



# Technical analysis of cogeneration projects

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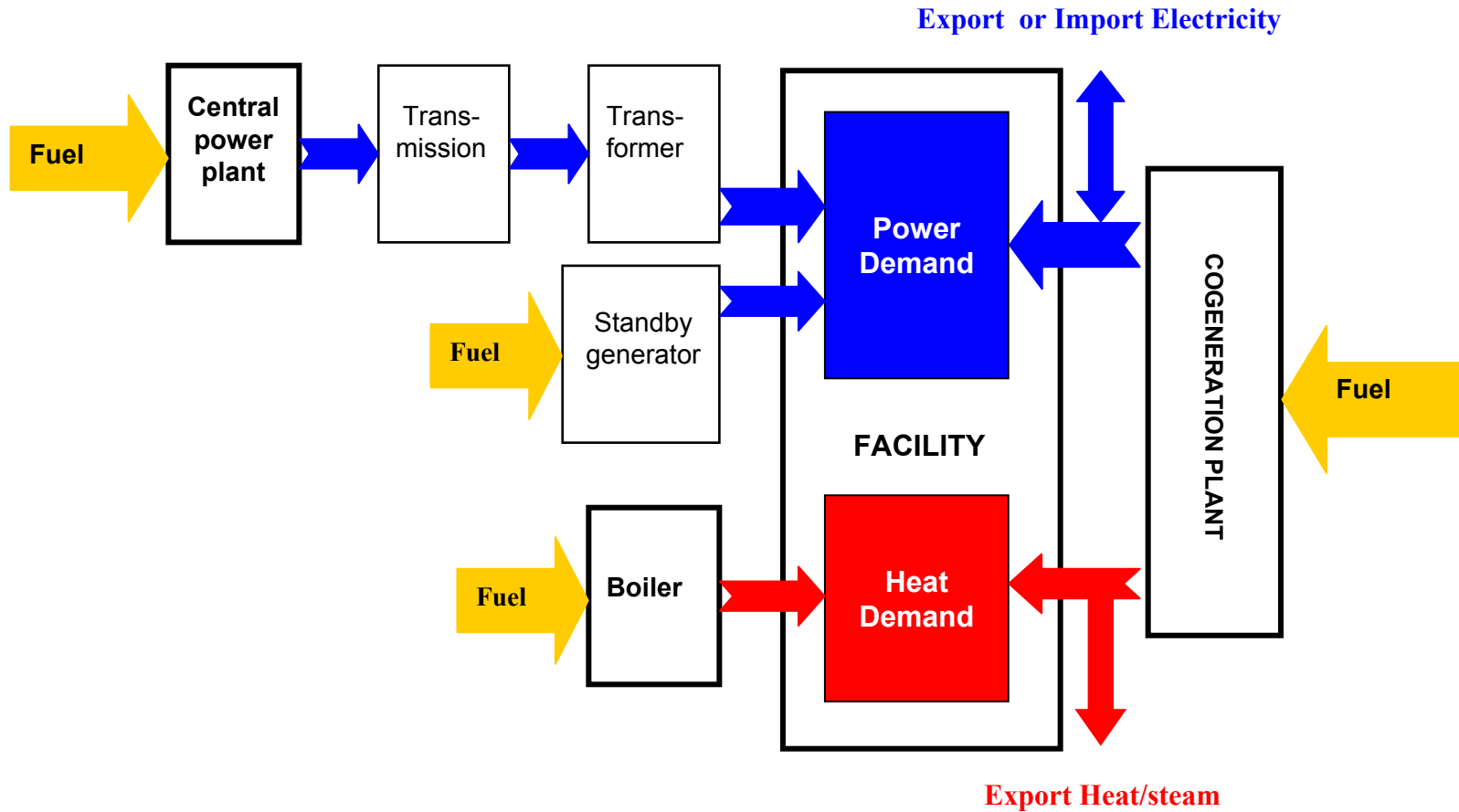
- **What is Cogeneration?**
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## What is cogeneration?

- Cogeneration is the sequential generation of **two** different forms of **useful** energy from a **single** plant
- The sequences of generation can be **any** combination of two different forms of useful energy (electricity & heat, mechanical energy & heat, electricity & cooling, etc.)
- **Tri**generation (electricity, heat & cooling)

# What is cogeneration?





# Available cogeneration technologies

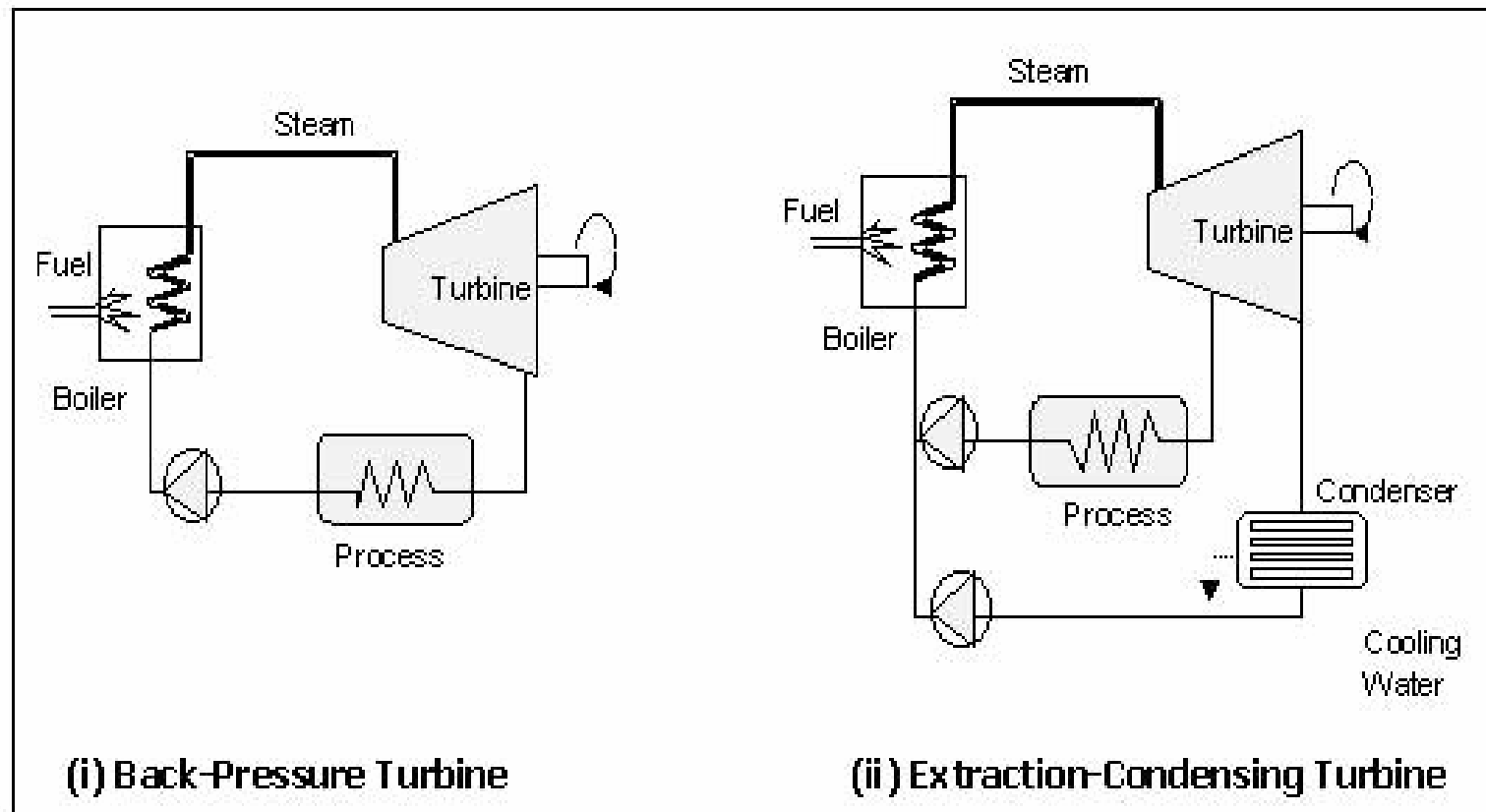
## Proven, commercially available cogeneration technologies

- Steam turbine (ST) cogeneration system
- Gas turbine (GT) cogeneration system
- Combined cycle gas turbine (CCGT) cogeneration system
- Internal Combustion Engine cogeneration system
- Steam Engine cogeneration system

## Other “less” commercially available cogeneration technologies:

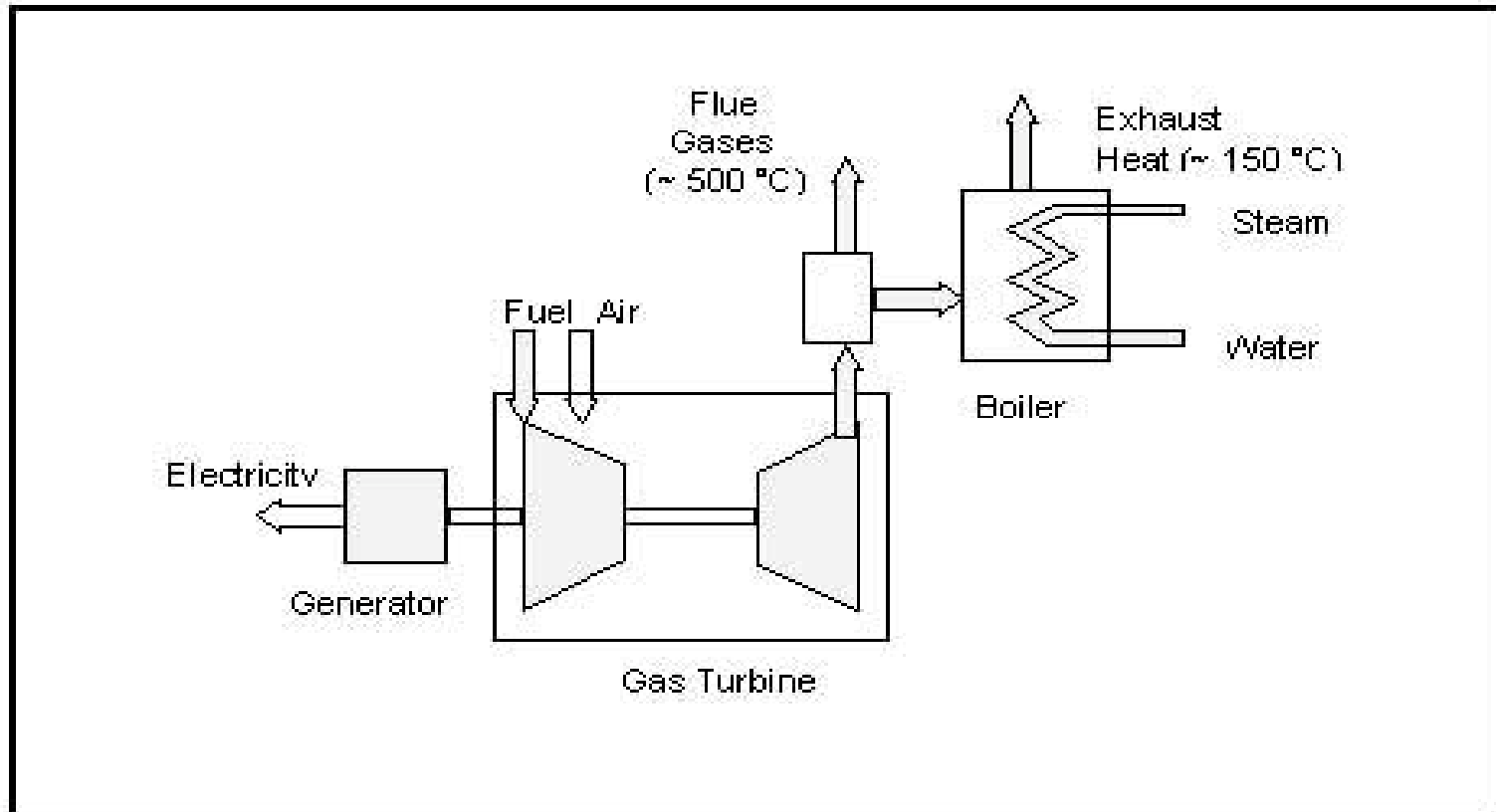
- Integrated Gasification Combined Cycle (IGCC)
- Micro-turbines
- Fuel cells

# Available cogeneration technologies



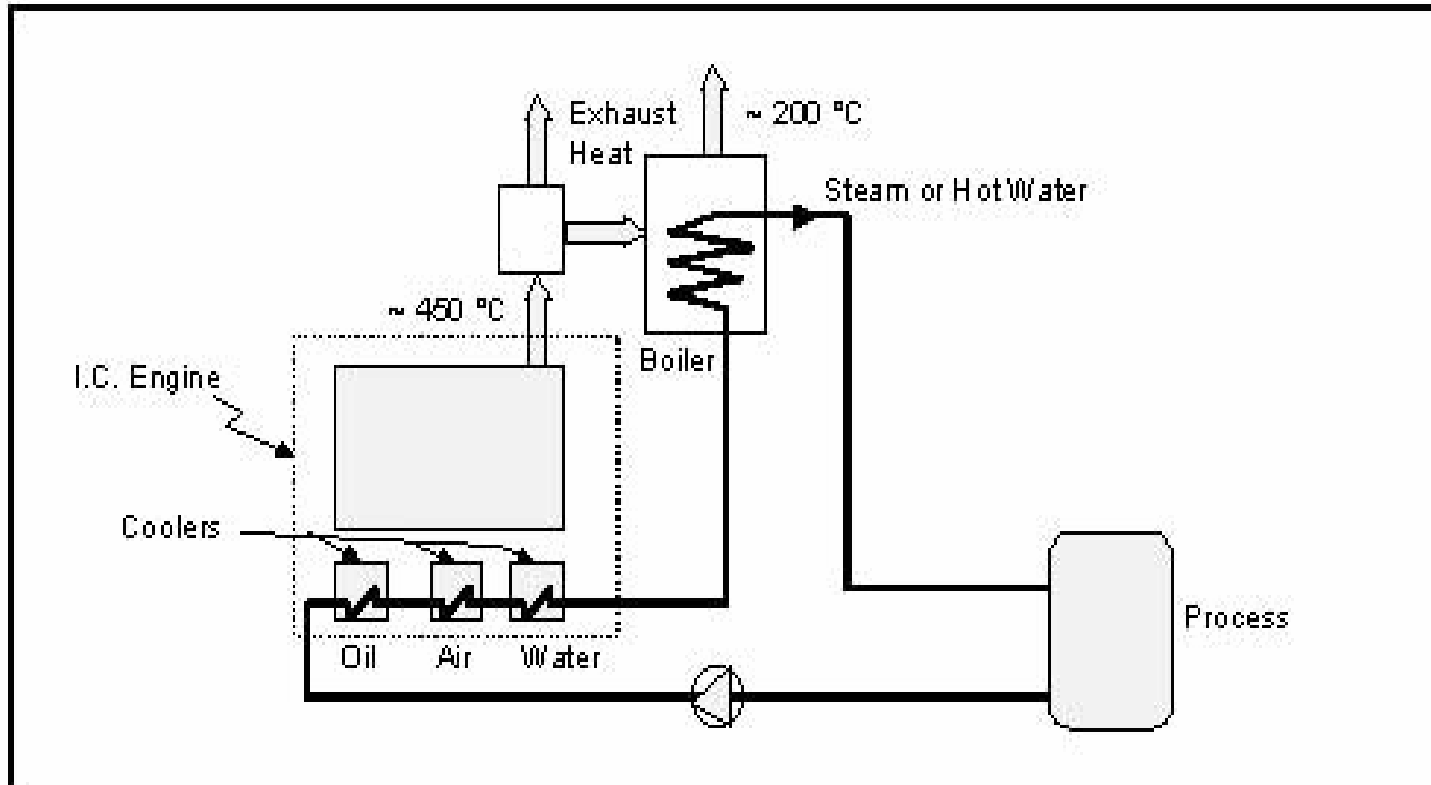
Schematic diagrams of steam turbine cogeneration systems

# Available cogeneration technologies



Schematic diagram of gas turbine cogeneration system

# Available cogeneration technologies



Schematic diagram of internal combustion engine cogeneration system



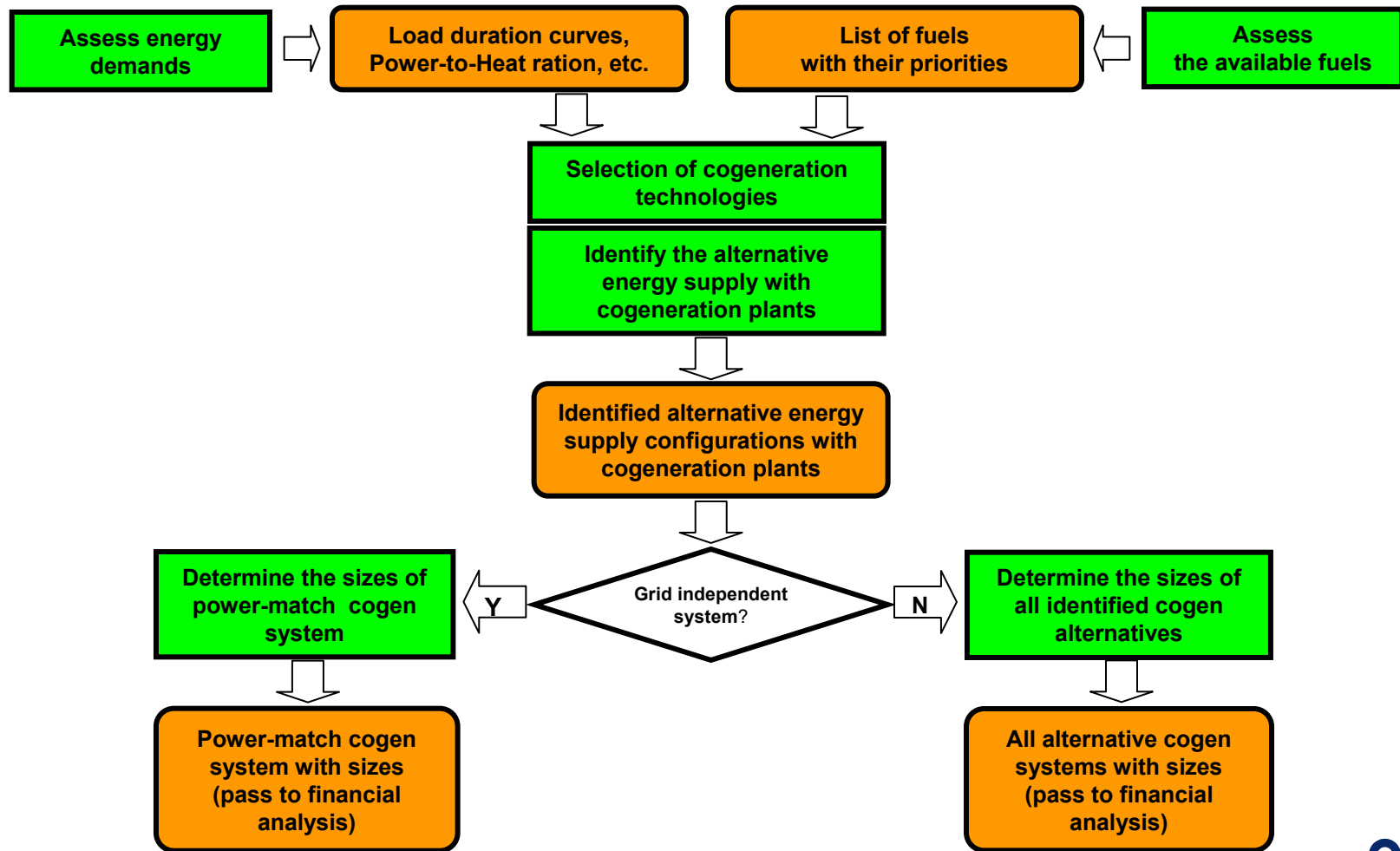
# Steps of Technical Analysis

## The tasks of Technical analysis of cogeneration projects:

- To select the suitable technologies for your proposed cogeneration plant
- To identify the possible alternatives of energy supply systems with cogeneration plant
- To determine the sizes of the selected cogeneration plants, i.e. the main technical input data needed for further financial analysis of cogeneration project



# Steps of Technial Analysis





# Assessment of energy demands (1)

## Energy Demands: how much? and when?

### What should be defined?

- Electricity demand
- Thermal energy/steam demand
- Cooling demand

### How to define the energy requirements?

- Energy audit done by consultant
- Own mapping and prediction

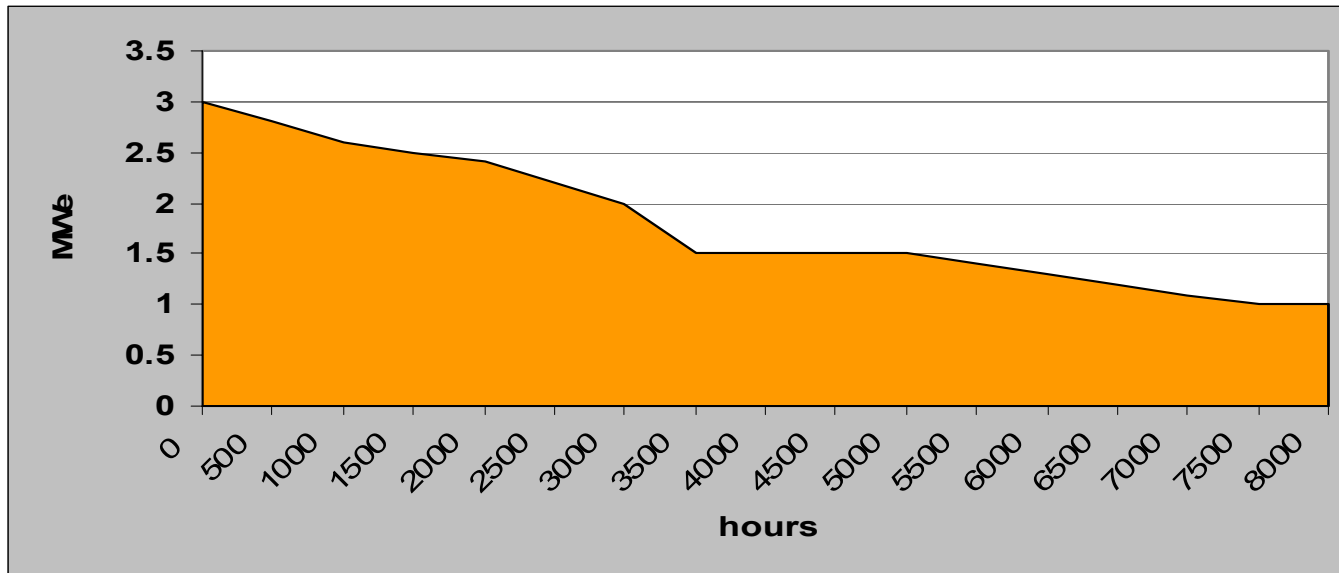
### Should be considered:

- Possible savings, process changes, process integration etc.
- Future energy requirements



# Assessment of energy demands (2)

## Electricity Demand



$We_{(max)} = 3 \text{ MW}$ ,  $We_{(min)} = 1 \text{ MW}$

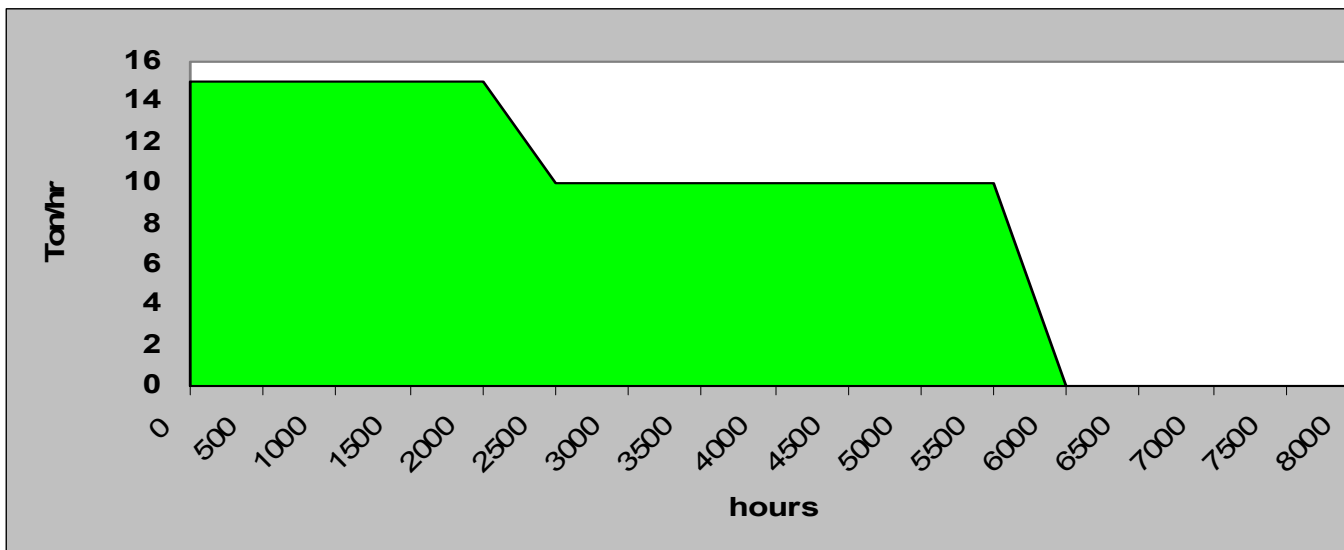
$Te = 8000 \text{ hours}$

Electricity consumption = 13,000 MWh



# Assessment of energy demands (3)

## Heat Demand



$Q_{th}(\max) = 15 \text{ ton/hr}$ ,  $Q_{th}(\min) = 10 \text{ ton/hr}$  @ 3 bar(a) saturated

$T_{th} = 6000 \text{ hours}$

Heat consumption = 69,000 MWh



# Assessment of available fuels

## The assessment is mainly based on:

- Long term availability of fuel
- Adherence to the local environmental regulation
- Fuel price and its expected escalation

**The result of fuel assessment is a list of the available fuels and their relative priorities**



# Selection of cogeneration technologies

Sector	Plant size	Coal + products	Gas	Heavy fuel oil	Light fuel oil	Biomass	Wastes	Biogas
Domestic	< 15 kW <sub>e</sub>		GE		GE			GE
Commercial	15-100 kW <sub>e</sub>		GE		GE	ST	ST	GE
	100kW <sub>e</sub> -1MW <sub>e</sub>		GE		GE	ST	ST	GE
	1-5 MW <sub>e</sub>	ST	GT/GE	ST	GT/GE	ST	ST	GT/GE
Industry	1-5 MW <sub>e</sub>	ST	GT/GE	ST	GT/GE	ST	ST	GT/GE
	5-50 MW <sub>e</sub>	ST	OCGT	ST	OCGT	ST	ST	OCGT
	> 50 MW <sub>e</sub>	ST	CCGT	ST	CCGT	ST	ST	CCGT

Notes: CCGT: Combined cycle gas turbine

GE: Gas engine

GT: Gas turbine

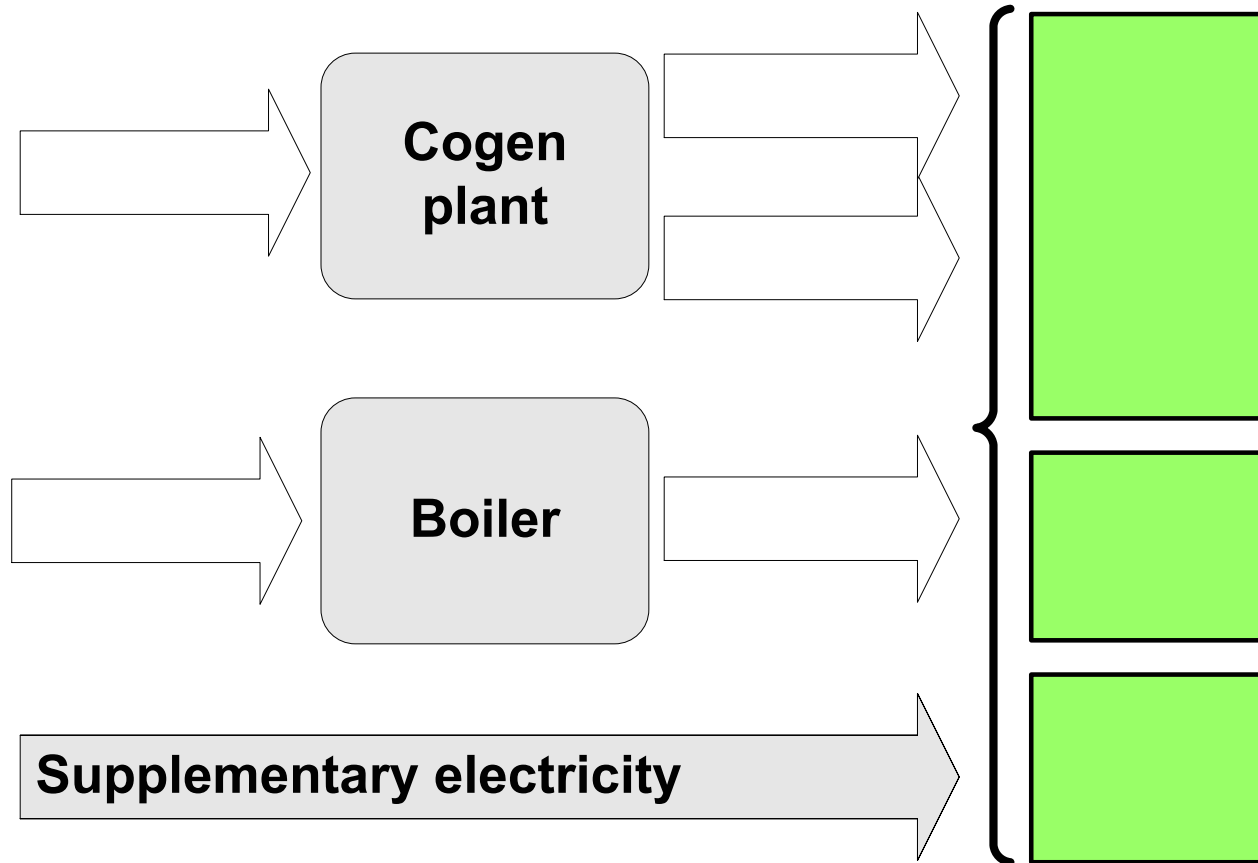
OCGT: Open cycle gas turbine

ST: Steam turbine

*Source: The Future of CHP in the European Market – The European Cogeneration Study, SAVE/Future COGEN, May 2001*



# Alternatives of energy supply with cogeneration plant





## Sizing of cogeneration systems

- Energy flows analysis
- Calculation of cogeneration efficiencies
- Determination of the capacities of key equipment (steam boiler, turbines, engines, generator,...) of the cogeneration system
- Determination of the capacities of the supplementary equipments (boiler, genset)



# Example of technical analysis of cogeneration systems (1)

## INPUT DATA:

Electricity demand:

$W_{\max} = 3 \text{ MW}$ ,  $W_{\min} = 1 \text{ MW}$

Heat demand: steam @ 3 bar(a) saturated

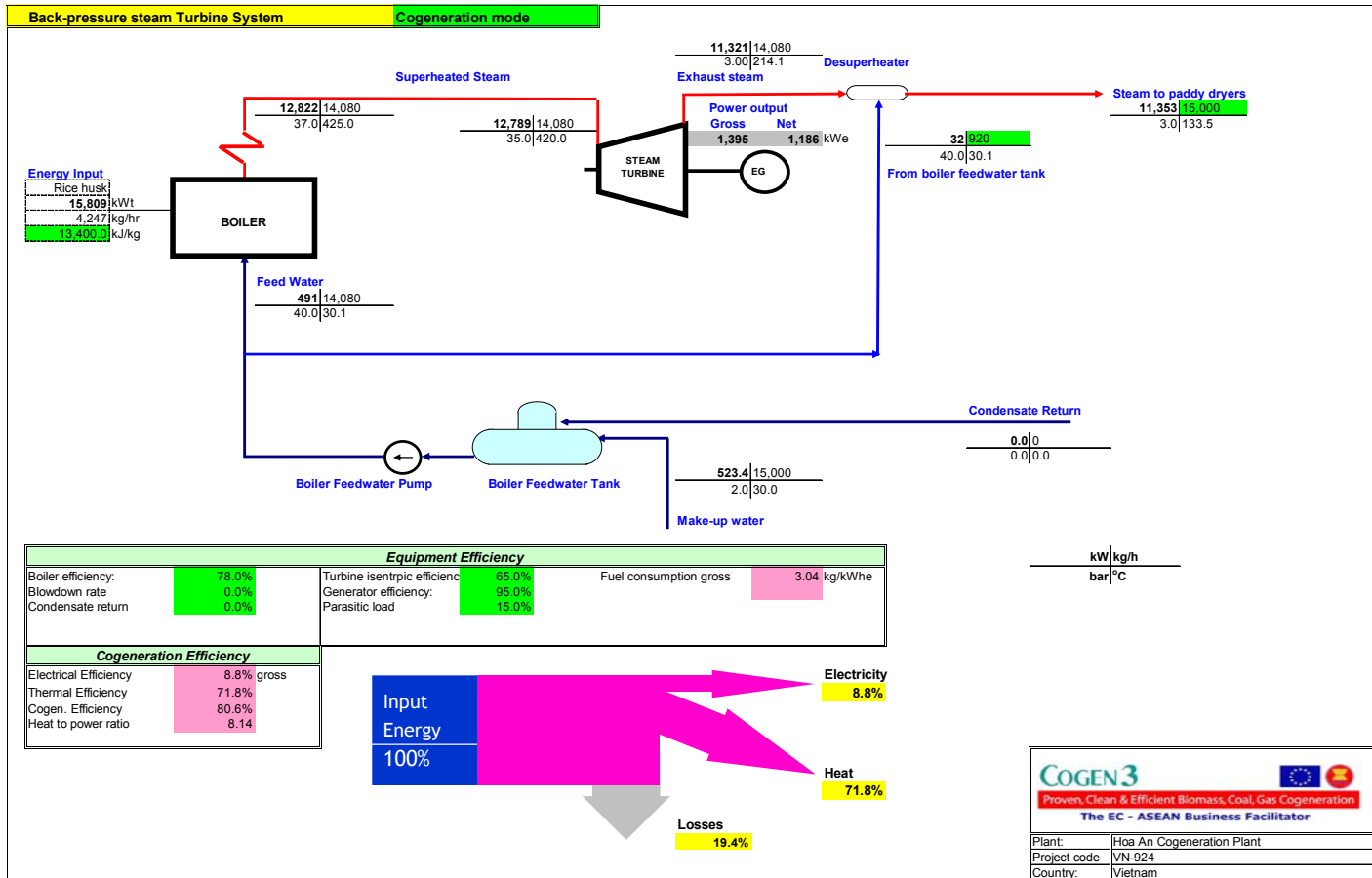
$Q_{\max} = 15 \text{ ton/hr}$ ,  $Q_{\min} = 10 \text{ ton/hr}$

Fuel: Natural gas

Cogen technology: Back-pressure steam turbine

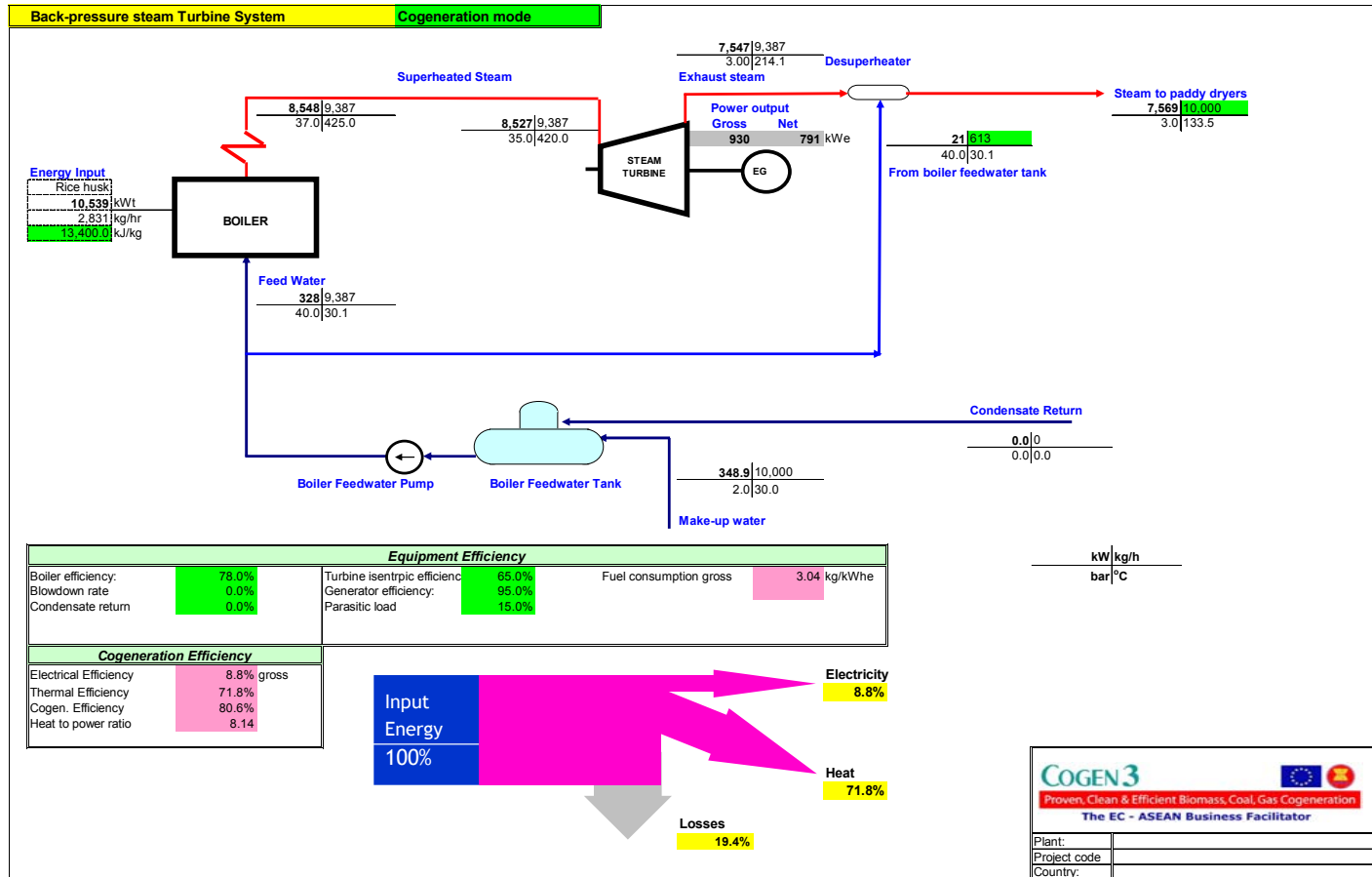


# Example of technical analysis of cogeneration systems (2)





# Example of technical analysis of cogeneration systems (3)





## Example of technical analysis of cogeneration systems (4)

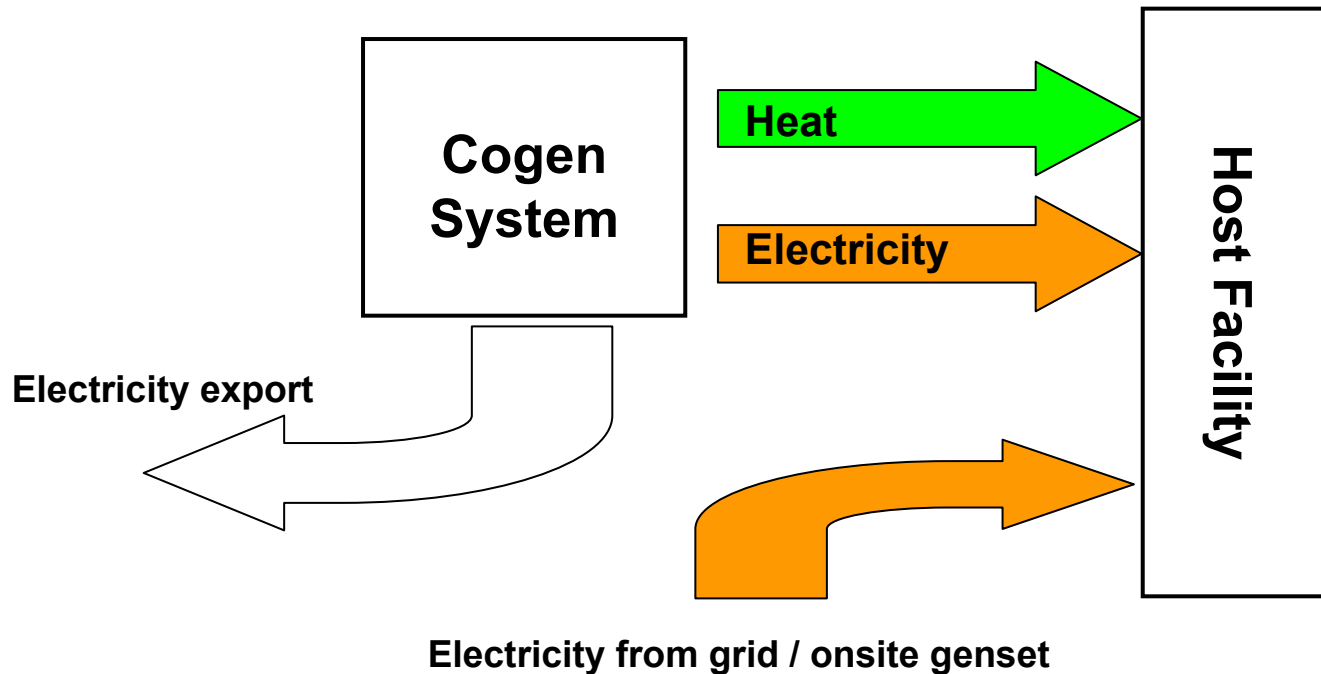
Main outputs of heat balance analysis

Steam/Heat generation	15 t/h (11.35 MW <sub>th</sub> )	10 t/h (7.57 MW <sub>th</sub> )
Electric power generation	1.2 MW <sub>e</sub>	0.8 MW <sub>e</sub>
Cogen electric efficiency	8.8%	8.8%
Cogen thermal efficiency	71.8%	71.8%
Overall cogen efficiency	80.6%	80.6%
Fuel input	15.8 MW <sub>th</sub>	10.5 MW <sub>th</sub>



## Example of technical analysis of cogeneration systems (5)

Alternative of energy supply with selected cogeneration plant





## Example of technical analysis of cogeneration systems (6)

Key equipments of cogeneration plant:

- Steam boiler: 15 ton/hr @ 37 bar(a) / 425 °C
- Back-pressure steam turbine: 1.4 MW<sub>e</sub> gross

Supplementary equipments:

- Sub-station or stand-by genset: 2.2 MW<sub>e</sub>



For more information,  
please visit COGEN 3 Website at:

<http://www.cogen3.net>

**Thank You !**