INSTITUTE FOR CHEMICAL PROCESSING OF COAL

1955-2015

3rd Post Combustion Capture Conference

9th September 2015

Pilot plant results for advanced CO_2 capture process using AMP/PZ solvent at Tauron's coal-fired Power Plant

Adam Tatarczuk, Institute for Chemical Processing of Coal, Poland
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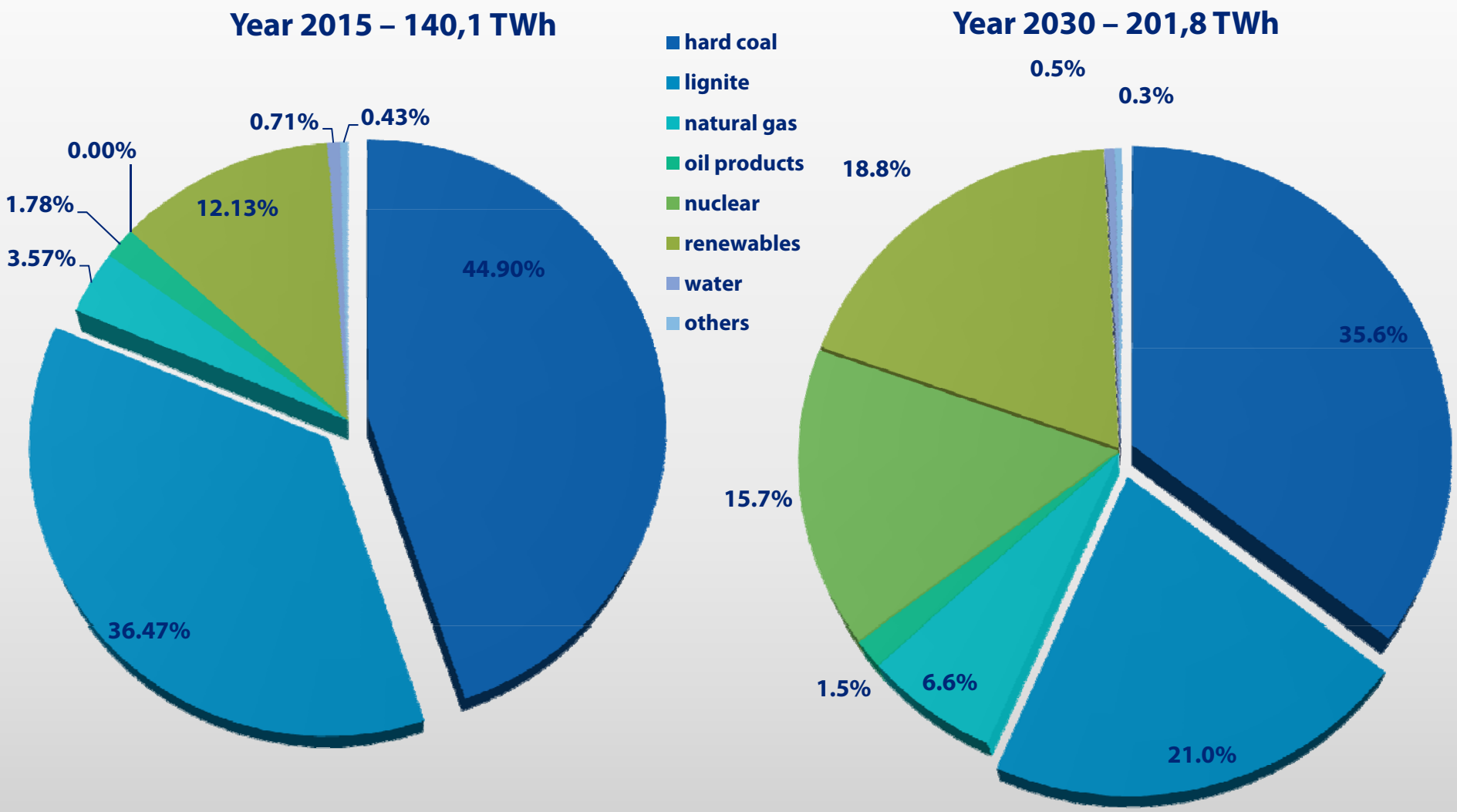
Fuel mix in power generation - Poland

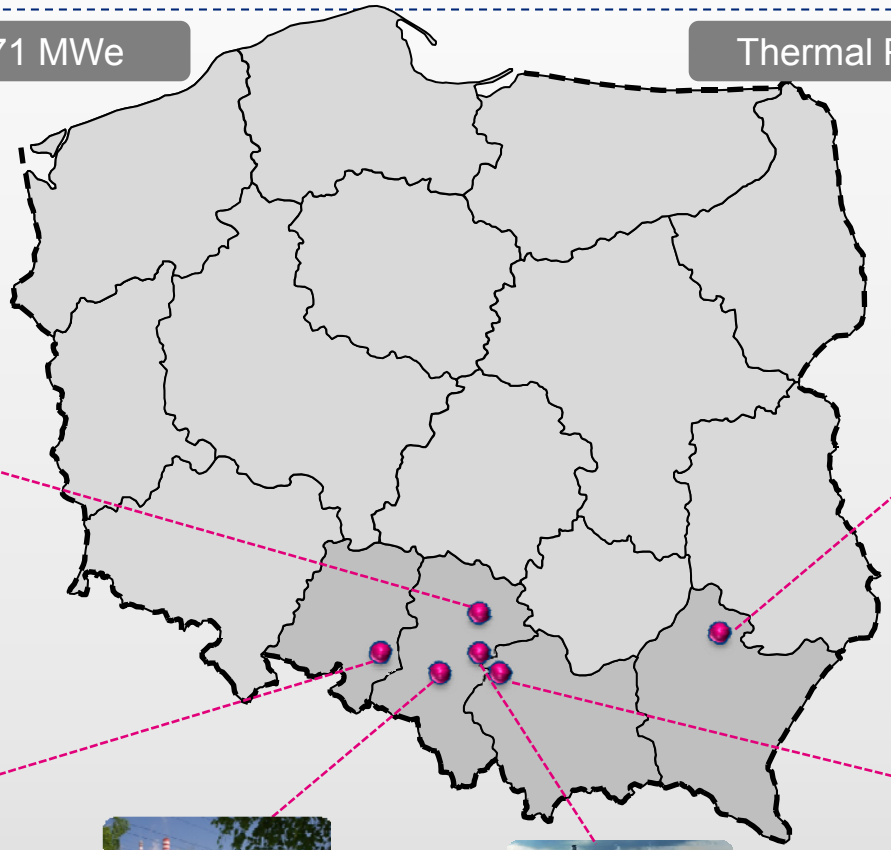


* „Energy Policy of Poland until 2030" (Ministry of Economy2009)

About TAURON Group – power plants

Electric Power– 4 671 MWe

Thermal Power– 1 667,1 MWt



Łagisza Power Plant

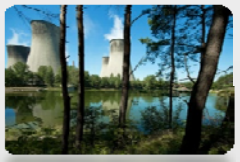
- 850 MWe
- 343,4 MWt

Stalowa Wola Power Plant

- 330 MWe
- 465,9 MWt

Blachownia Power Plant

- 165 MWe
- 256 MWt



Siersza Power Plant

- 666 MWe
- 36,5 MWt

Łaziska Power Plant

- 1 155 MWe
- 196 MWt

Jaworzno Power Plant

- 1 535 MWe
- 369,3 MWt

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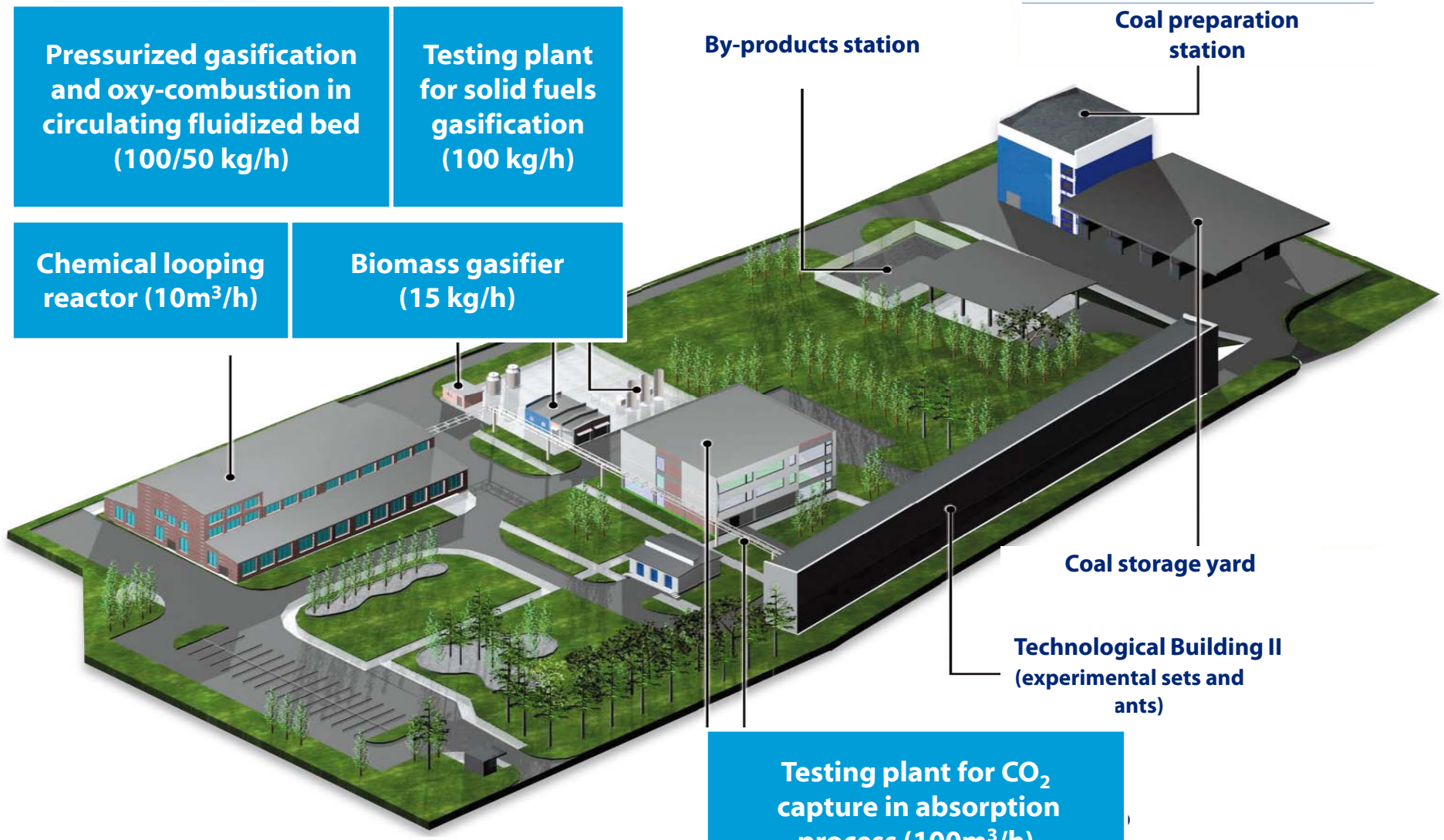
Institute for Chemical Processing of Coal, Zabrze, Poland

Clean Coal Technology Centre

Institute for Chemical Processing of Coal

Clean Coal Technology Centre in Zabrze (Upper Silesia, Poland)



General information

- **Project name:**
  Development of a technology for highly efficient zero-emission coal-fired power units integrated with CO_2 capture.

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

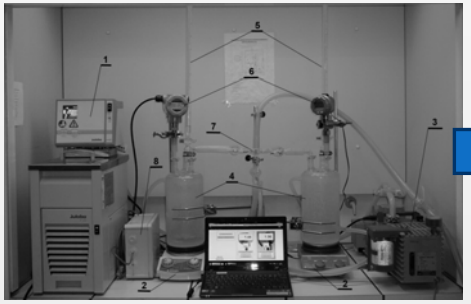
- **Principal:**
  National Research and Development Center (Poland)

- **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_2 capture process scale-up strategy

Experimental apparatus of CO_2 absorption kinetics and equilibriums in amine blends (2010)



Lab stand for CO_2 capture process – 5 m^3/h (2011)

PDU for CO_2 capture process – 100 m^3/h (2012-IChPW Zabrze)

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

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

Column diameter:	300 mm
Column height:	15,0 m
Number of devices:	40
Measurements:	180 points
Solvent:	amines solution
Solvent stream:	up to1800 dm^3/h
Gas stream:	up to 200 m^3_n/h
Tested gas:	Flue gas from hard–coal boiler

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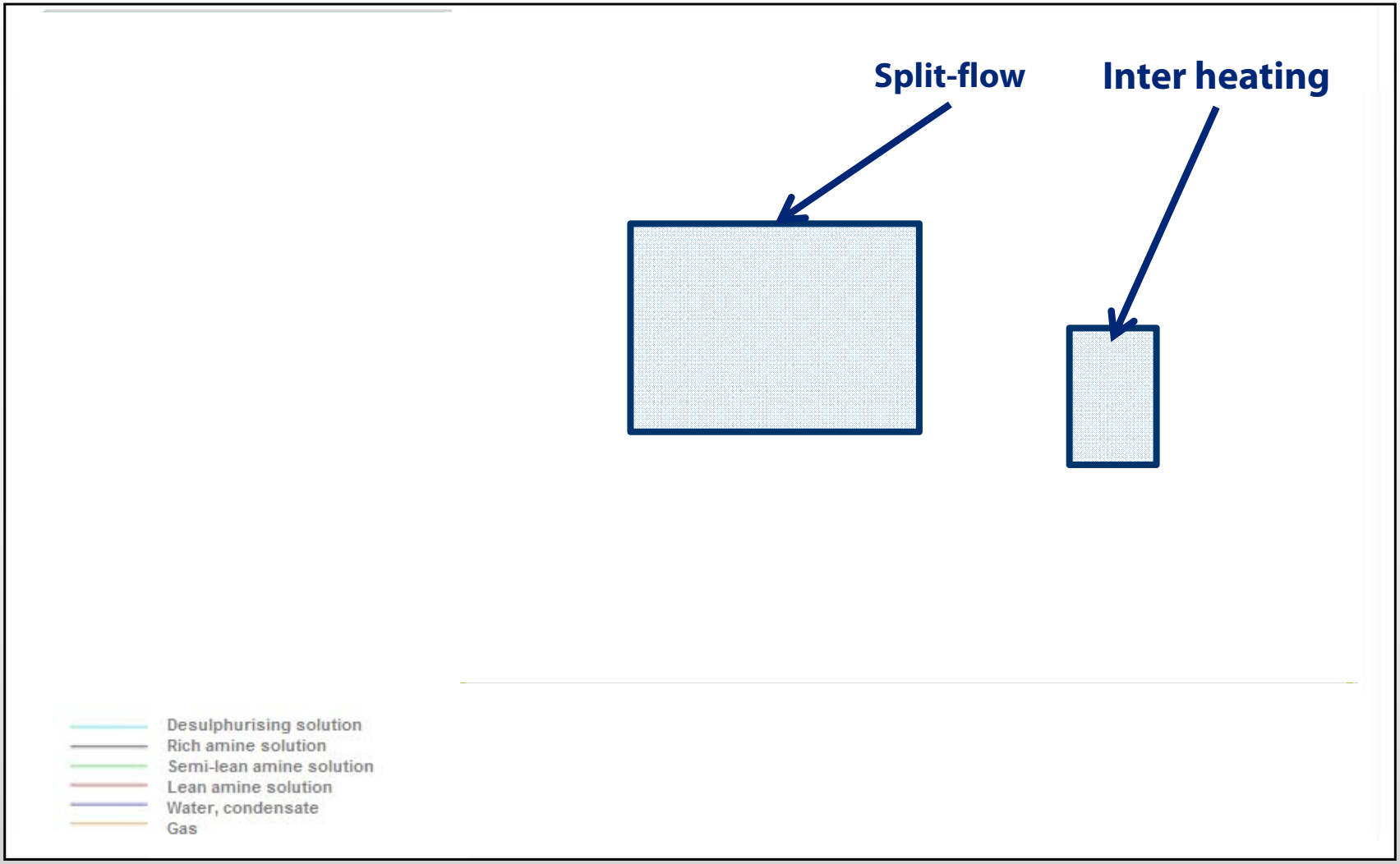
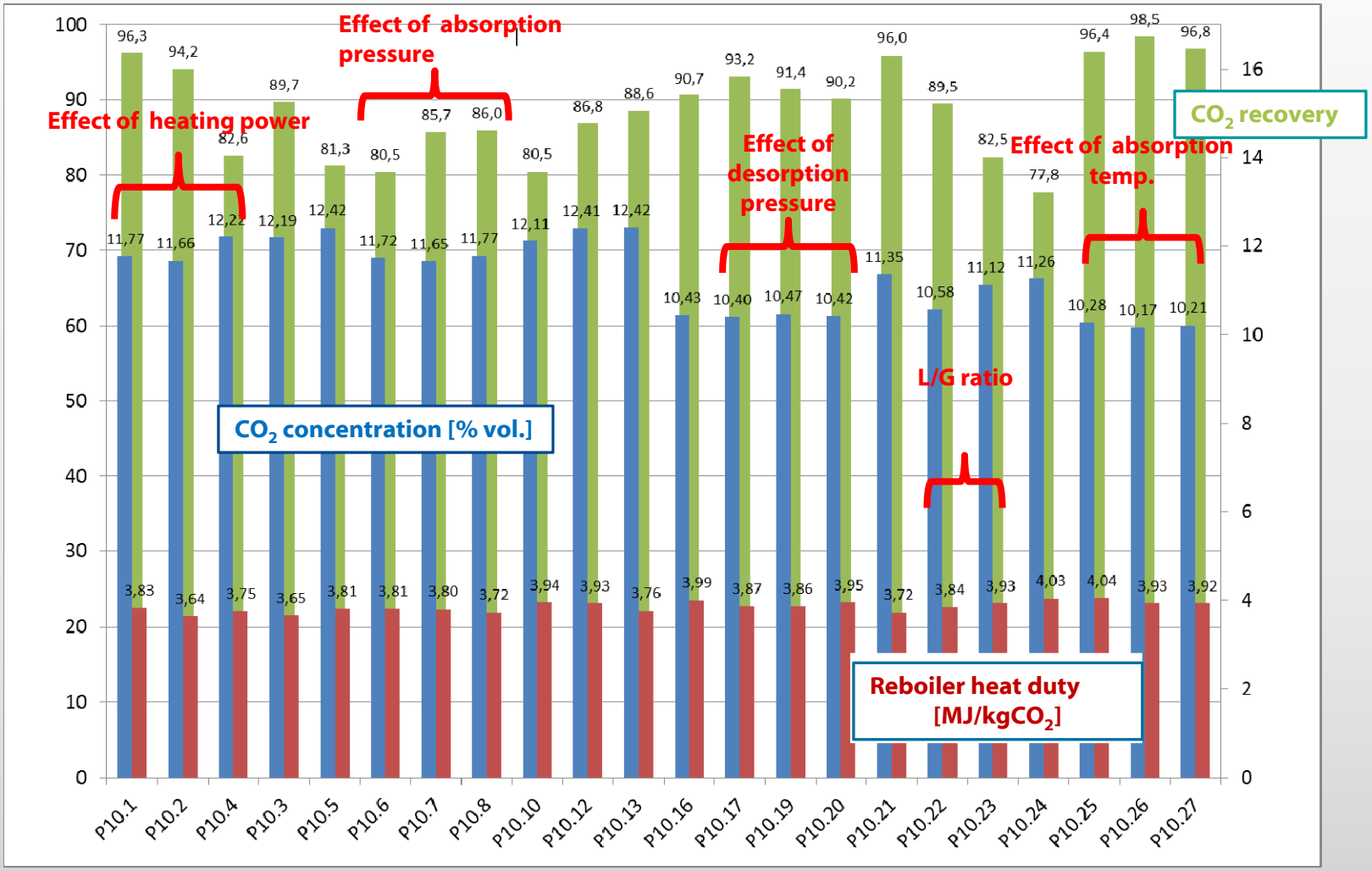
The Pilot Plant simplified flow diagram



Results and discussion
Nomenclature

Parameter	Description	Unit
CO_2 recovery	Amount of CO_2 captured divided by amount of CO_2 in flue gas Typical values: 80 – 90	%
Reboiler heat duty	Energy delivered to the process divided by amount of CO_2 captured Typical values: 3 – 5	$\frac{\mathrm{MJ}}{\mathrm{kg}_{\mathrm{CO}_2}}$

Results and discussion– selected campaign



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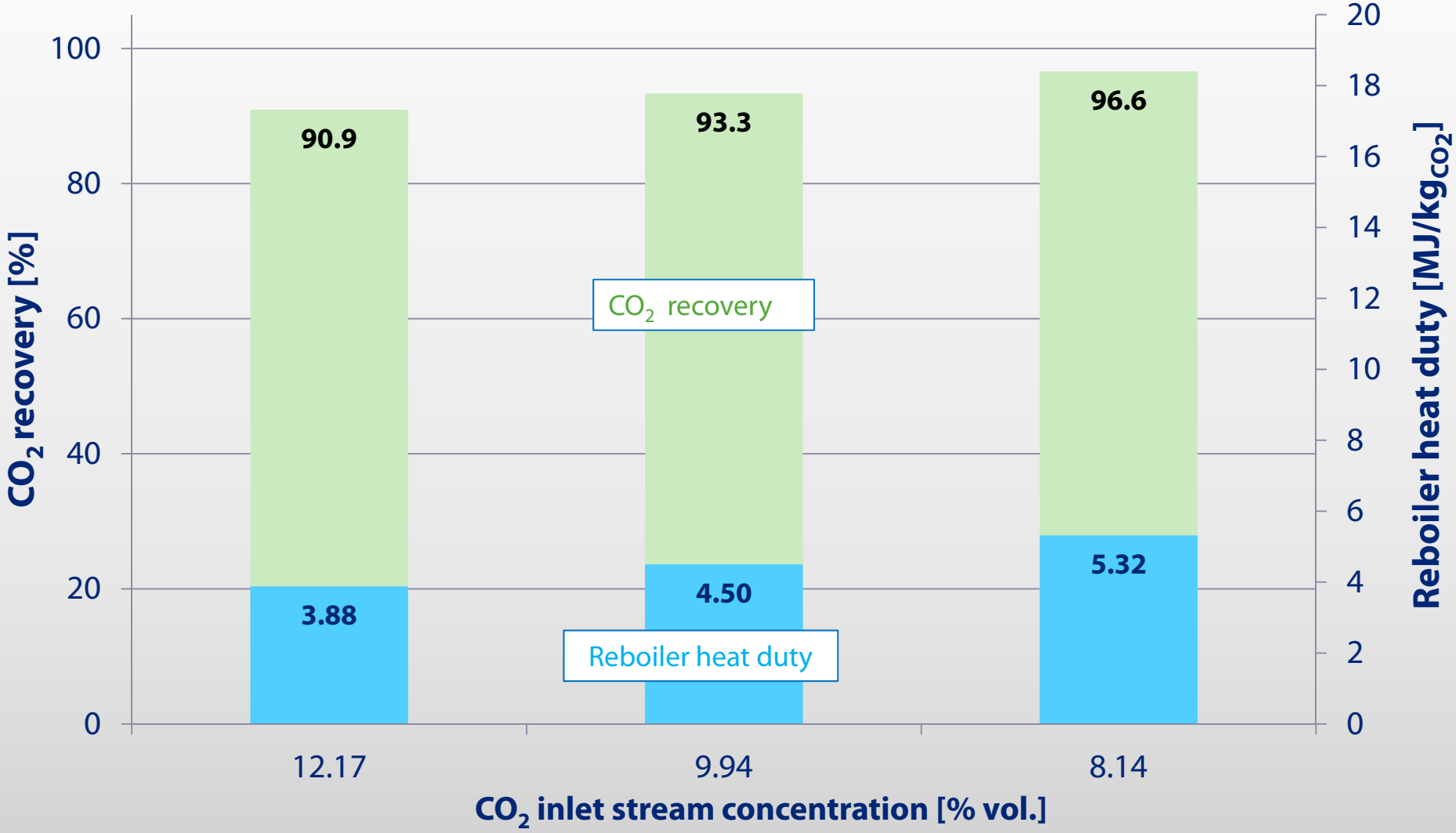
Effect of CO_2 inlet stream concentration on CO_2 recovery and reboiler heat duty



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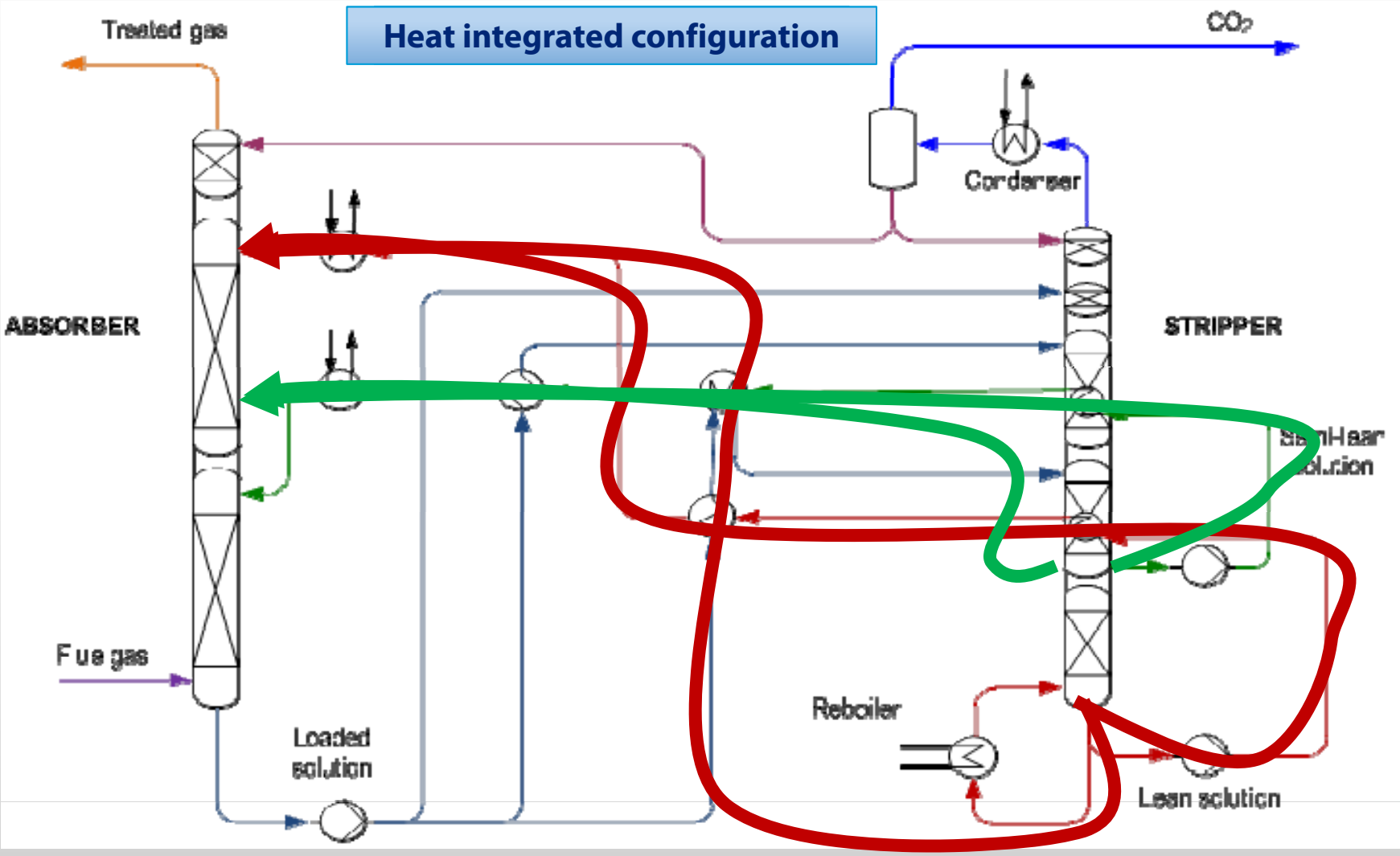
Standard versus advanced configuration



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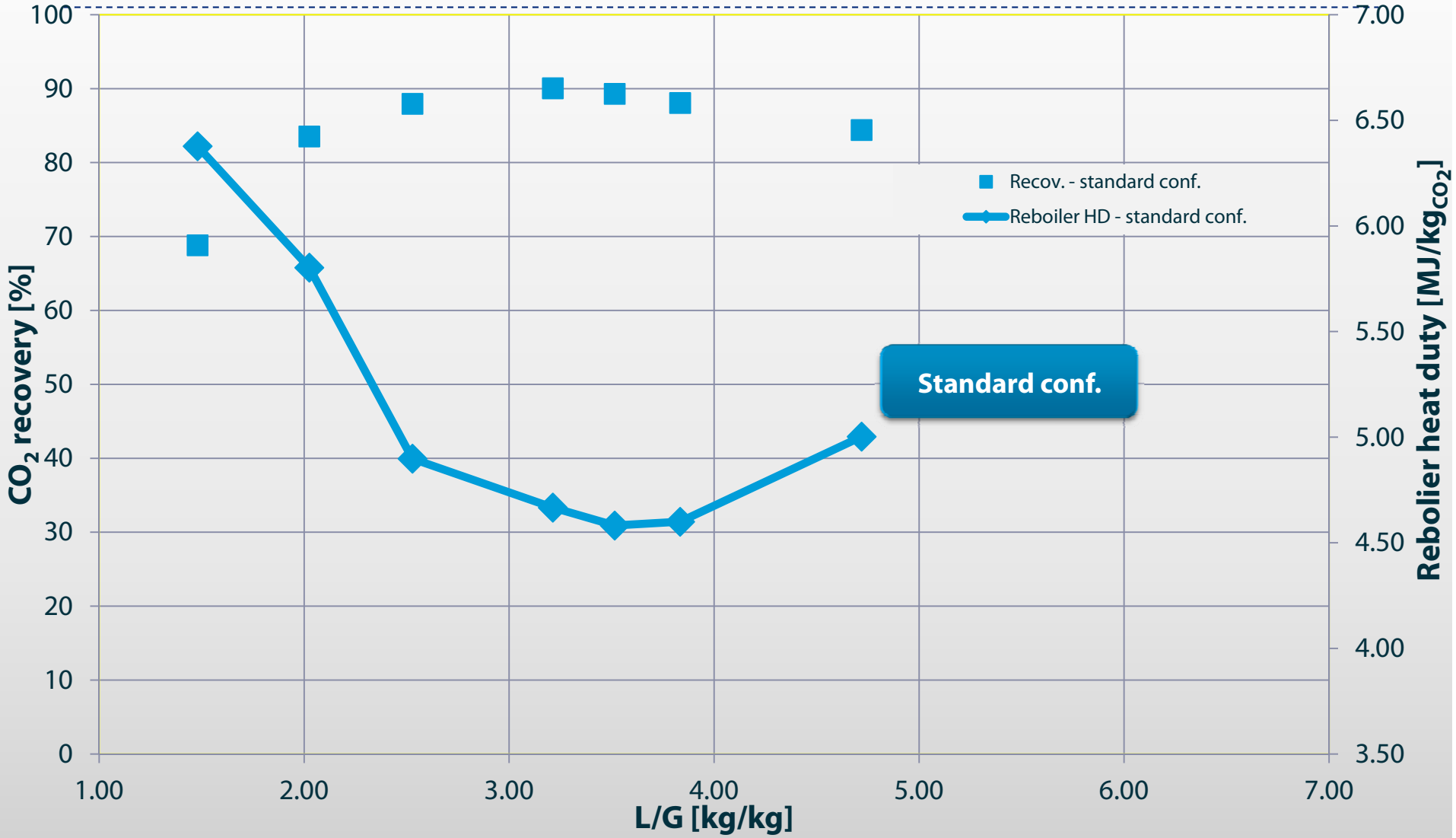
Effect of L/G ratio on CO_2 recovery and reboiler heat duty - 30 wt% MEA (different process configurations)



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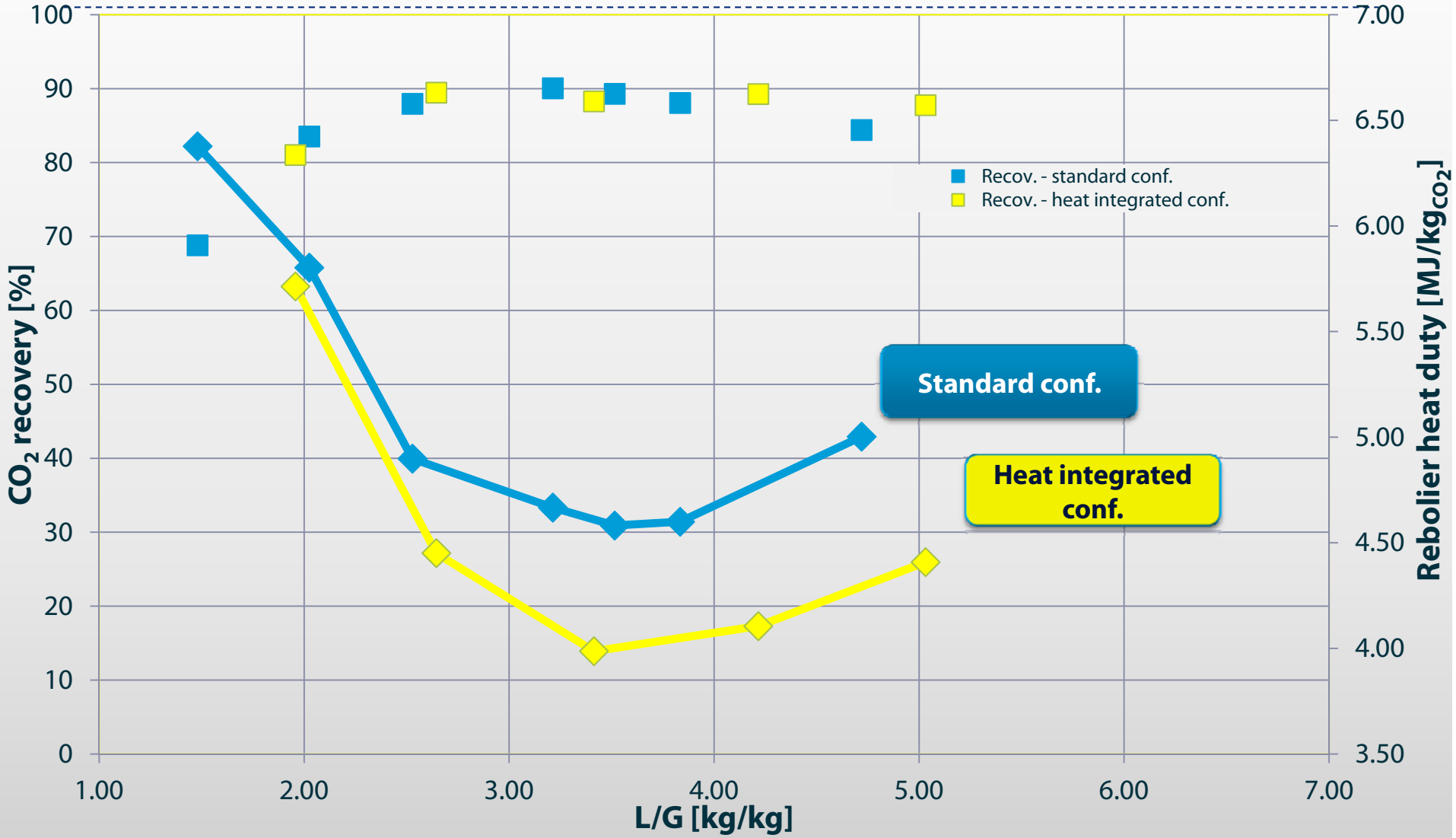

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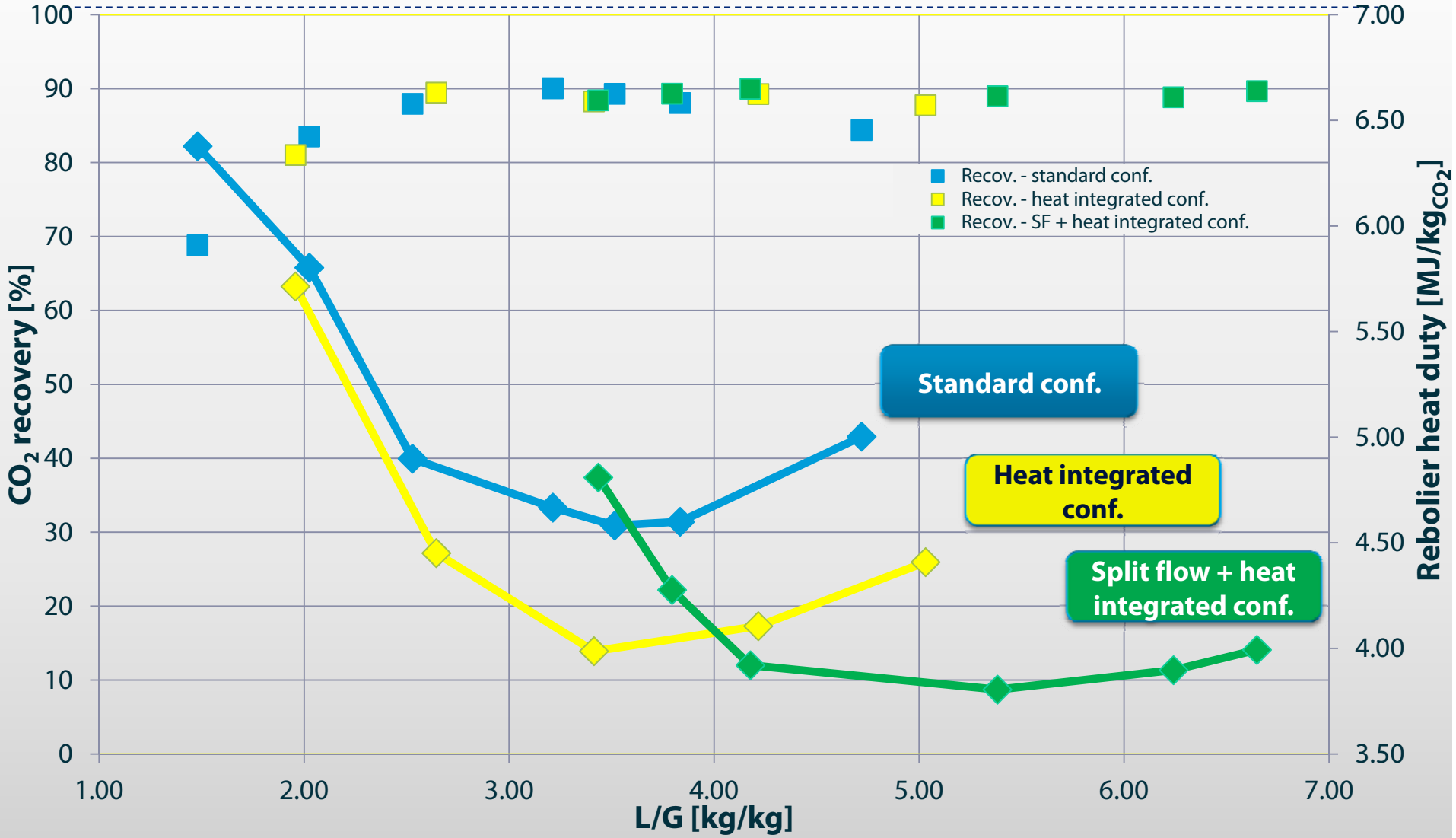

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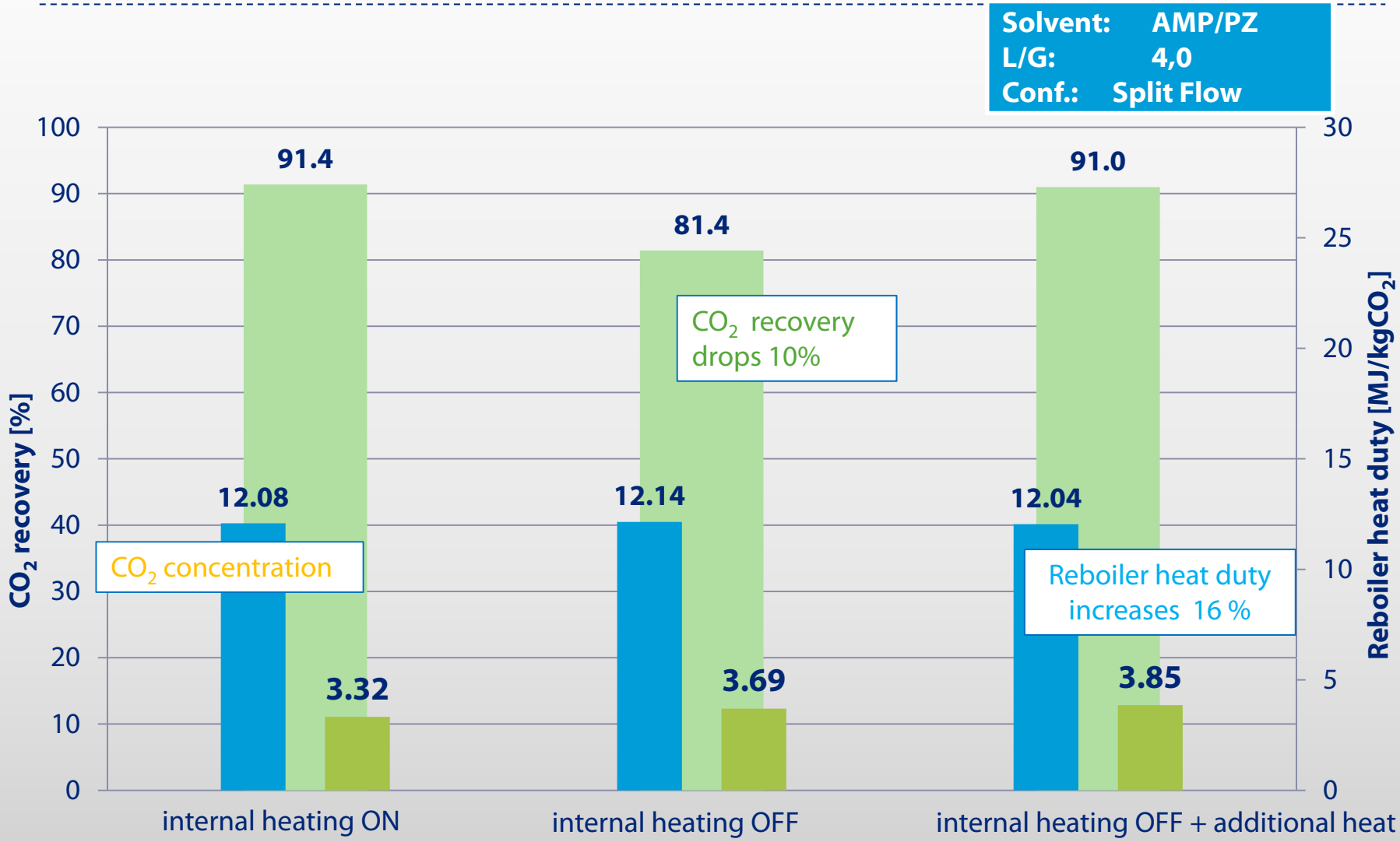
Effect of stripper internal heating on CO_2 recovery and reboiler heat duty



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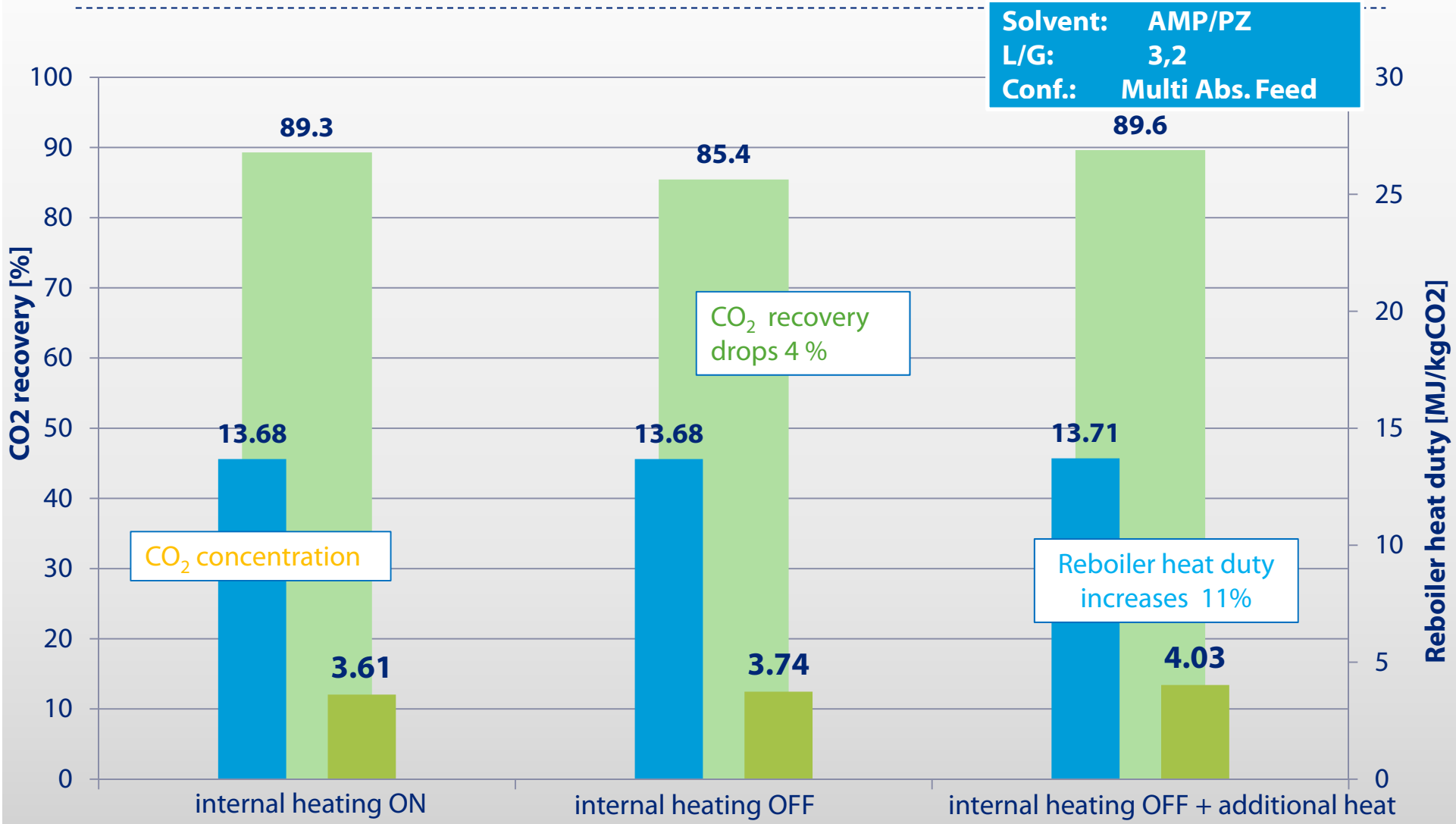
Effect of stripper internal heating on CO_2 recovery and reboiler heat duty



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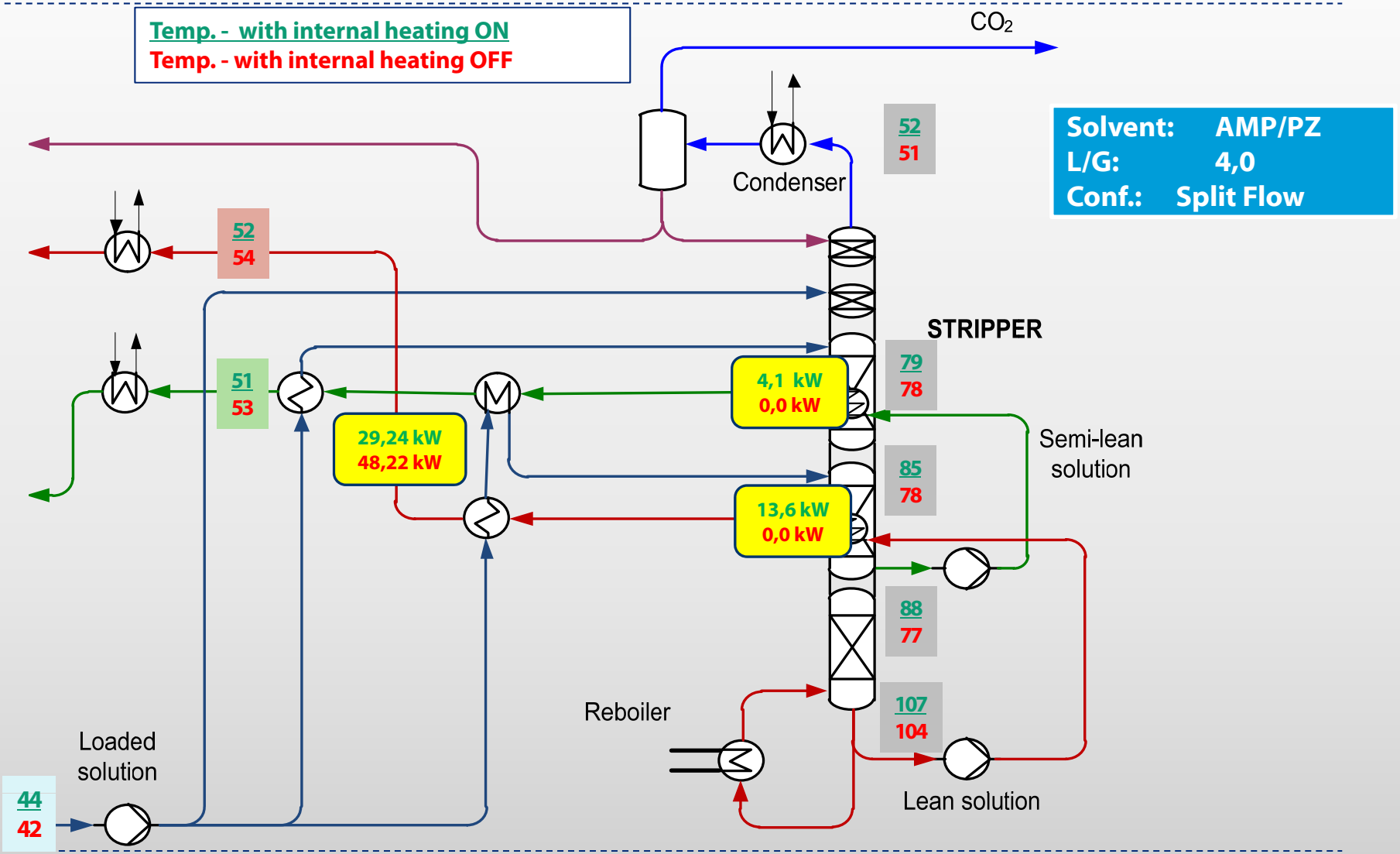
Results - stripper internal heating temperature profile



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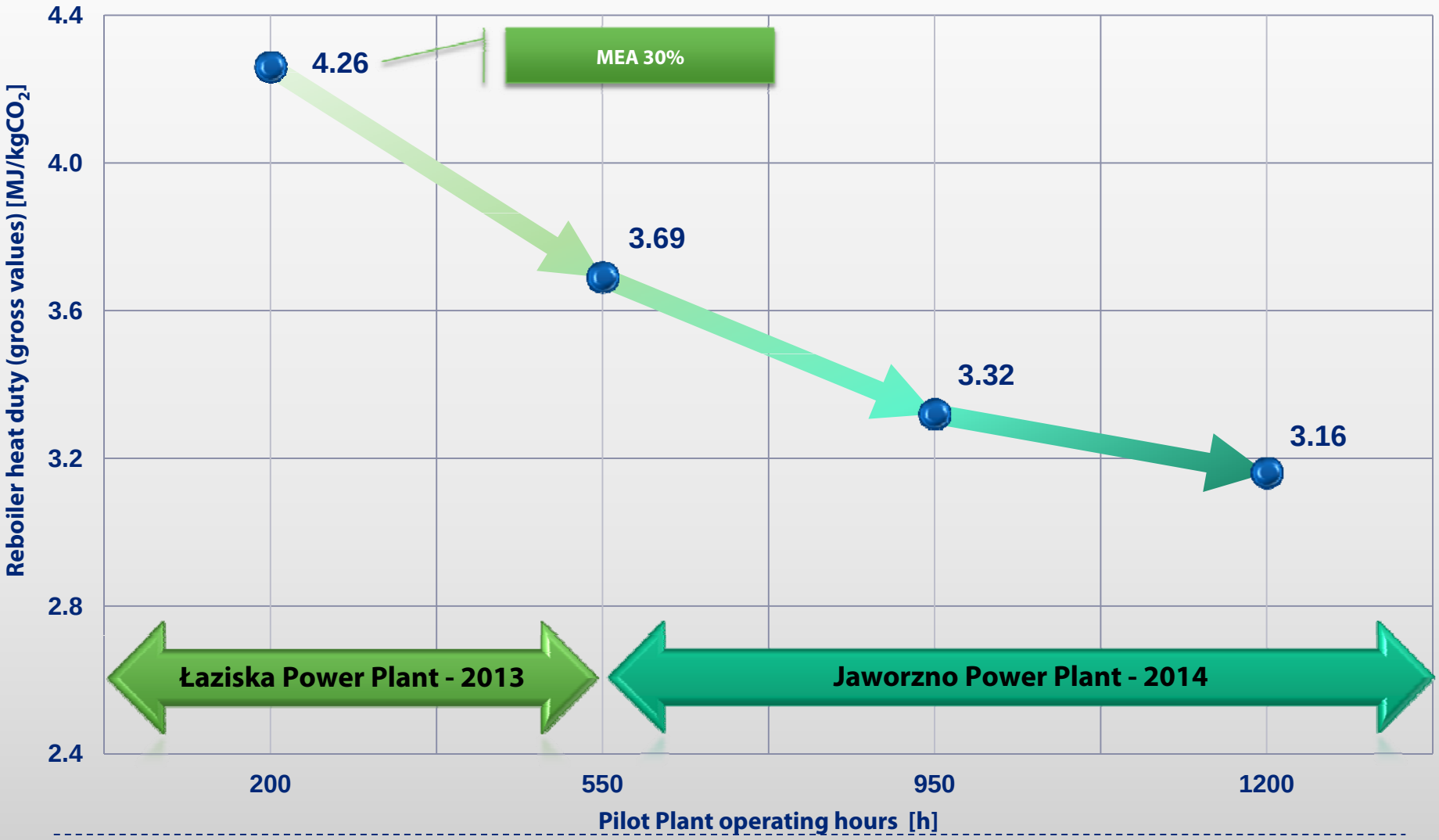
Results - Stripper internal heating influence matrix

Internal heat integration influence tests				
Campaign	Solvent	L/G (kg/kg) (Configuration)	Lean loading reduction [molCO_2/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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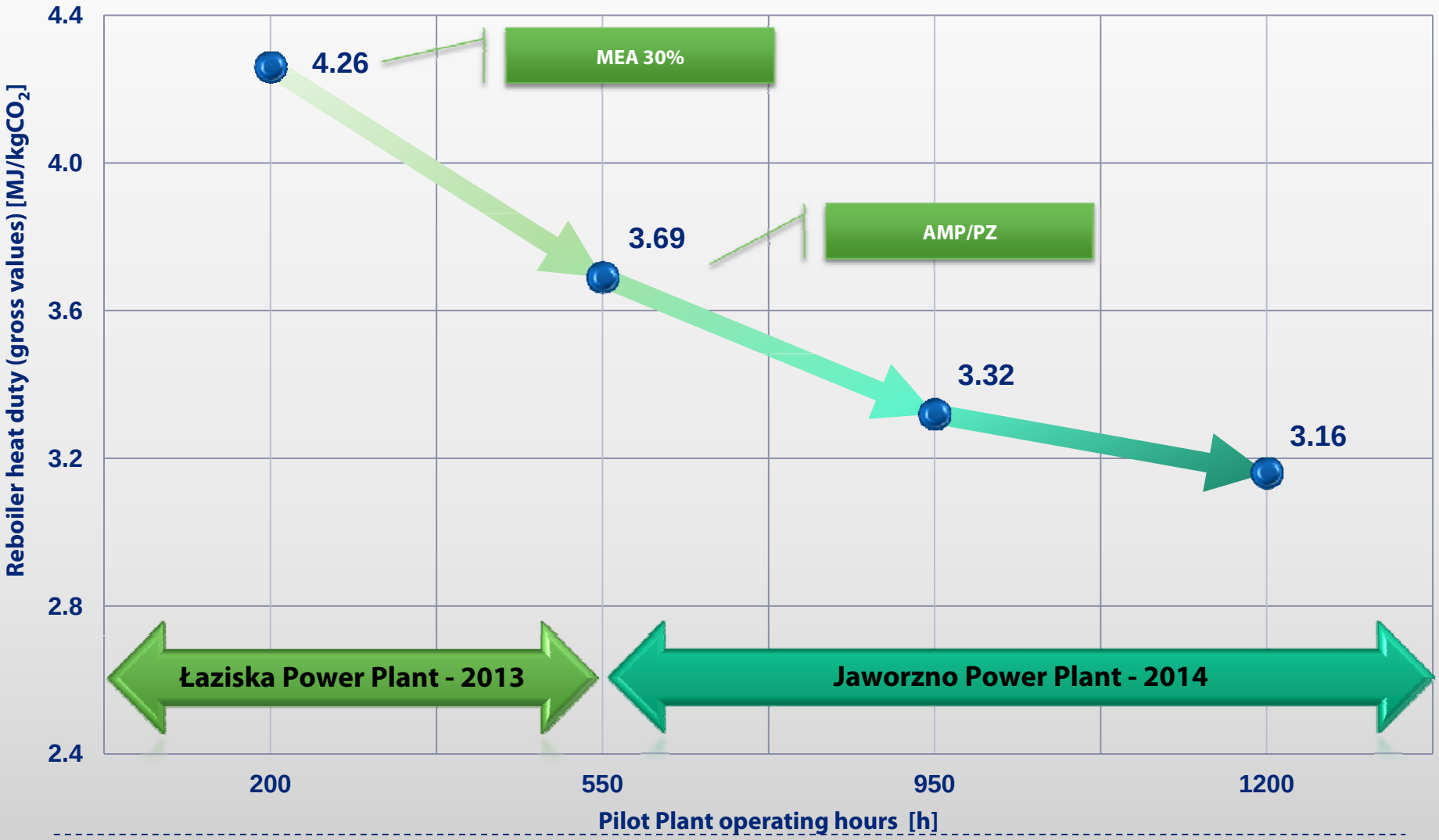
Results – IChPW reboiler heat duty reduction road map (2013-2014)



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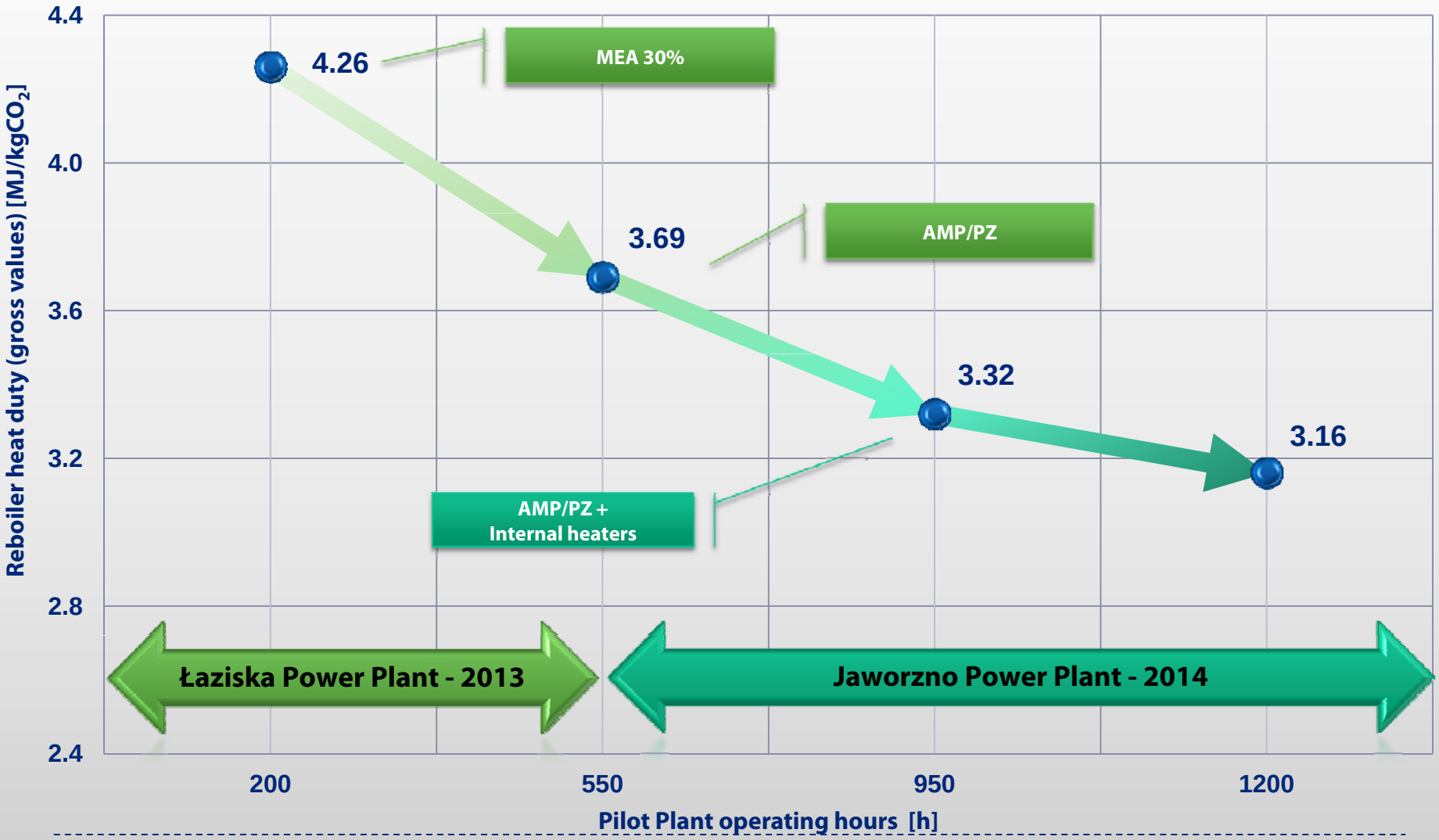

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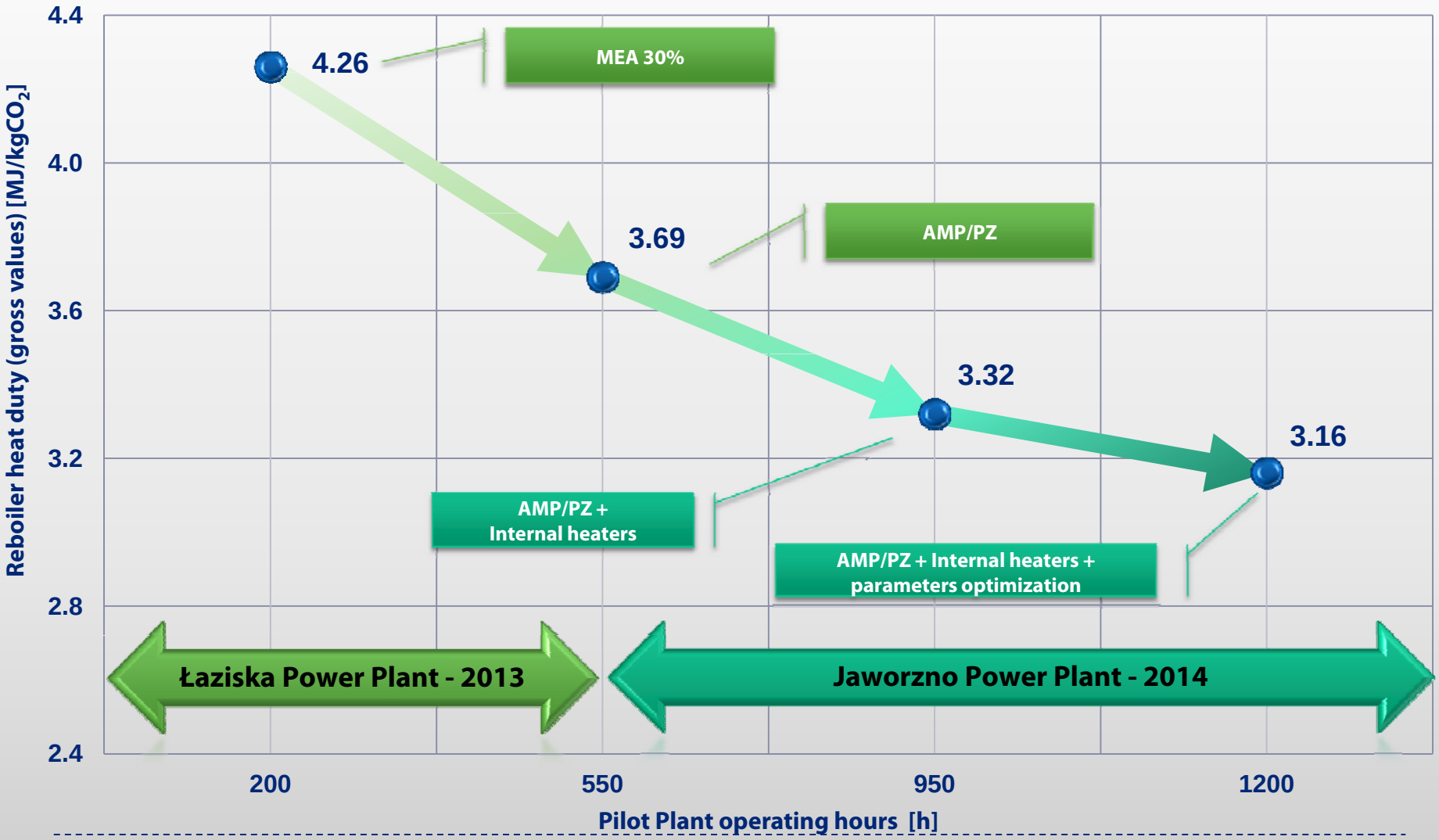

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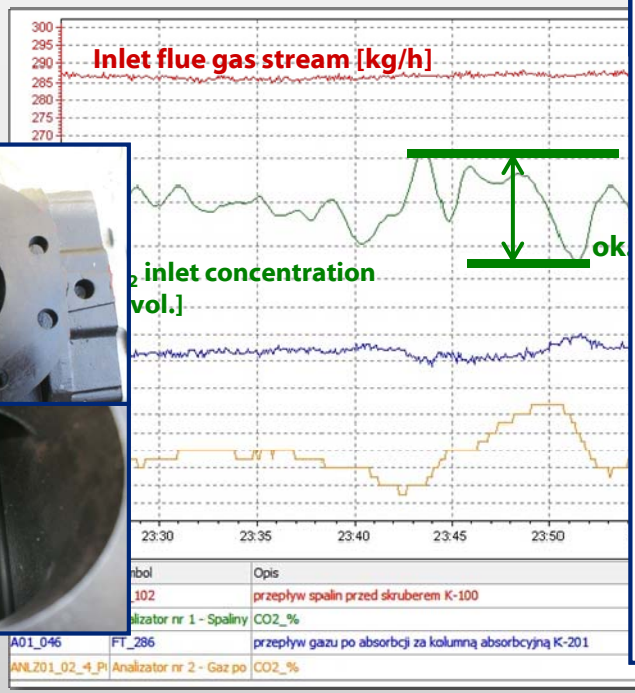
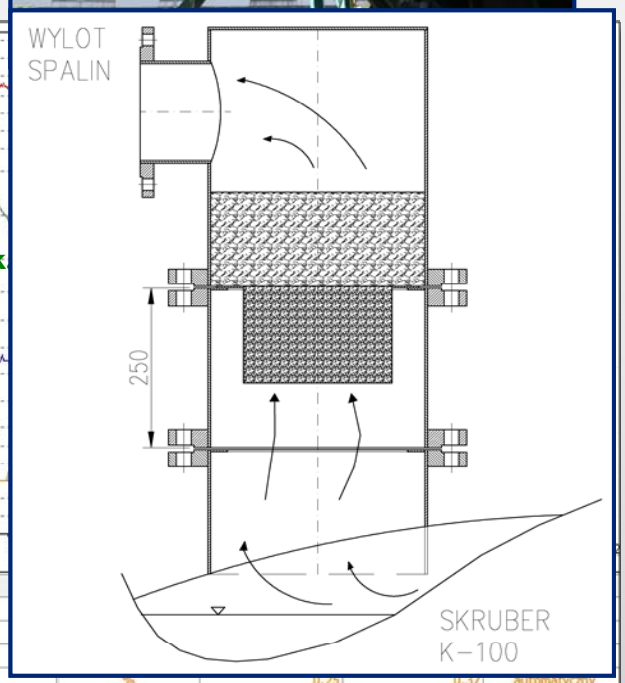
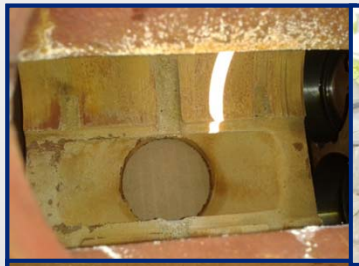
Results - The Pilot Plant operational difficulties

- CO_2 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







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

- Higher CO_2 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

The full chain CCS demonstration plant, captures and stores the CO_2 from 250MW (175 tonnes of CO_2/h) of net electricity generation unit, with 100km CO_2 pipeline, solvent: 30 wt% MEA, CO_2 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?

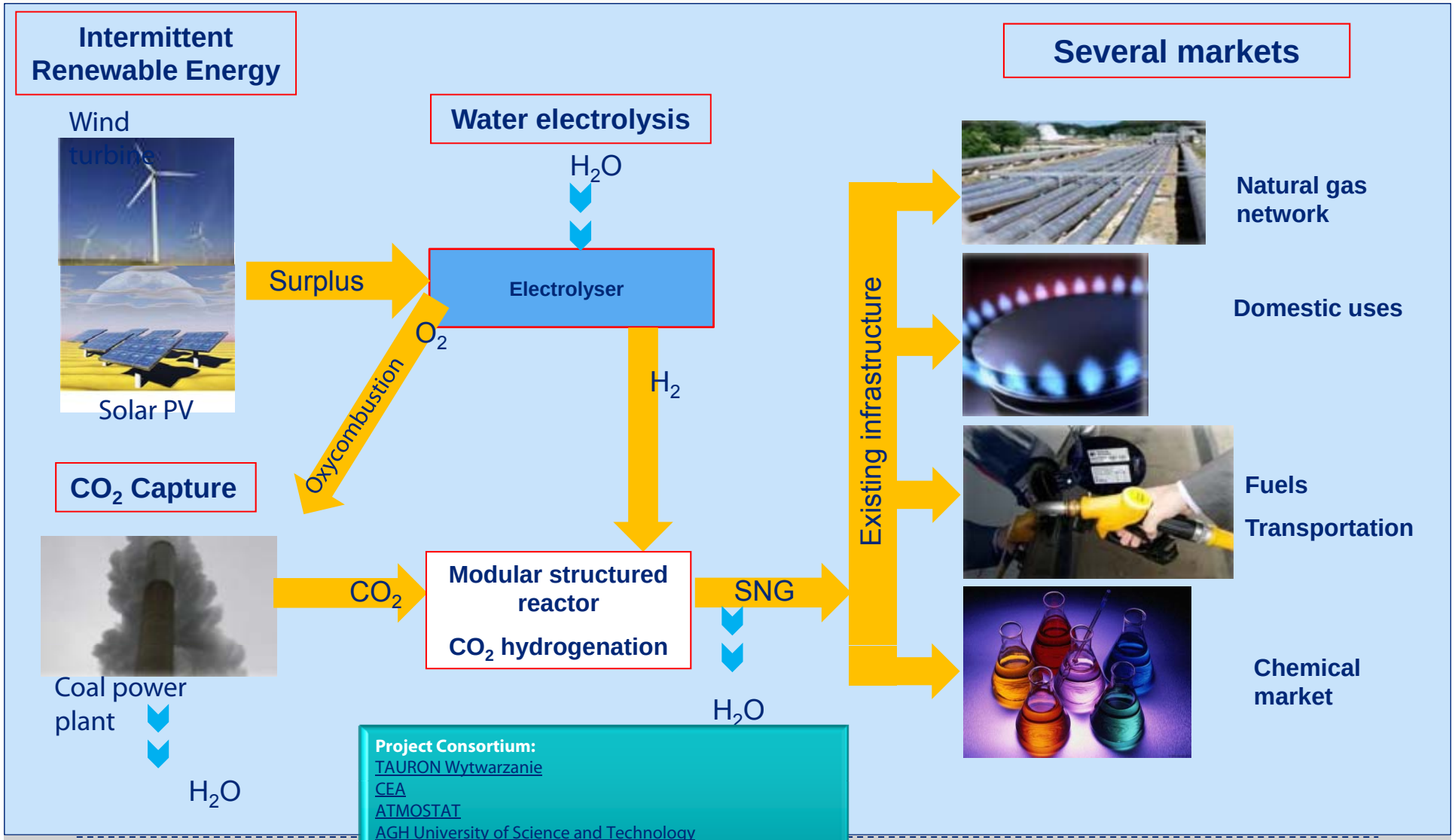
CAPEX difference (PLN 22.1M) will be paid in less then 6 years!

The Pilot Plant research summary

- The pilot plant campaigns successfully demonstrated reliable operation allowing the removal of over 80 000 kg of CO_2 from real flue gas (2000h).
- The energy requirement for solvent regeneration was found about 3,16 MJ/kgCO2 (gross value) with 90% CO_2 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_2 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_2 removed	approx. 80 000 kg

New project – CO_2 methanation system for electricity storage through SNG production



Project Consortium:
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.

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.

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- mgr inż. Adam Tatarczuk
- mgr inż. Marcin Stec
- mgr inż. Tomasz Szczypiński
- mgr inż. Piotr Kolon
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- mgr inż. Tomasz Spietz
- mgr inż. Aleksander Krótki
- mgr inż. Andrzej Wilk

Industrial partners team:

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- mgr inż. Sławomir Dziaduła – TAURON Wytwarzanie SA
- inż. Stanisław Gruszka – TAURON Wytwarzanie SA
- mgr inż. Jerzy Janikowski– TAURON Polska Energia SA
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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

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

Thank you for attention

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