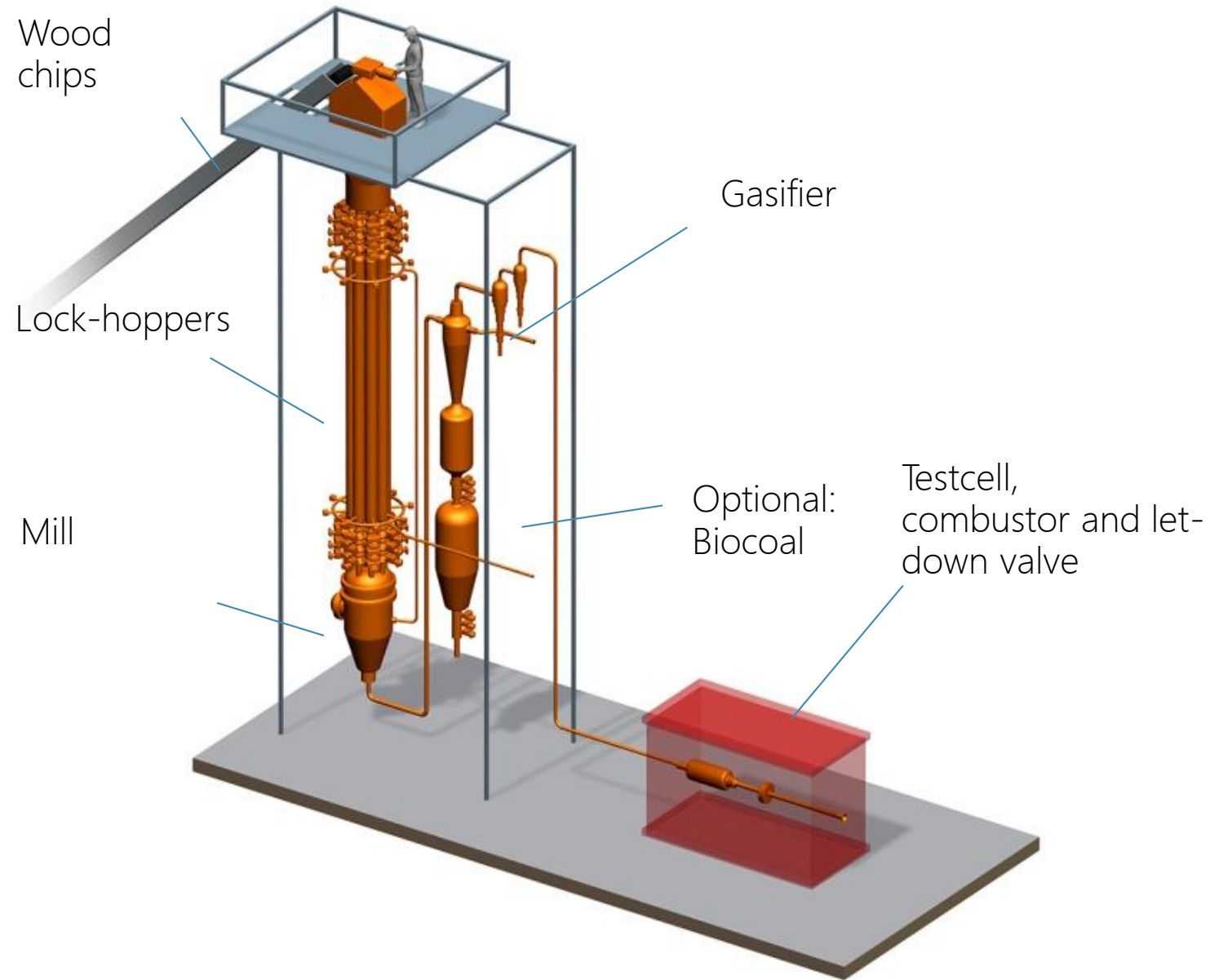
Test Bed 200kW\_fuel 2018-2020

Integrated system, 1/200 scale, 40 bar  
Phoenix labs

Test Bed 5MW\_fuel 2020

Verification, 1/10 scale, 70 bar  
Phoenix labs

# TEST BED



# CO-OPERATION MODEL



# WANT TO KNOW MORE?

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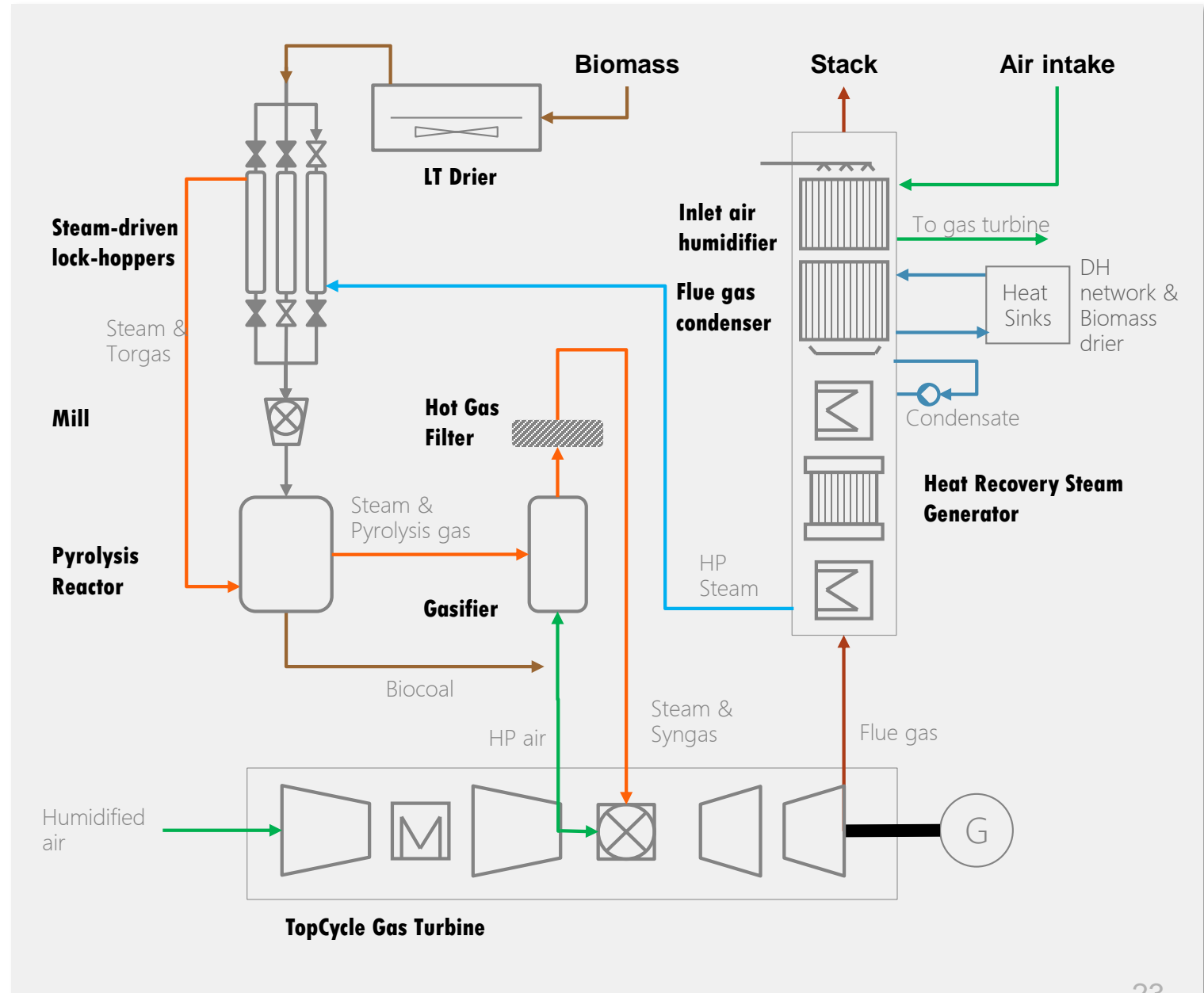
c/o InnoEnergy

Valhallavägen 79

SE-114 28 Stockholm

# THE BTC PROCESS

- 70 bar biomass pre-treatment
  - Pressurisation, steam-driven lock-hopper
  - Torrefaction and pyrolysis
  - Milling at pressure
- Gasifier
  - Air-blown, entrained flow
  - Quenched with pyrolysis gas
  - Hot gas filter to remove particles, alkalis
- TopCycle gas turbine
  - Intercooled
  - Combustor with 3 MJ/Nm<sup>3</sup> fuel & lambda 1,1
  - 50% vol. steam in expander
  - Steam and air cooled
- Heat recovery
  - Single pressure HRSG
  - SCR
  - Flue gas condenser providing heat at 78C
  - Condensate recovery and treatment



# 60%: CLIMBING THE EFFICIENCY LADDER

1. Move from steam cycle
  - Advanced gas turbine cycle efficiencies (53% NG)
2. Optimise TopCycle with gasifier exit heat
  - Increases combustor inlet temperature
  - Saves fuel and increases efficiency
3. Dry biomass with waste heat from flue gas condenser
  - Upgrades fuel more efficiently compared to steam
4. Increase gasification inlet temperature
  - Cold gas efficiency increase
5. Increase the turbine firing temperature (scale-up)

