Methanol Technologies of tkIS

A brief overview

Essen, 18.07.2018

engineering.tomorrow.together.

thyssenkrupp

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1. AdWinMethanol® and AdWinCombined™ Technology

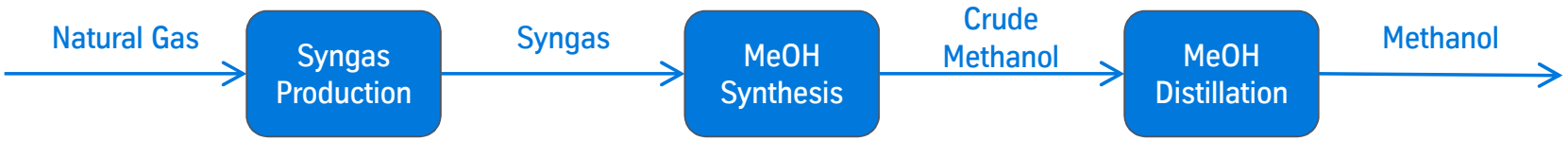
The technological concept is based on proven technologies

- AdWinMethanol® technology enables methanol production with considerable economic advantages, in particular at large scale capacities from 3,000 t/d up to 10,000 t/d in a single train.
- Approx. 10% less CAPEX and up to 4% less Natural Gas consumption compared to current plant concepts.
- Process: Conventional and/or non conventional short-chain hydrocarbons into syngas via Catalytic Partial Oxidation (ATR) with a high feed stock flexibility. Utilization of isothermal reactors only.
- AdWinCombined™ technology is the highly integrated combination of the advantages of AdWinMethanol ® with thyssenkrupp Industrial Solutions´ Uhde Ammonia™ process .
- AdWinCombined™ : Highly integrated, very flexible operations, approx. 30% less CAPEX, approx. 10% nat. gas consumptions
- Conventional methanol distillation

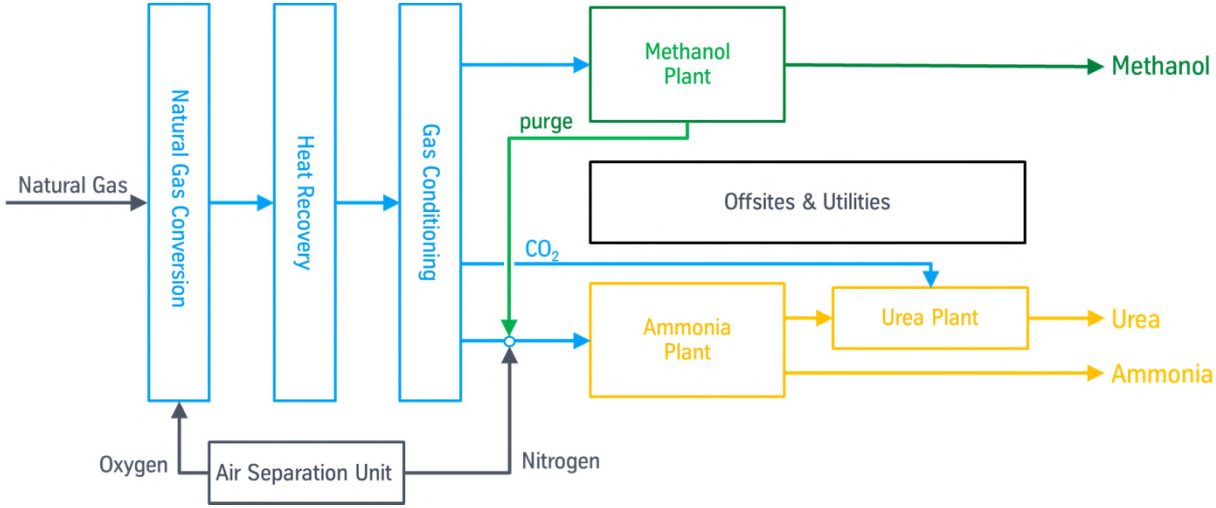
AdWinMethanol® - up to 10,000 t/d in a single train

1. AdWinMethanol® and AdWinCombined™ Technology

- Simplified process flow diagram AdWinMethanol® :



- Simplified process flow diagram AdWinCombined™:

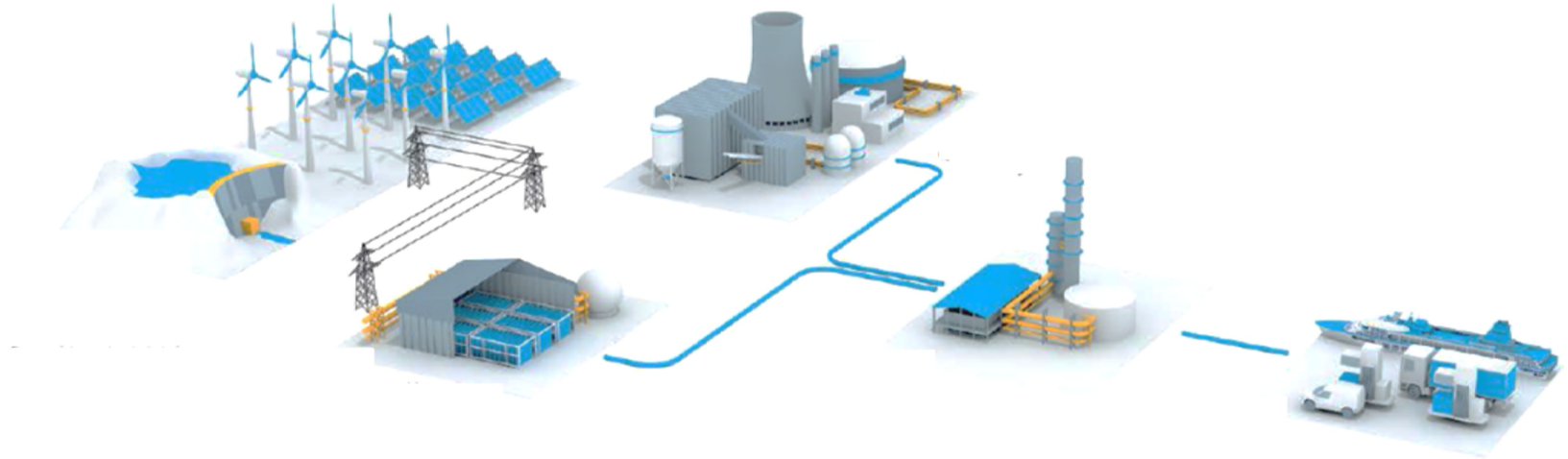


AdWinCombined™: up to 30% less CAPEX and approx. 10% less Feedstock consumption

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

Business Idea

- Storage of green power as green fuel
- Replacement of fossil gasoline
- Decentralized production in direct proximity to power plant substation, no transmission losses
- CO_2-compensation
- Production independent from oil or fuel imports
- Increased economics of renewable power generation



Renewable Methanol directly utilized as green fuel

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

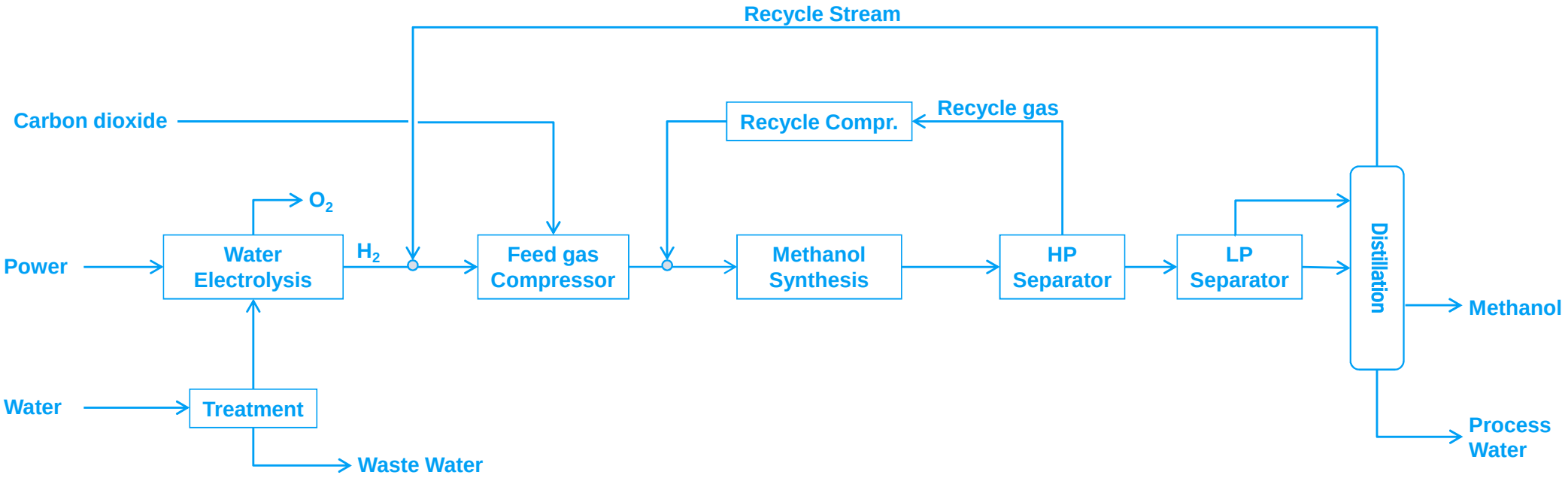
Major Milestones of Partnership SLF / tkIS

• First studies and R&D developments of SLF	2006-2014
• Pilot Plant of SLF in Switzerland	2012-2014
• Feasibility Study network SLF-plants in Switzerland	Jun 2016
• Application procedures (qualification as biofuel, tax exemption)	2016-2018
• Signature Cooperation Agreement SLF / tkIS	Sep 2016
• First Basic Engineering completed	Jun 2017
• Modularization concept completed	Aug 2017
• EPC Budget completed	Nov 2017
• Project Implementation Agreement Me2Go signed (5 plants at BKW hydropower sites in Switzerland)	Dec 2017
• Site selection Me2Go completed	May 2018

SLF / Uhde Methanol plants – tested and ready to be implemented

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

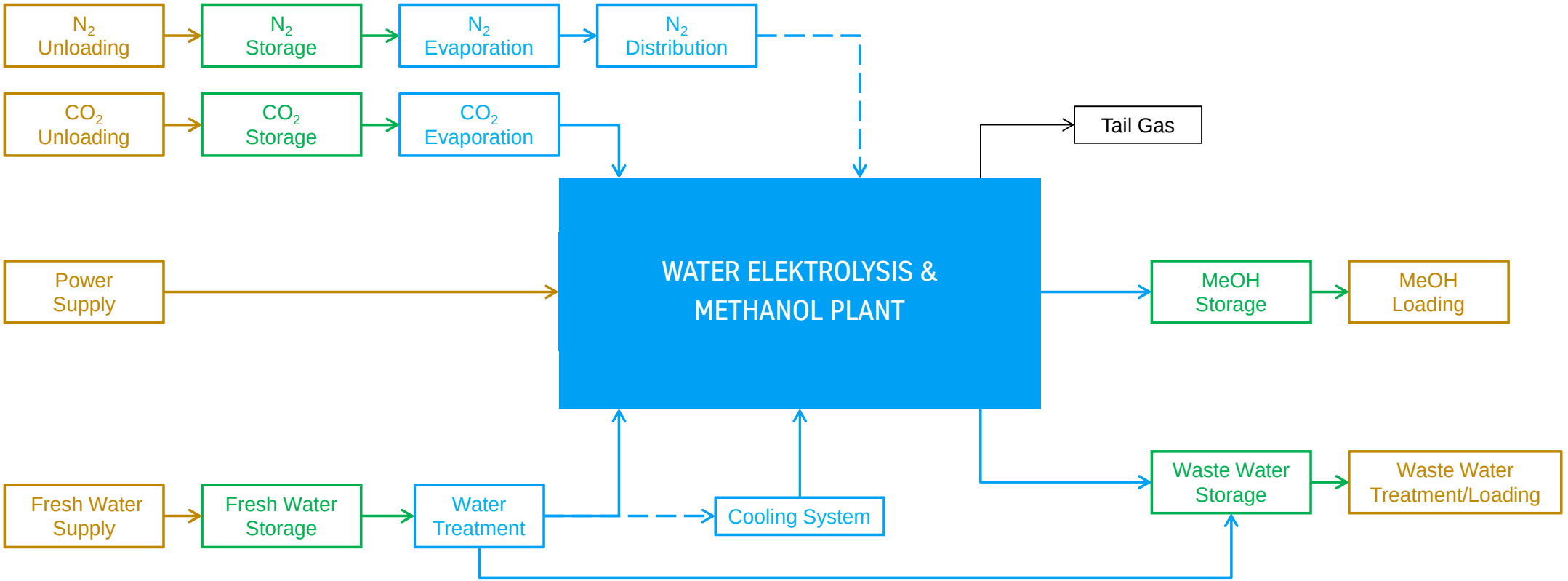
Advanced plant configuration optimized for small capacities



SLF / UHDE Technology is the most advanced technology for small scale methanol plants

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

Offsite & Utilities



Surface Water Collection & Disposal	Fire Fighting Water Collection & Disposal	Storm Water Collection & Disposal	Monitoring Gas Detection & CCV	Substation	DCS & ESC

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

Our additional contribution: H_2 at scale - large water electrolysis plants

Advanced Water Electrolysis by thyssenkrupp

- Alkaline atmospheric
- EPC turnkey installations at large scale
- Established supply chains

Experience cannot be copied.

#1 49% market share
supplier for electrolytic hydrogen production

600
electrochemical plants realized worldwide

over **10 GW**
of power installed

Hydrochloric acid diaphragm electrolysis

Hydrochloric acid ODC[1] membrane electrolysis

Chlor-alkali membrane electrolysis

[1] ODC: Oxygen Depolarized Cathodes

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

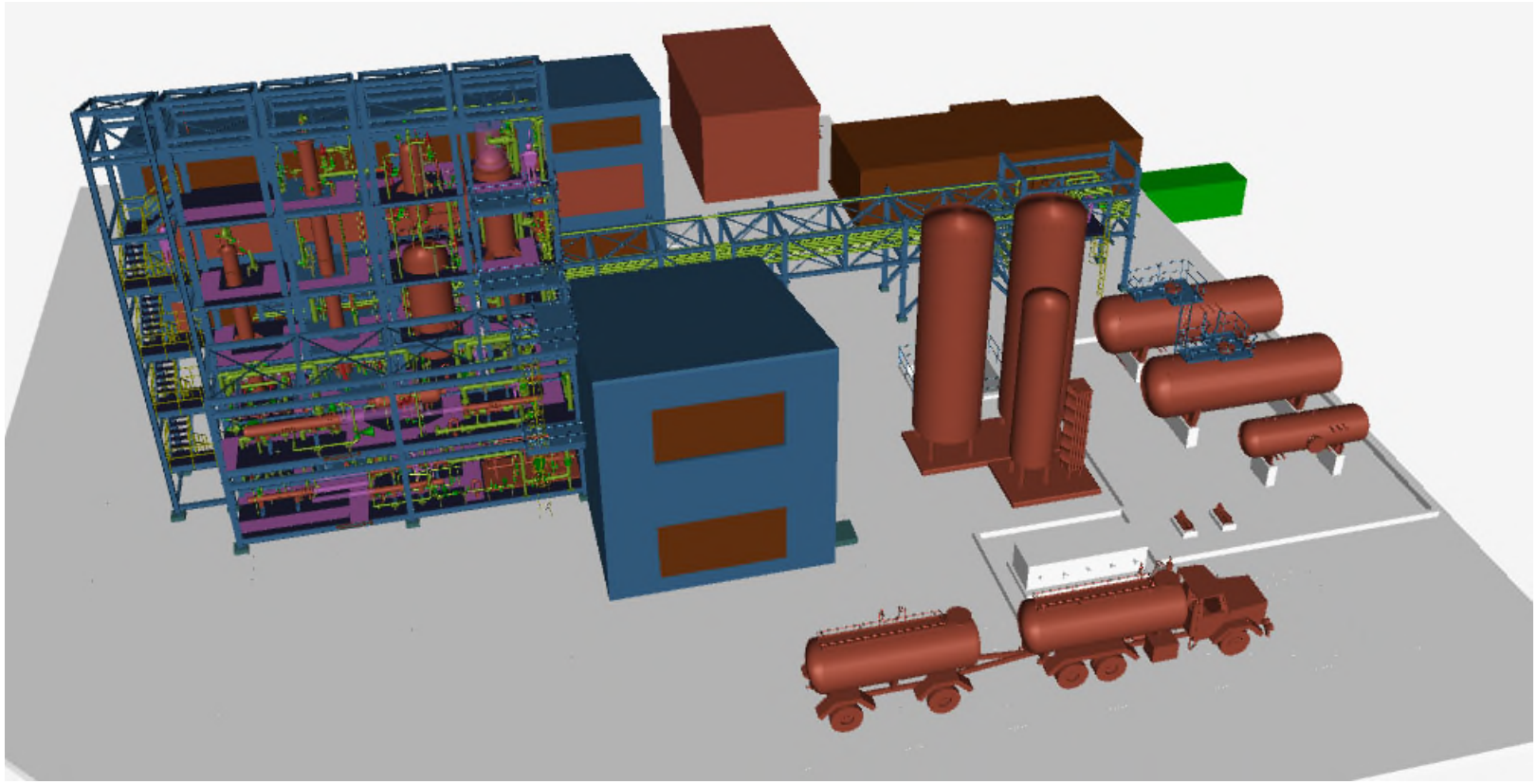
Green H_2 through water electrolysis - New dimensions for renewable energy integration

Water Electrolysis by thyssenkrupp

- Market potential 2017-23 for water electrolysis systems > €1.0 bn
  (Source: own assessment)
- Proven technology, scale economies
- Design for plants larger than 100 MW
- Target applications
  - Power-to-Gas (H_2/ energy storage),
  - Power-to-X (e.g. methanol/ fuel, ammonia)

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

Advanced modularized concept optimized for small capacities



Modularization improves economics, all truckable, first capacity template ready to implement

2. SLF / UHDE Technology For Small Scale Renewable Methanol Plants

Typical Figures for a Me2Go-type Modules

❑ Plant type:	Methanol from CO_2 and H_2
❑ Technology:	Methanol: SLF / UHDE Technology
	Water Electrolysis: tkIS
❑ Production capacity:	~ 12 mtpd fuel grade methanol
❑ Typical scope of supply:	EPC LSTK
❑ Total Investment:	~ 35 Mio. € (depending on location)

Ready to implement based on available tkIS Electrolysis and SLF/UHDE Methanol technology