



**INSTITUTE FOR CHEMICAL  
PROCESSING OF COAL**



**1955-2015**

**3rd Conference on  
CCS**

**BASREC, Warsaw  
29<sup>th</sup> October 2015**

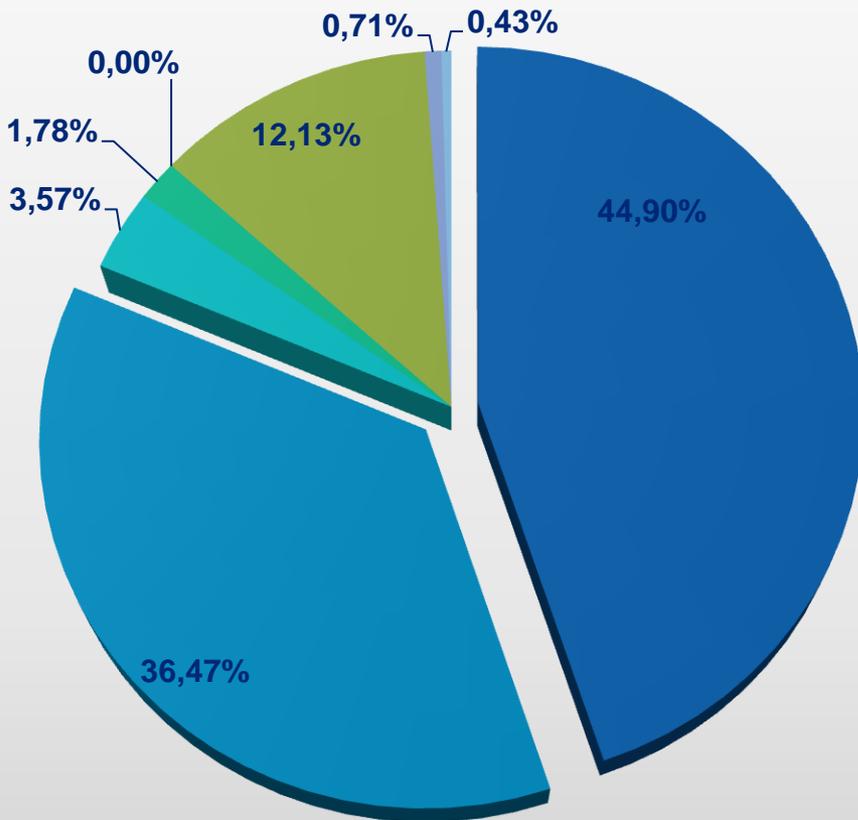
## **Polish CO<sub>2</sub> capture pilot, amine technology**

**Lucyna Więclaw-Solny, Adam Tatarczuk, Institute for Chemical Processing of Coal, Poland**

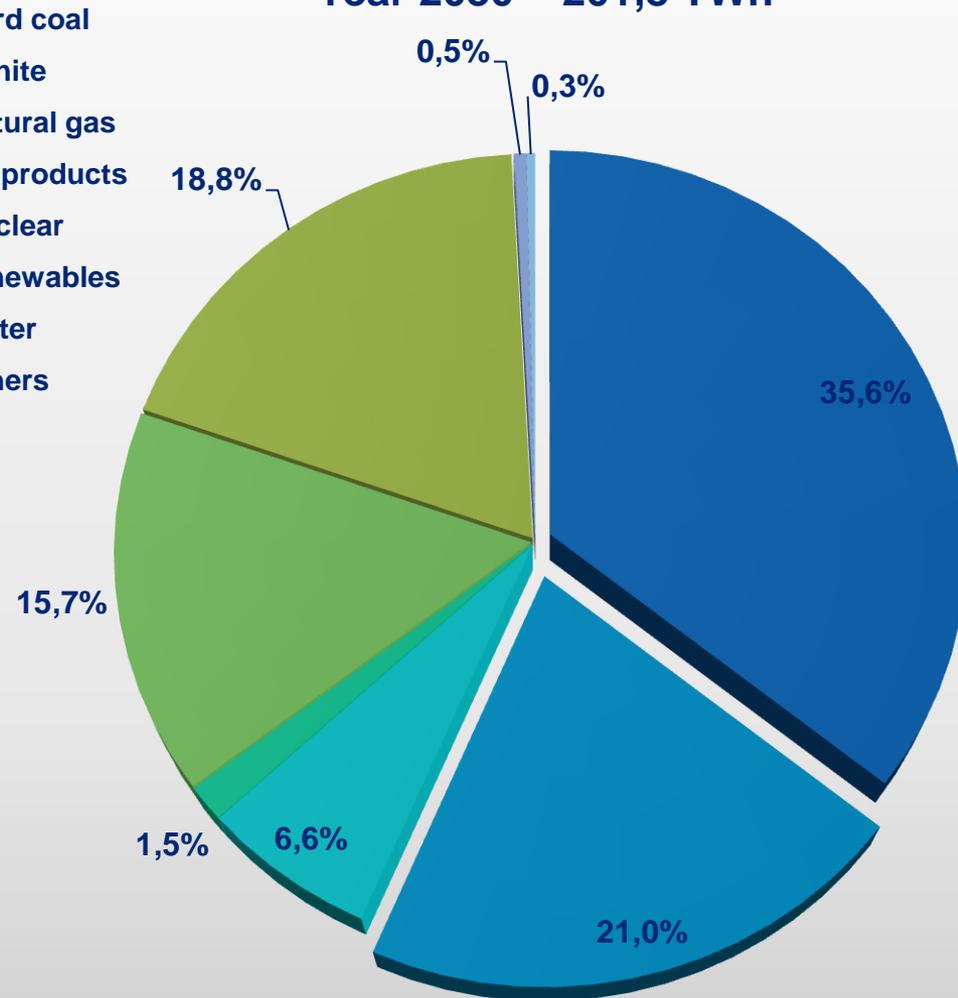
**[lwieclaw@ichpw.pl](mailto:lwieclaw@ichpw.pl) [tatarczuk@ichpw.pl](mailto:tatarczuk@ichpw.pl)**

# Fuel mix in power generation - Poland

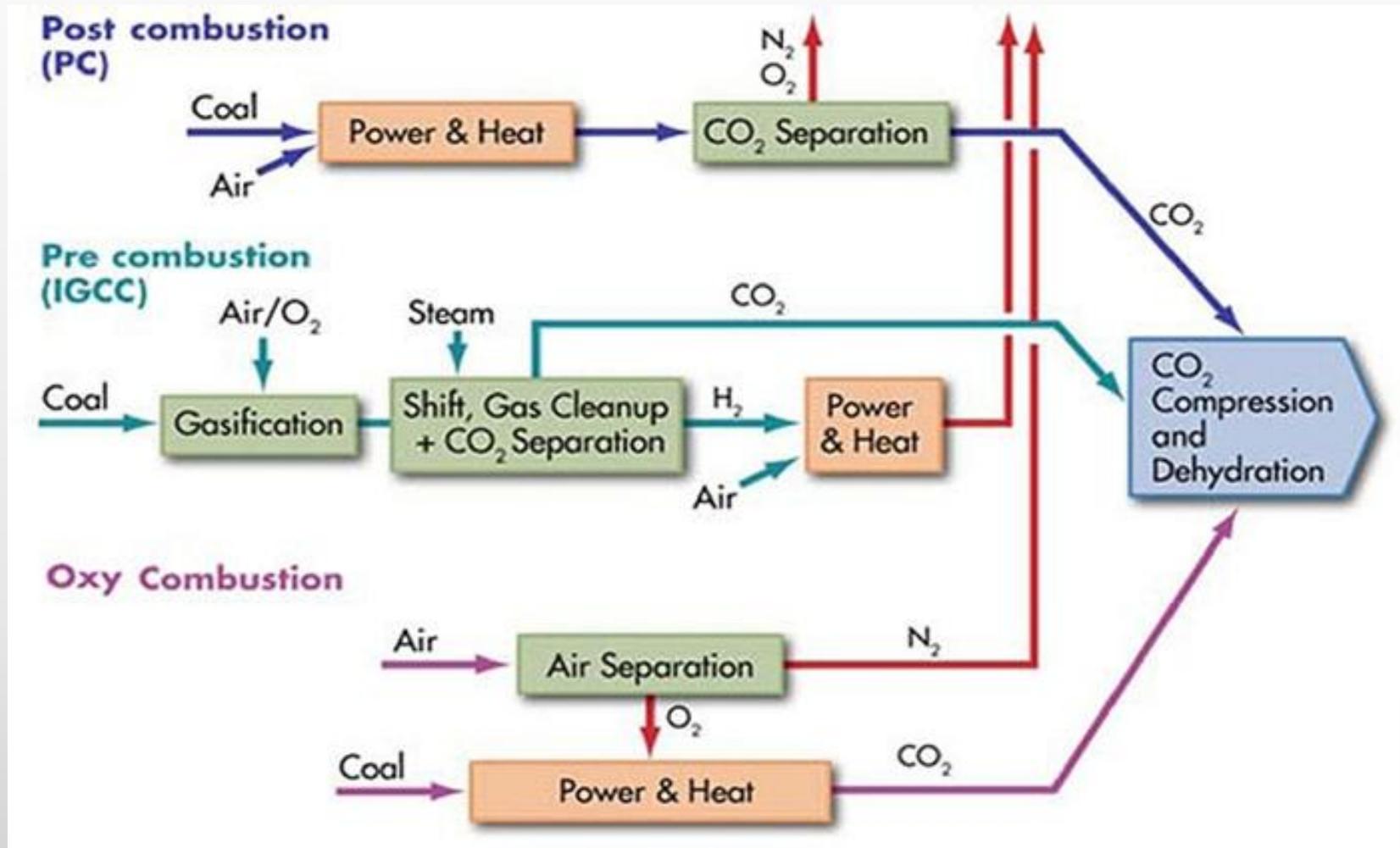
Year 2015 – 140,1 TWh



Year 2030 – 201,8 TWh



# The main technology options for CO<sub>2</sub> capture from power plant



# „...post-combustion carbon capture is winning.”

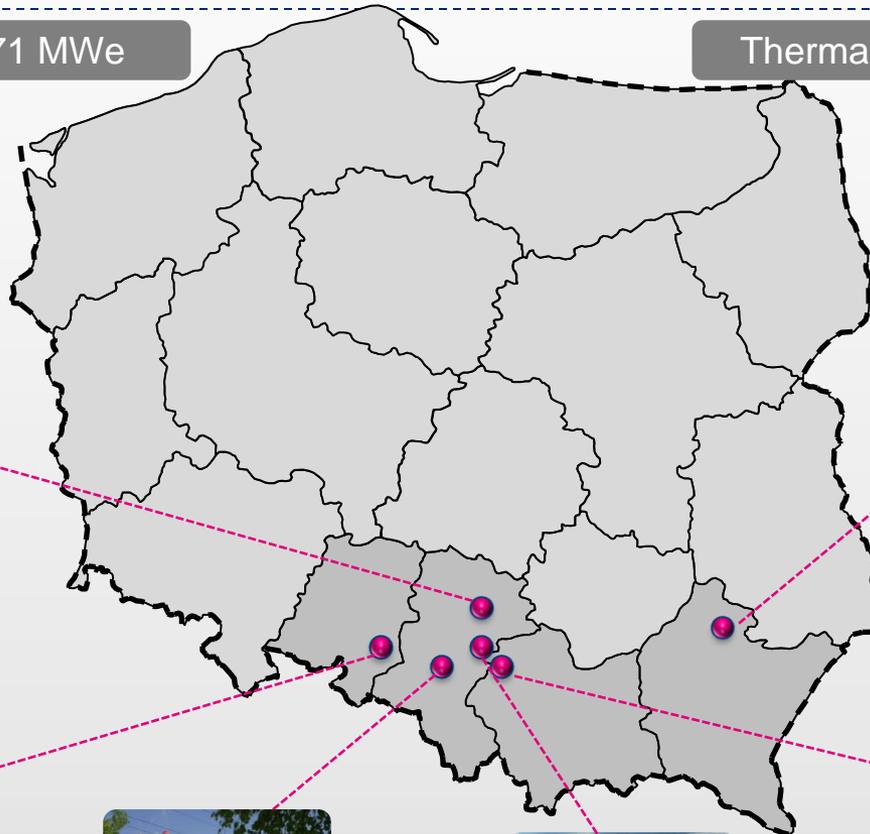
- Possible to implement to existing Power Plants
- High efficient coal-fired power units „50 +”
- Large demonstration projects with post- combustion CCS :
  - WA Parish Petra Nova , US, start 2016 – 240 MW,
  - ROAD , NL, start 2017 – 250 MW,
  - Boundary Dam, Kanada, 2014 – 150 MW,



# About TAURON Group – power plants

Electric Power– 4 671 MWe

Thermal Power– 1 667,1 MWt



Łagisza Power Plant

- 850 MWe
- 343,4 MWt



Blachownia Power Plant

- 165 MWe
- 256 MWt



Łaziska Power Plant

- 1 155 MWe
- 196 MWt



Jaworzno Power Plant

- 1 535 MWe
- 369,3 MWt



Stalowa Wola Power Plant

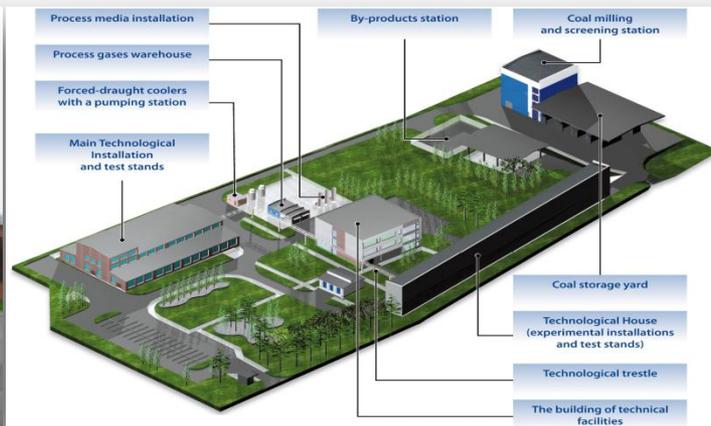
- 330 MWe
- 465,9 MWt



Siersza Power Plant

- 666 MWe
- 36,5 MWt

# Institute for Chemical Processing of Coal, Zabrze, Poland



## Clean Coal Technology Centre



## Institute for Chemical Processing of Coal

# Clean Coal Technology Centre, Zabrze, Poland



**Pressurized gasification and oxy-combustion in CFB reactor (50 kg/h)**



**Biomass gasifier (15 kg/h)**

**Solid fuels dryer (100 kg/h)**



**Coal Coking test plant (40 kg)**

**Chemical looping reactor (10m<sup>3</sup>/h)**

# General information

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- **Project name:**

Development of a technology for highly efficient zero-emission coal-fired power units integrated with CO<sub>2</sub> capture.



- **Objective:**

The main purpose of the project was to demonstrate the post combustion process in pilot plant connected to coal-fired power plant.

- **Principal:**

National Research and Development Center (Poland)



- **Project duration:**

1.04.2010 – 30.11.2015 (67 months)

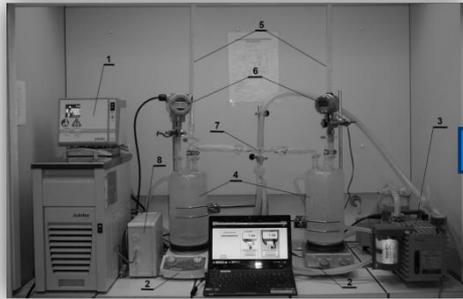
- **Executors:**

TAURON Polish Energy, TAURON Production, Institute for Chemical Processing of Coal (**ICHPW**)



# IChPW CO<sub>2</sub> capture process scale-up strategy

Experimental apparatus of CO<sub>2</sub> absorption kinetics and equilibria in amine blends (2010)



Lab stand for CO<sub>2</sub> capture process – 5 m<sup>3</sup>/h (2011)



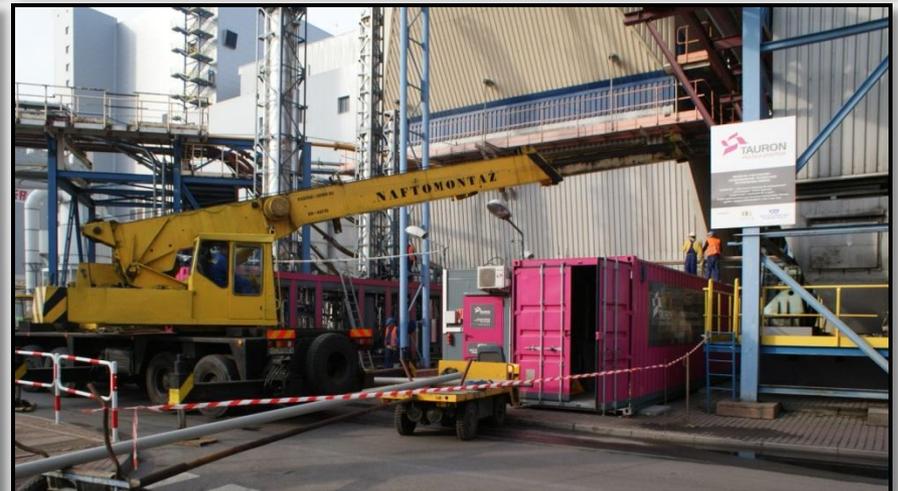
The Mobile Pilot Plant – 200 m<sup>3</sup>/h (2013-Tauron Power Plant)



PDU for CO<sub>2</sub> capture process – 100 m<sup>3</sup>/h (2012-IChPW Zabrze)



# Pilot plant deployment - Jaworzno Power Plant – 04.2014



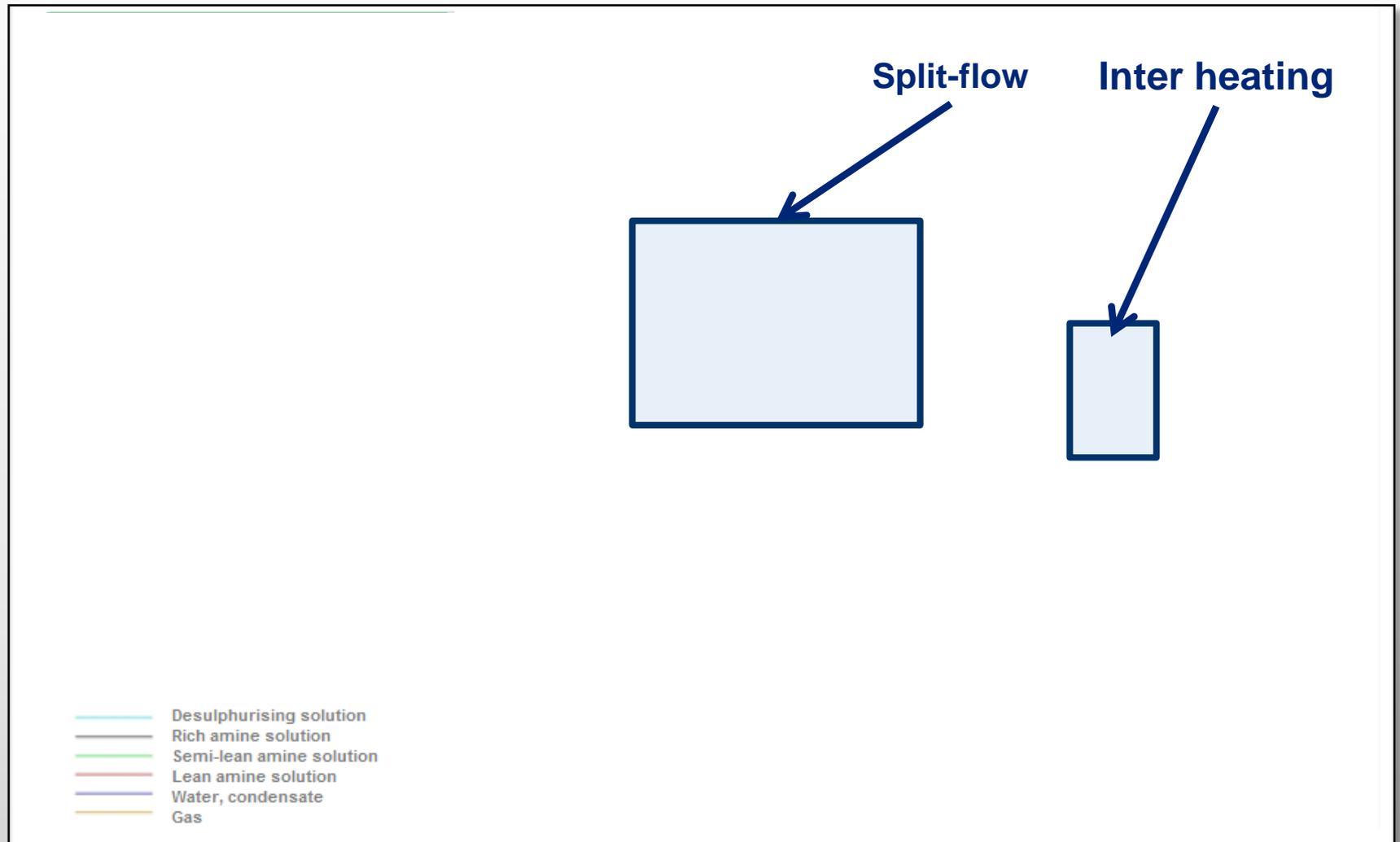
# The Pilot Plant commissioning–05.2014 Jaworzno Power Plant (TAURON)

Column diameter:  
Column height:  
Number of devices:  
Measurements:  
Solvent:  
Solvent stream:  
Gas stream:  
Tested gas:

300 mm



# The Pilot Plant simplified flow diagram



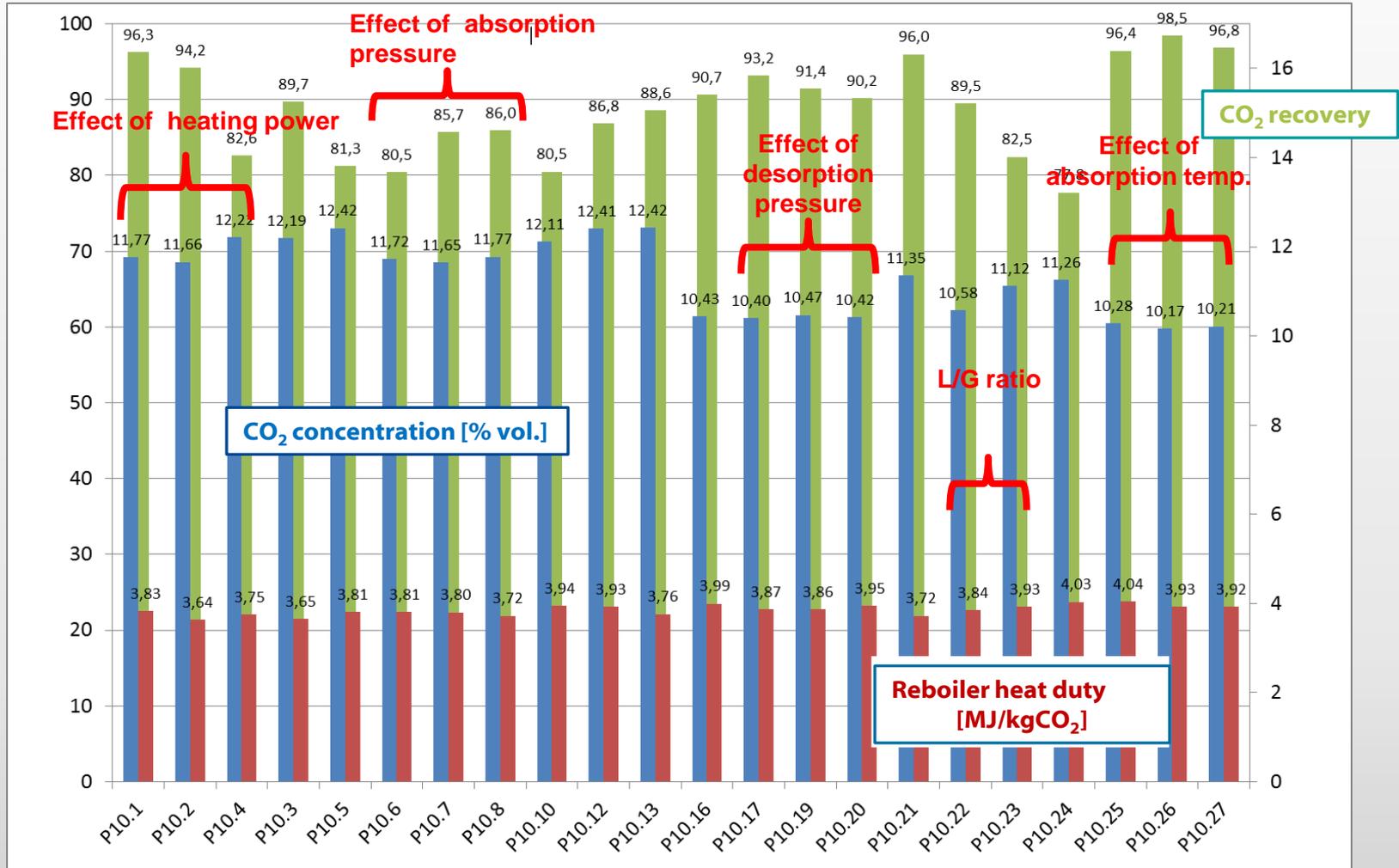
# Results and discussion

## Nomenclature

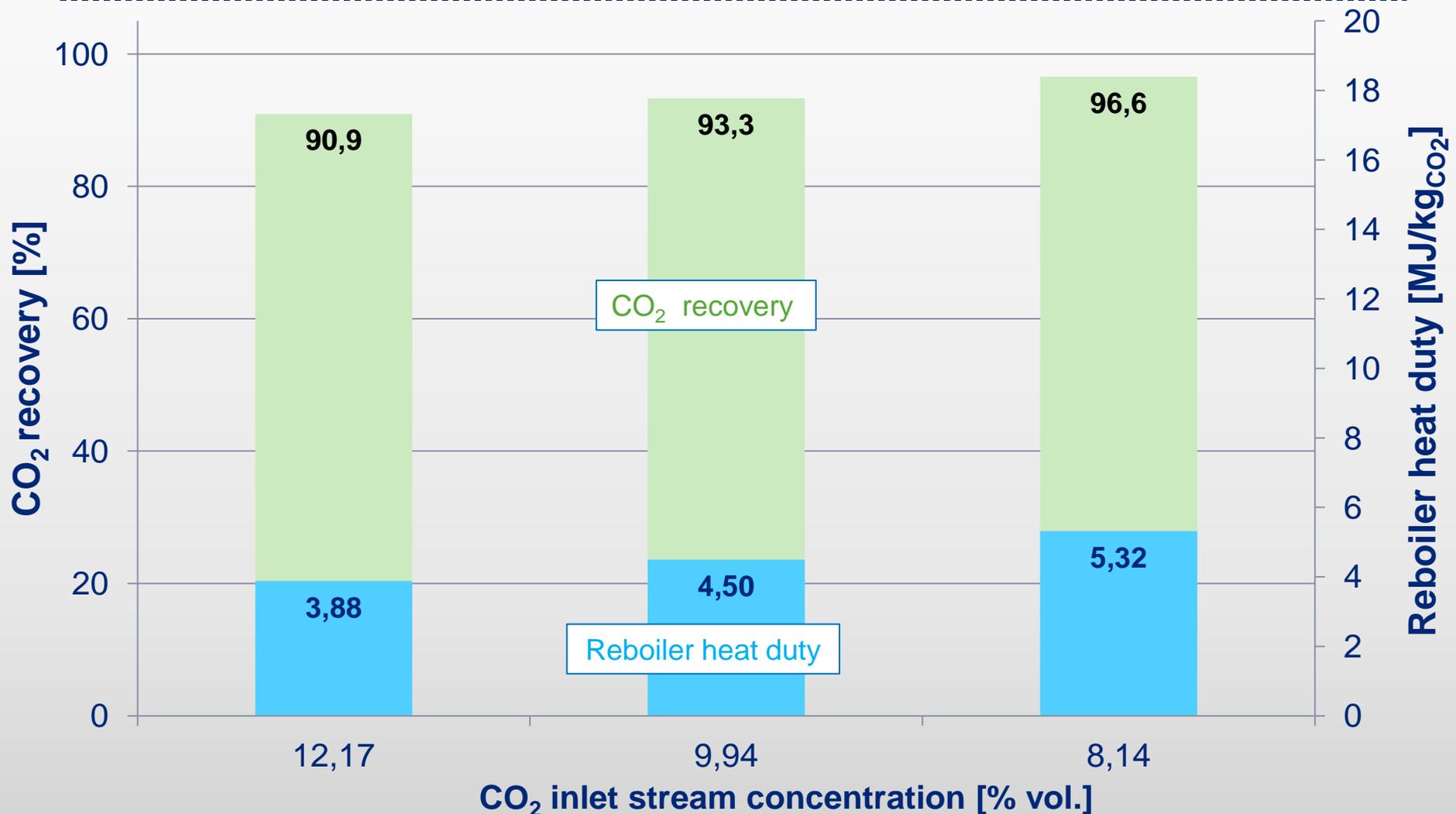
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Parameter	Description	Unit
CO <sub>2</sub> recovery	Amount of CO <sub>2</sub> captured divided by amount of CO <sub>2</sub> in flue gas  Typical values: 80 – 90	%
Reboiler heat duty	Energy delivered to the process divided by amount of CO <sub>2</sub> captured (gross values- with heat losses)  Typical values: 3 – 5	$\frac{\text{MJ}}{\text{kgCO}_2}$

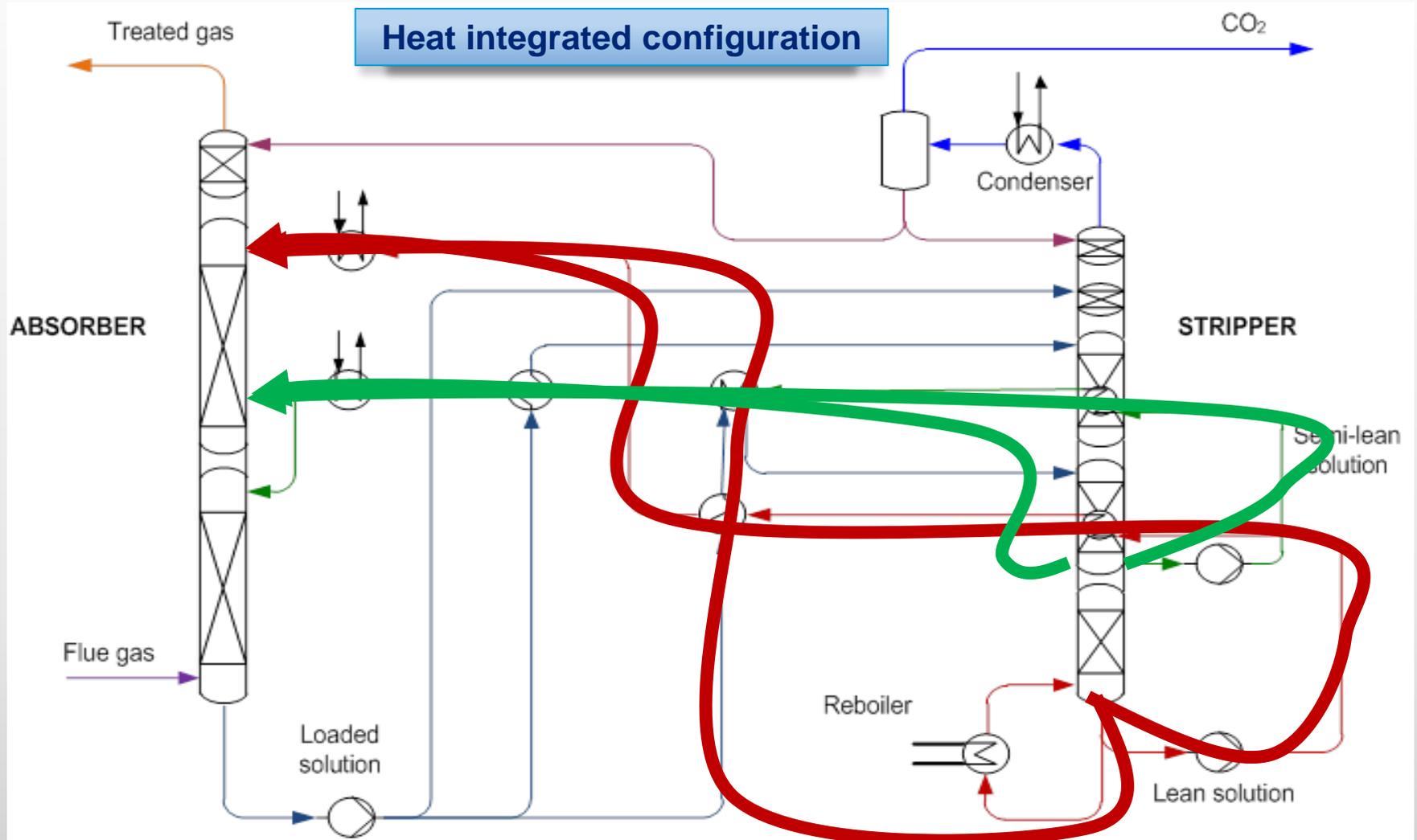
# Results and discussion– selected campaign



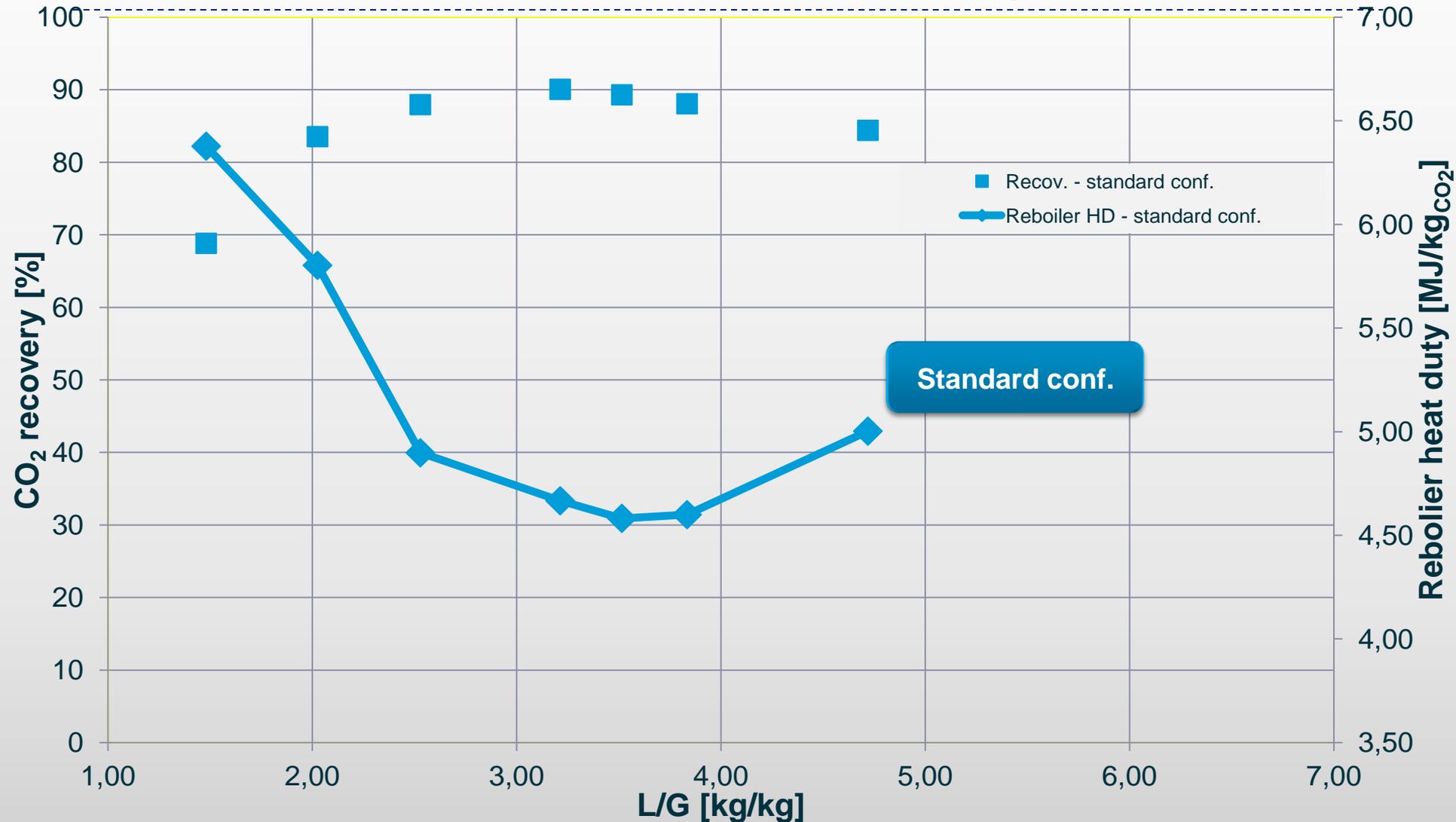
# Effect of CO<sub>2</sub> inlet stream concentration on CO<sub>2</sub> recovery and reboiler heat duty



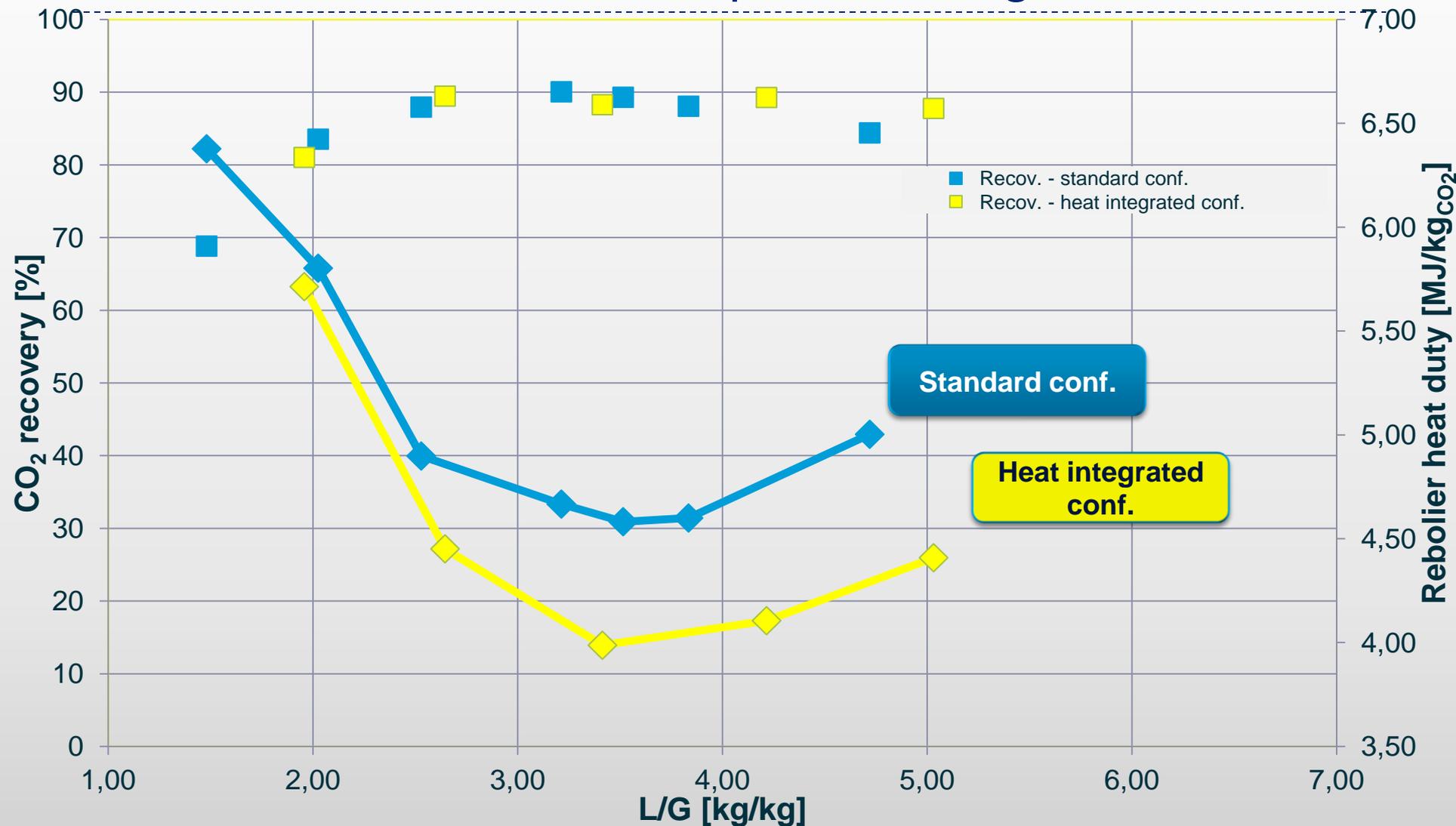
# Standard versus advanced configuration



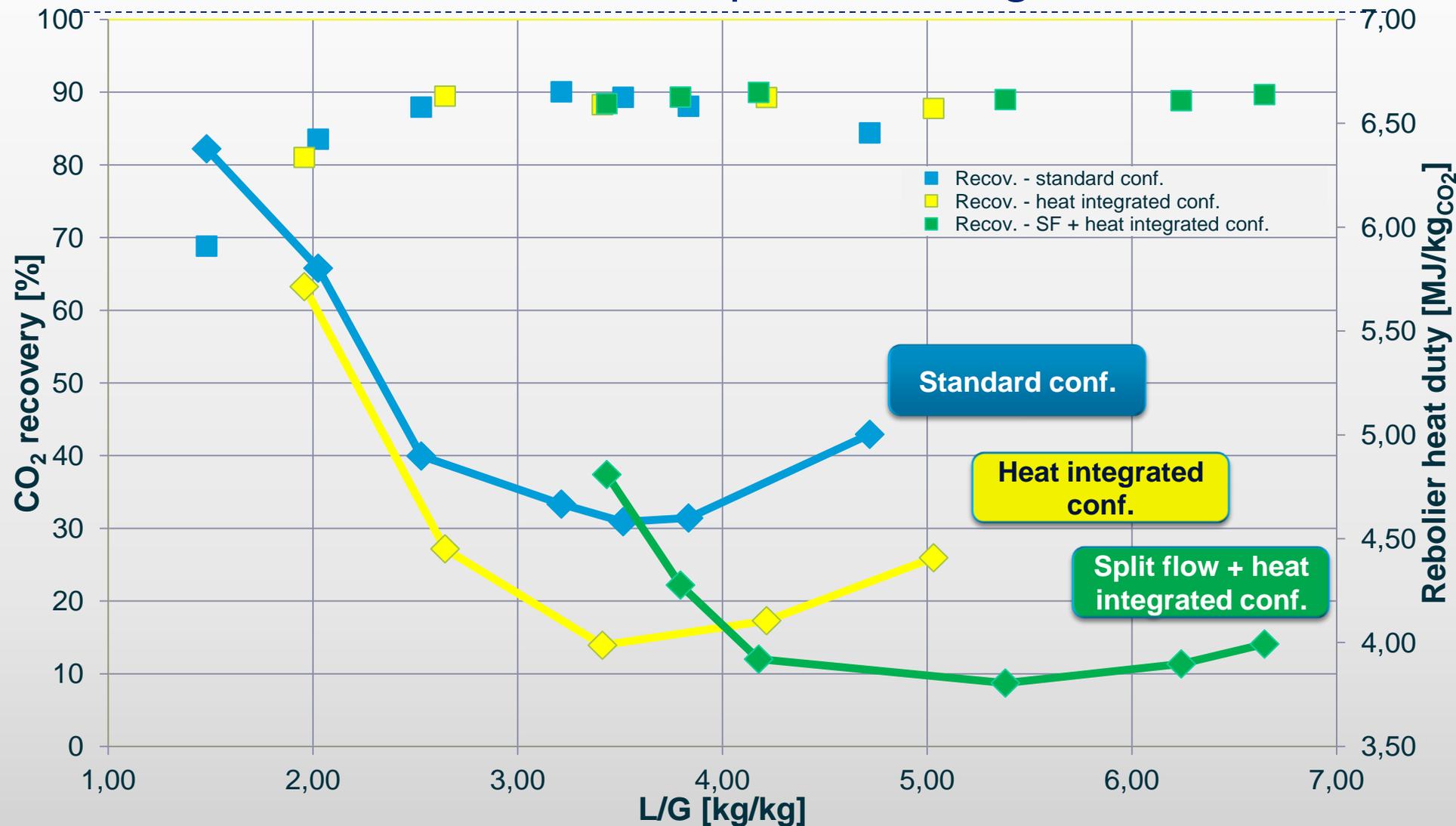
# Effect of L/G ratio on CO<sub>2</sub> recovery and reboiler heat duty - 30 wt% MEA (different process configurations)



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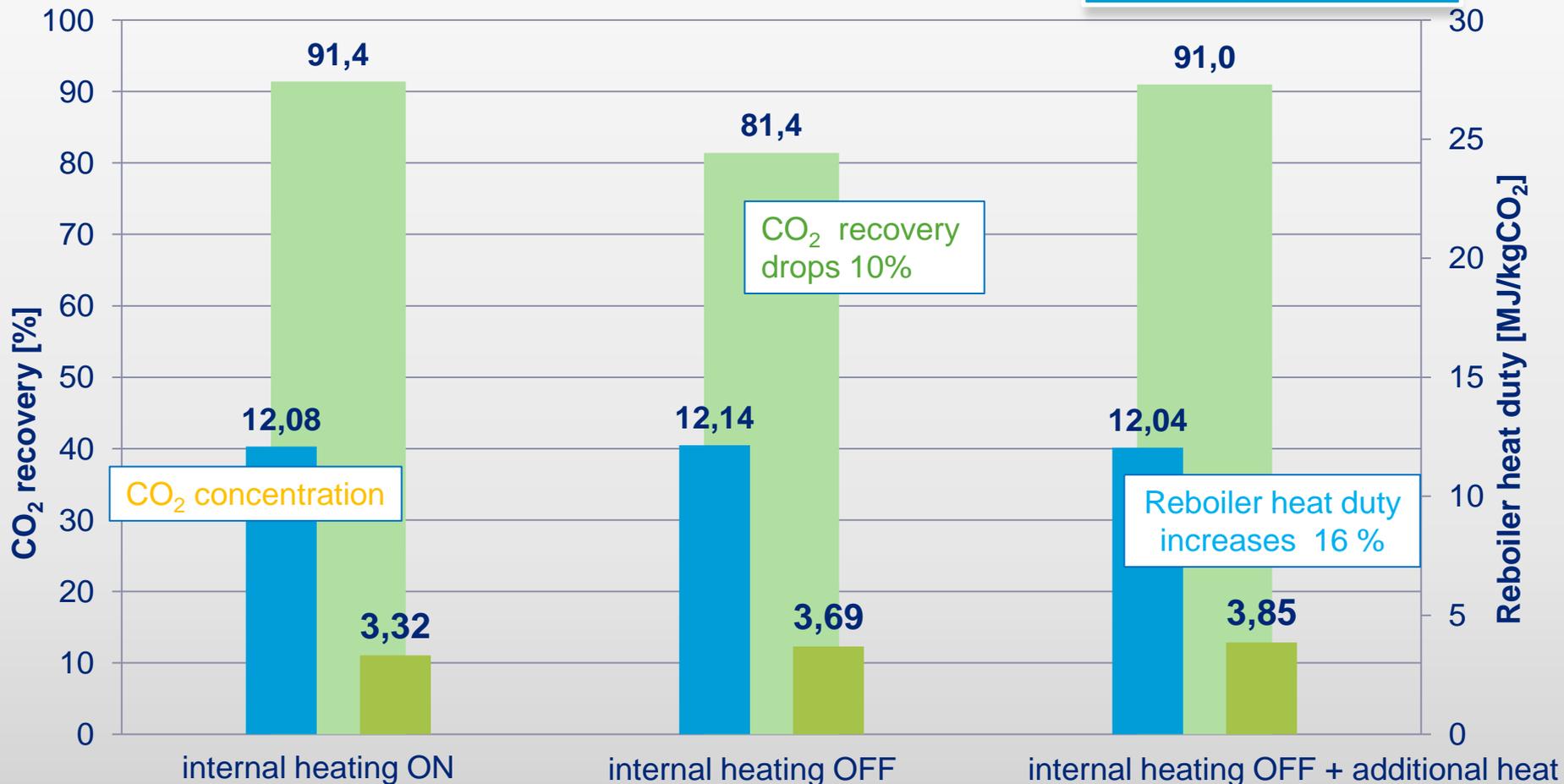


# Effect of L/G ratio on CO<sub>2</sub> recovery and reboiler heat duty - 30 wt% MEA (different process configurations)

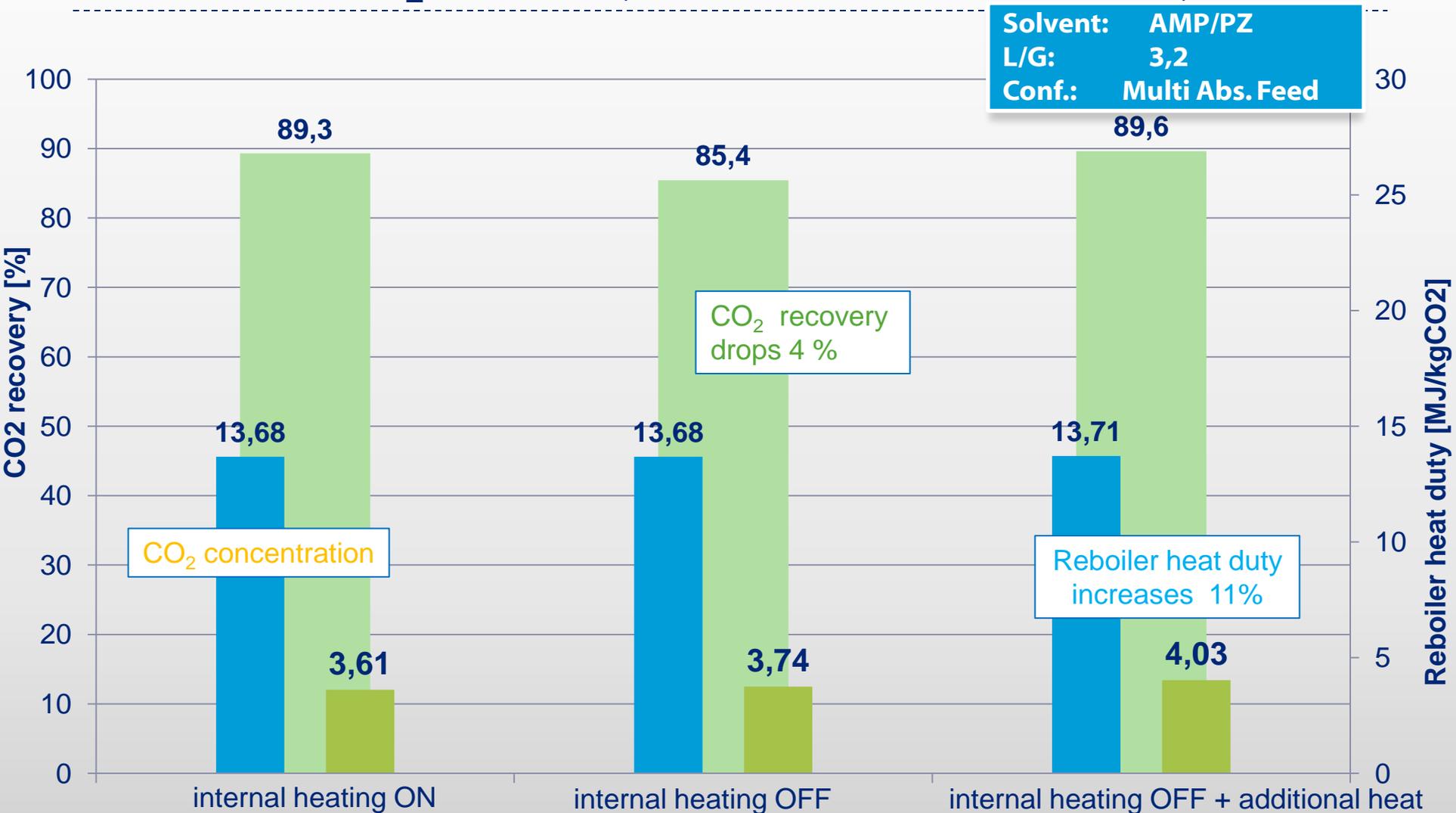


# Effect of stripper internal heating on CO<sub>2</sub> recovery and reboiler heat duty

Solvent: AMP/PZ  
L/G: 4,0  
Conf.: Split Flow



# Effect of stripper internal heating on CO<sub>2</sub> recovery and reboiler heat duty



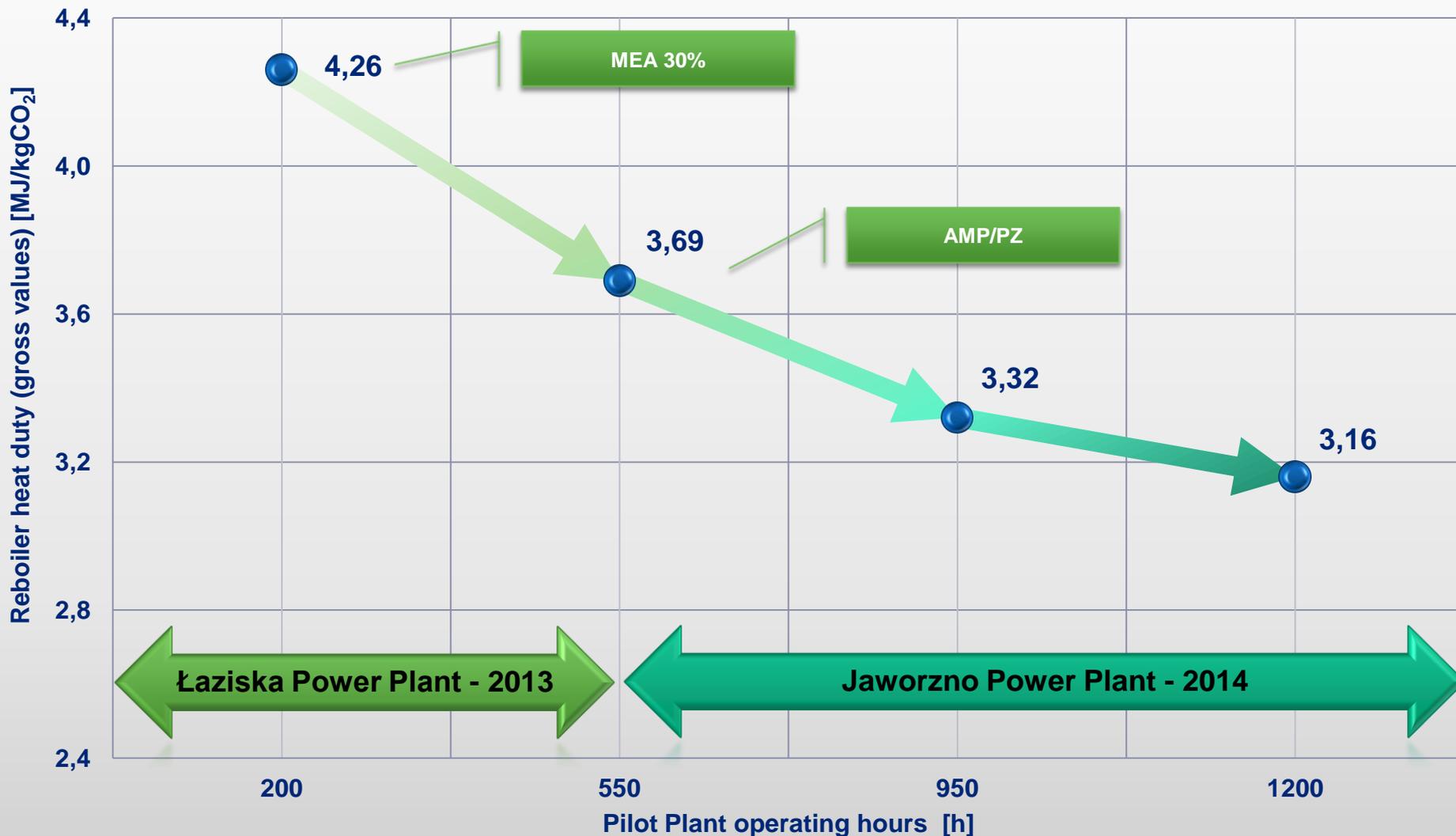
# Results - Stripper internal heating influence matrix

Internal heat integration influence tests				
Campaign	Solvent	L/G (kg/kg) ( Configuration)	Lean loading reduction [molCO <sub>2</sub> /mol amine]	Heat duty reduction [%]
J1	MEA	5,7 (Split-flow)	0,025	11,2
J5	AMP/PZ	5,7 (Split-flow)	0,050	14,0
J8	AMP/PZ	4,0 (Split-flow)	0,054	16,0
J10	AMP/PZ	3,17 (Multi absorber feed)	0,031	11,6
J13	Multicomponent	4,0 (Split-flow)	0,051	16,0

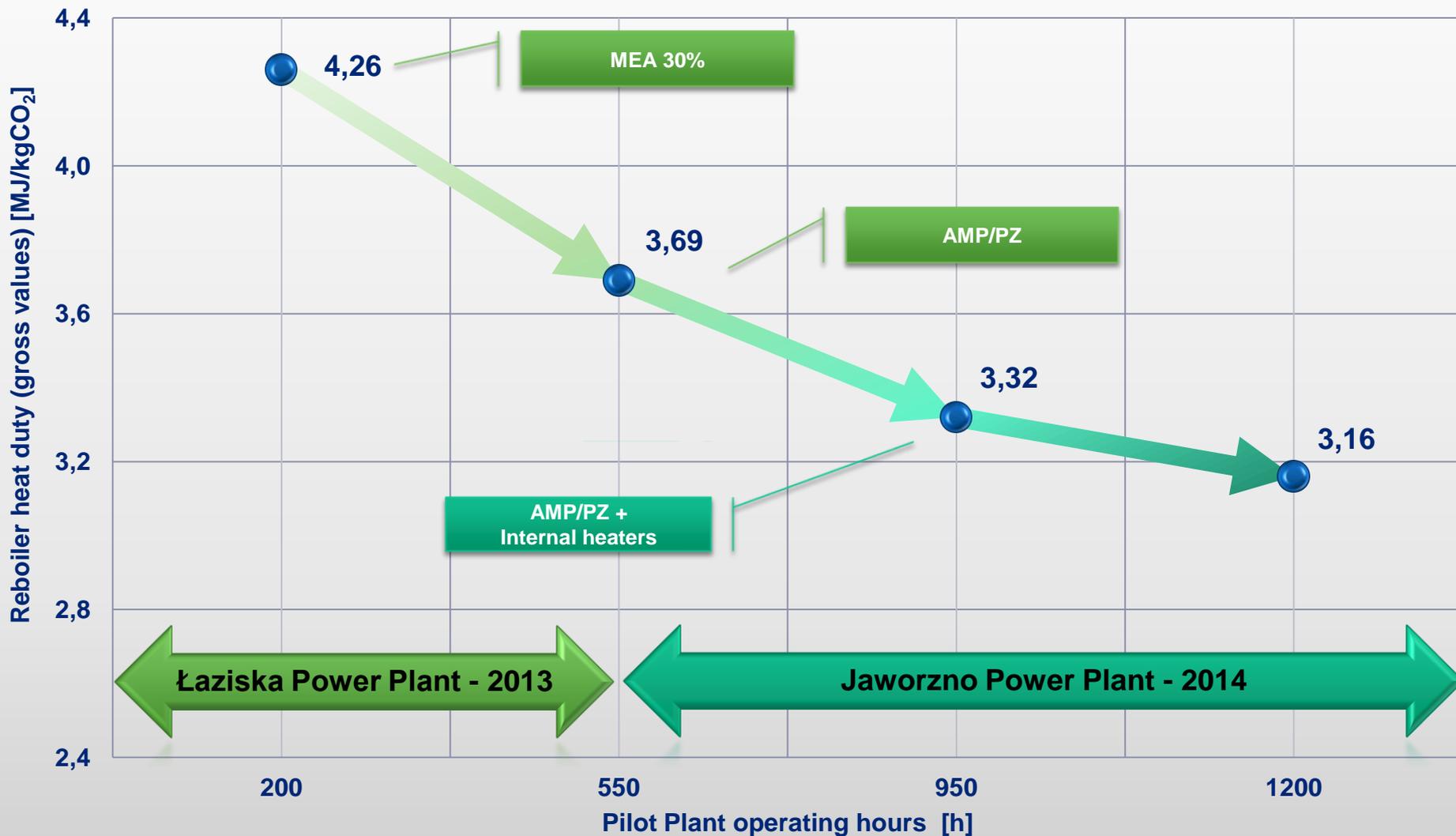
# Results – IChPW reboiler heat duty reduction road map (2013-2014)



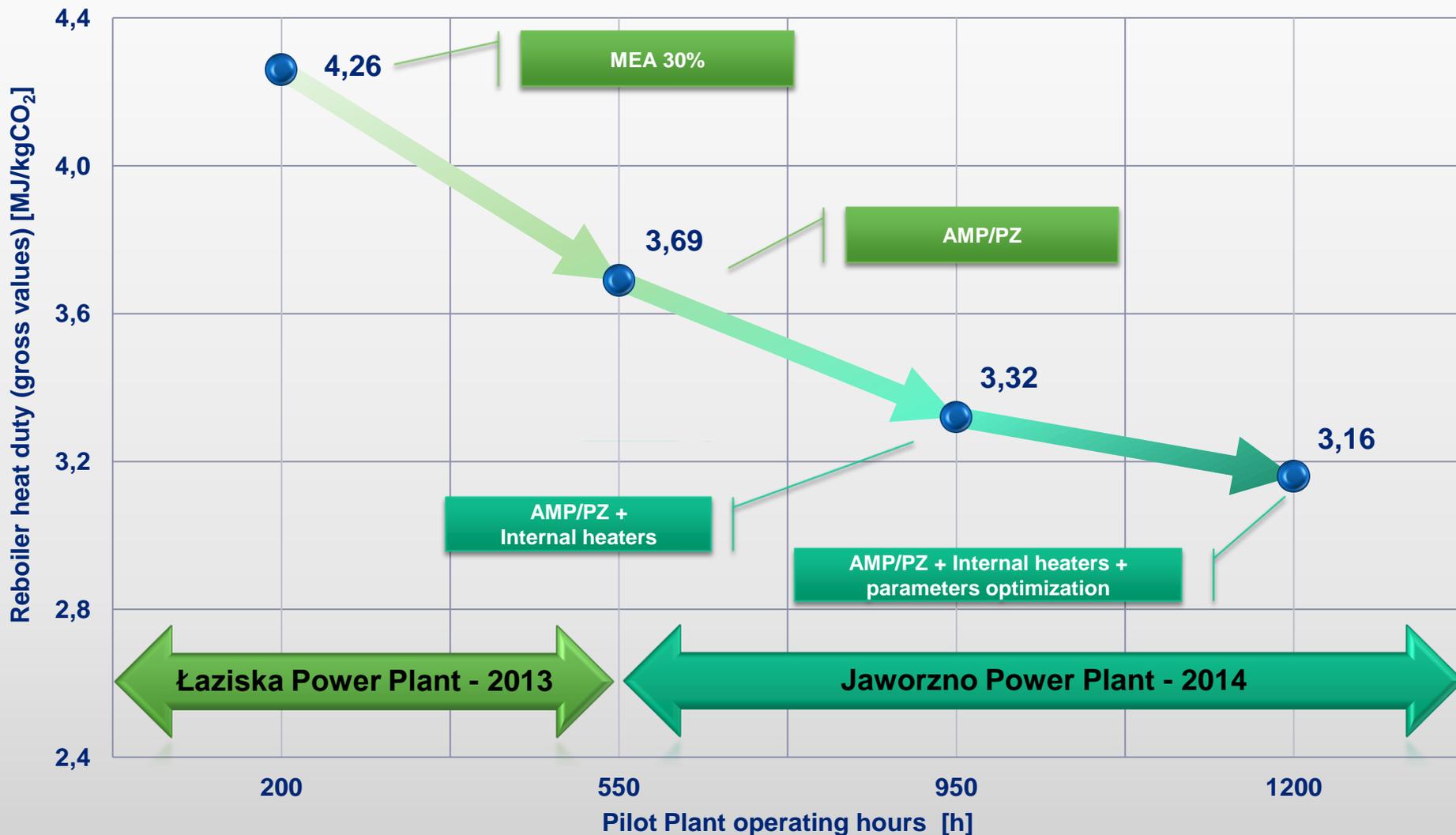
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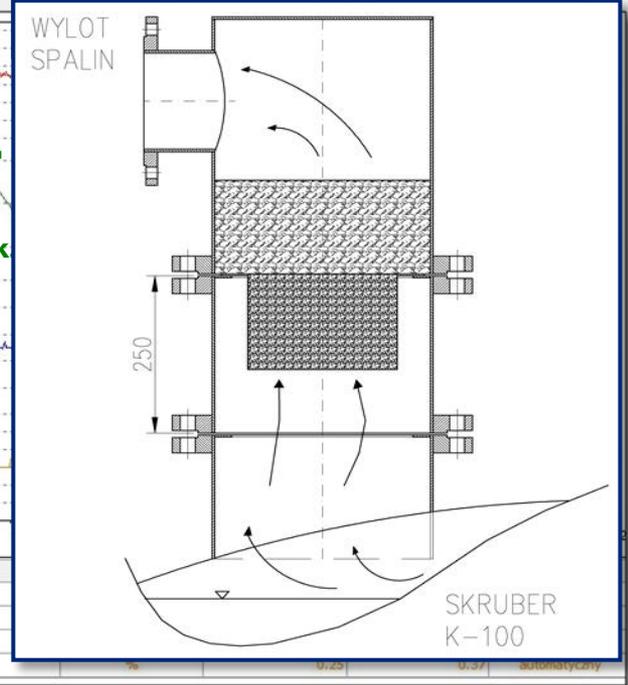
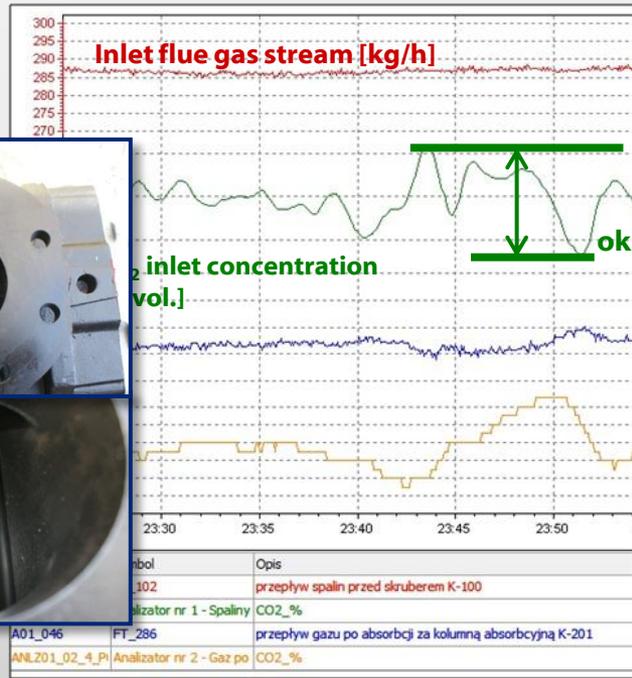


# Results – IChPW reboiler heat duty reduction road map (2013-2014)



# Results - The Pilot Plant operational difficulties

- CO<sub>2</sub> concentration fluctuations in inlet flue gas stream
- Inlet flue gases pipeline drainage
- Additional Venturi scrubber demister due to flue gases moisture
- Rapid corrosion in blower

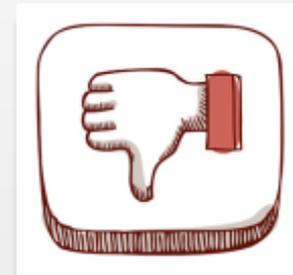


# Results - Pros and cons of the stream-splitting and internal heating

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- Higher CO<sub>2</sub> recovery
- Lower reboiler heat duty
- Lower OPEX due to reduced steam demand



- Higher CAPEX due to stripper modification, additional piping and equipment (pumps)

# Results - Simplified economic analysis

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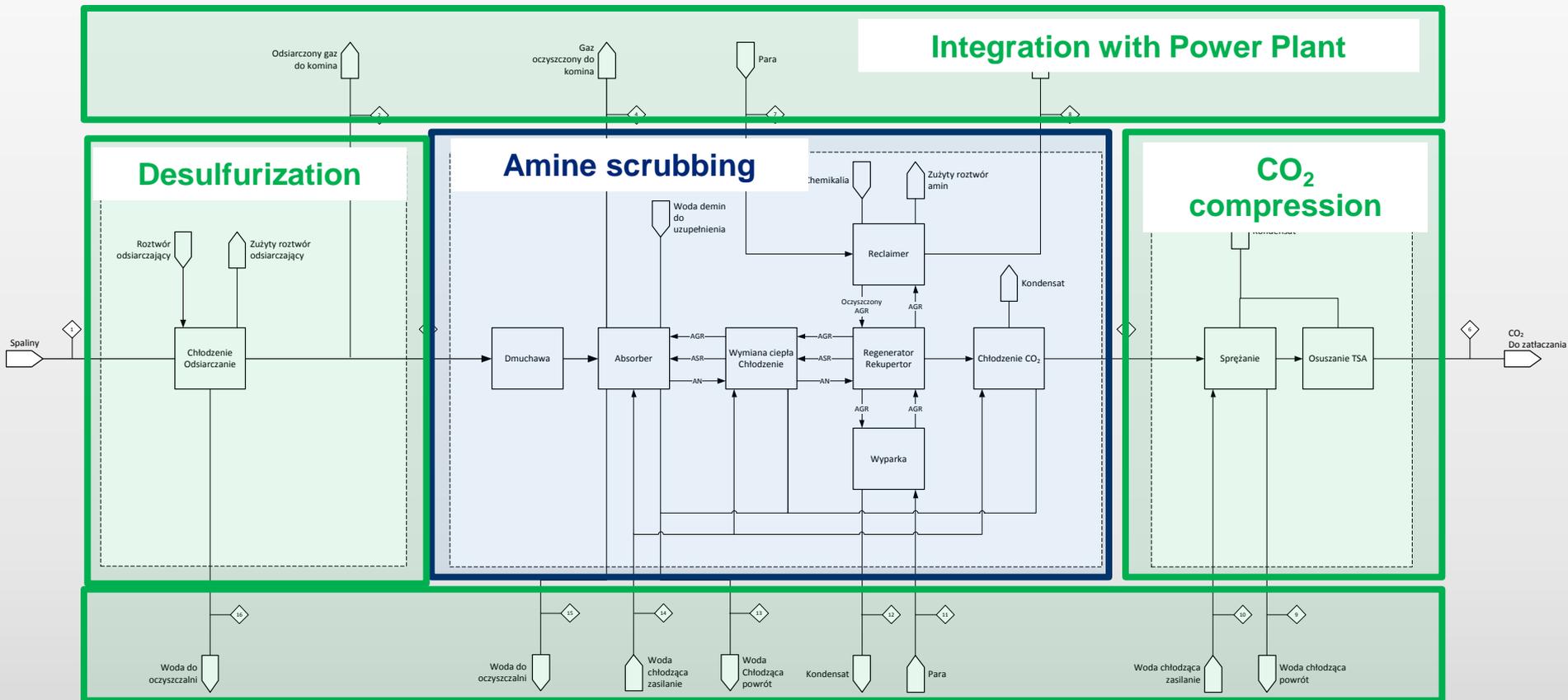
The full chain CCS demonstration plant, captures and stores the CO<sub>2</sub> from 250MW (175 tonnes of CO<sub>2</sub>/h) of net electricity generation unit, with 100km CO<sub>2</sub> pipeline, solvent: 30 wt% MEA, CO<sub>2</sub> recovery: ca. 90%

Standard configuration	Advanced configuration
CAPEX: PLN 978.2 M	CAPEX: PLN 1000.3 M
OPEX: PLN 159.7M / year	OPEX: PLN 155.7M / year

**How long will it take an advanced  
CCS plant to pay for itself?**

**CAPEX difference (PLN 22.1M) will be  
paid in less than 6 years!**

# Block diagram of demo CCS PLANT



Demo Plant Capacity = 175 tonnes of CO<sub>2</sub>/h

# The Pilot Plant research summary

- The pilot plant campaigns successfully demonstrated reliable operation allowing the removal of over 80 000 kg of CO<sub>2</sub> from real flue gas (2000h).
- The energy requirement for solvent regeneration was found about 3,16 MJ/kgco<sub>2</sub> (gross value) with 90% CO<sub>2</sub> removal efficiency .
- Experimental data was presented to verify effectiveness of the modifications which were up to this time presented mainly through modelling.
- Presented modifications resulted in an increase of CO<sub>2</sub> recovery ranging from 4% to 16% while reducing the reboiler heat duty up to 16%.

Parameter	Value
Number of campaigns	29
Number of tests	360
Operation time	2000 h
CO <sub>2</sub> removed	approx. 80 000 kg



# New project – CO<sub>2</sub> methanation system for electricity storage through SNG production

## Intermittent Renewable Energy

Wind turbine



Solar PV

## Water electrolysis

H<sub>2</sub>O

Electrolyser

Surplus

Oxycombustion O<sub>2</sub>

H<sub>2</sub>

Modular structured reactor  
CO<sub>2</sub> hydrogenation

SNG

H<sub>2</sub>O

## Several markets

Natural gas network

Domestic uses

Fuels  
Transportation

Chemical market

Existing infrastructure

## CO<sub>2</sub> Capture



Coal power plant

H<sub>2</sub>O

### Project Partners:

[TAURON Wytwarzanie](#)  
[CEA](#)  
[ATMOSTAT](#)  
[AGH University of Science and Technology](#)  
[Institute for Chemical Processing of Coal](#)  
[RAFAKO S.A.](#)  
[West Technology & Trading Polska Sp. z o.o.](#)

# Cooperation opportunities in low carbon energy

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- Pre and post combustion pilot plant tests
- Biomass gasification pilot plant tests
- Implementing post combustion CCS in other than Energy Sector
- Deep cleaning of a captured CO<sub>2</sub> stream (from ppm to ppb)
- Utilisation of captured CO<sub>2</sub> as a feedstock
- Geological storage with enhanced gas recovery

## STRATEGIC RESEARCH PROGRAM – ADVANCED TECHNOLOGIES FOR ENERGY GENERATION

TASK No. 1 – „Advanced technologies for energy generation: Development of a technology for highly efficient zero-emission coal-fired power units integrated with CO<sub>2</sub> capture”

Project co-financed by the National Centre of Research and Development in the framework of Contract SP/E/1/67484/10, dated 05 May 2010r.

### Research team:

- dr inż. Aleksander Sobolewski
- dr inż. Krzysztof Dreszer
- mgr inż. Józef Popowicz
- dr inż. Lucyna Więclaw Solny
- mgr inż. Adam Tatarczuk
- mgr inż. Marcin Stec
- mgr inż. Tomasz Szczypiński
- mgr inż. Piotr Kolon
- mgr inż. Dariusz Śpiewak
- mgr inż. Tomasz Spietz
- mgr inż. Aleksander Krótki
- mgr inż. Andrzej Wilk



### Industrial partners team:

- dr inż. Stanisław Tokarski – TAURON Polska Energia SA
- mgr inż. Janusz Tchórz – TAURON Wytwarzanie SA
- mgr inż. Sławomir Dziaduła – TAURON Wytwarzanie SA
- inż. Stanisław Gruszka – TAURON Wytwarzanie SA
- mgr inż. Jerzy Janikowski – TAURON Polska Energia SA
- mgr inż. Janusz Zdeb – TAURON Wytwarzanie SA



### Project manager:

- dr hab. inż. Marek Ściążko, prof. nadzw.

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We invite you to take a virtual tour of the Clean Coal Technology Centre:

<http://ichpw.wkraj.pl/#/65563/0>

and to watch the movie about the Institute:

[http://koala.ichpw.zabrze.pl/video/Institute for Chemical Processing of Coal.mp4](http://koala.ichpw.zabrze.pl/video/Institute%20for%20Chemical%20Processing%20of%20Coal.mp4)



*Tauron's Pilot Plant - That's one small step for [an] engineer,  
one giant leap for Poles.*

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Thank you for attention