Maschinenfabrik Reinhausen

IEEE PowerTalks, 16-18 September, 2024, Muscat, Oman

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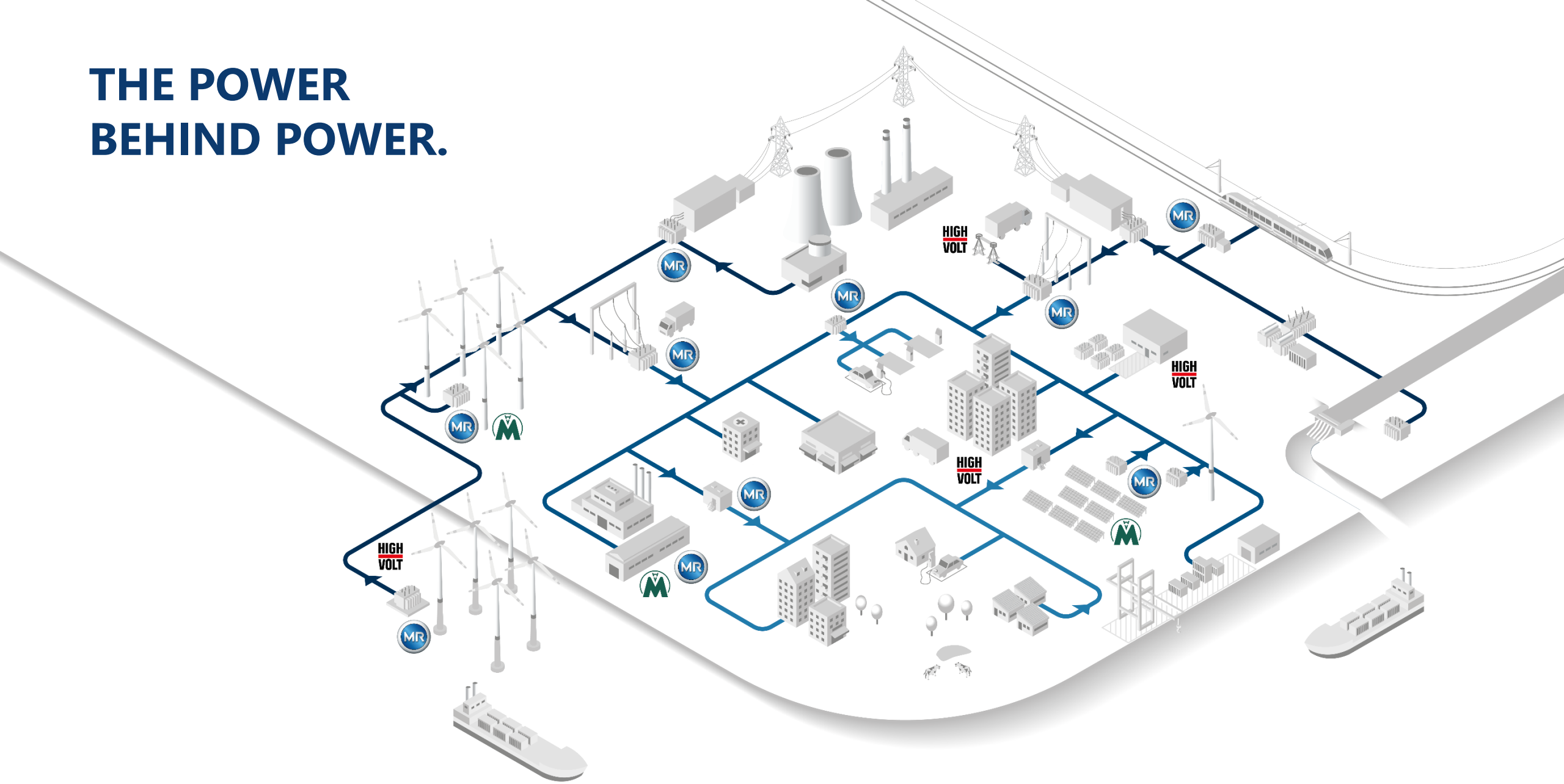
THE POWER BEHIND POWER.



At a glance

Family business since

1868

in the sixth generation
family owned

Economically healthy

1 billion

euros revenue in 2023
Highest rating (AAA)

Employees

4,000

61 nationalities
at 60 locations

World market leader

50%

of the world's electricity
flows through our products

Reliability

50+ years

of OLTC lifetime proves the
unmatched MR product quality

Present all over the world

8,000

customers
in 185 countries

28 subsidiaries and 11 joint ventures worldwide

1868		Maschinenfabrik Reinhausen GmbH (MR)	5		
Jul 1980	1	MR do Brasil Ind. Mec. Ltda. (MRB)	1		
Okt 1987	2	Reinhausen Australia Pty. Ltd. (RA)	1		
Dez 1989	3	Reinhausen Manufacturing Inc. (RM)	5		
Nov 1993	4	Reinhausen Italia S.r.l. (RI)	2		
Okt 1995	I	Easun-MR Tap Changers (P) Ltd. (EMR)	2		
Jul 1996	5	Reinhausen Asia-Pacific Sdn. Bhd. (RAP)	1		
Jan 1999	6	Messko GmbH (MS)	1		
Jan 2002	7	MR Japan Corp. (MRJ)	1		
Feb 2002	8	HIGHVOLT Prüftechnik Dresden GmbH (HV)	2		
Jun 2003	9	OOO MR (MRR)	1		
Nov 2005	10	Reinhausen South Africa (Pty) Ltd. (RZA)	2		
Dez 2005	II	Iran Transfo After Sales Service Co. (ITASS)	1		
Mai 2006	11	MR China Ltd. (MRT)	1		
Sep 2006	12	Jiangsu MR Manufacturing Co., Ltd. (MRM)	1		
Sep 2006	13	Reinhausen Middle East FZE (RME FZE)	0		
Jan 2009	14	Reinhausen Korea Ltd. (RKR)	2		
Aug 2009	15	Reinhausen Power Composites GmbH (RPC)	1		
Sep 2009	16	Reinhausen Luxembourg S.A. (RLU)	1		
Jan 2010	17	Reinhausen Canada Inc. (RCA)	2		
Mrz 2011	18	PT. Reinhausen Indonesia (RID)	1		
Okt 2011	III	Reinhausen 2e d.o.o. (RSI)	1		
Apr 2012	19	Reinhausen Nordic AB (RSE)	1		
Okt 2014	20	Reinhausen Mexico S. de R.L. de C.V. (RMX)	1		
Jun 2015	21	Amantys Power Electronics Ltd. (APE)	1		
Jan 2016	22	Cedaspe S.r.L. (CEDASPE)	2		
Jan 2016	IV	Reinhausen Singapore Pte. Ltd. (RSG)	1		
Jan 2016	23	Sukrut Electric Company Pvt Ltd. (SECPL)	1		
Jan 2016	24	British Transformer Components Ltd. (RGB)	1		
Apr 2016	V	Reinhausen (Thailand) Ltd. (RTH)	1		
Apr 2016	25	Reinhausen España S.L. (RES)	1		
Okt 2016	VI	Reinhausen Enerji Çözümleri Anonim Şirketi (RTR)	1		
Jul 2017	26	Hans von Mangoldt GmbH (HVMAC)	1		
Jul 2017	VII	Hans von Mangoldt Taiwan Co. Ltd. (HVMTW)	1		
Jul 2017	VIII	Meher Mangoldt Inductors Pvt, Ltd. (MMIPL)	1		
Okt 2019	IX	Aditya Birla Power Composites Ltd. (ABPC)	1		
Jan 2020	X	Reinh. Middle East Energy Solutions LLC (RME LLC)	1		
Aug 2022	27	Advanced Testing Systems Inc. (HVATS)	1		
Sep 2023	28	TOO Reinhausen Kazakhstan (RKA)	1		
Sep 2023	29	C.B. System-Oil S.L. (CBS)	1		

Factory Office

Note: Exclusively operating companies

Uniquely inventive – since 1929

1929
High-speed resistor-type tap-changer

1974
Semi-conductor tap-changer

1990
Reactor-type tap-changer

2000
Vacuum technology

2012
Modular active filter

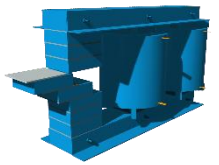
2016
Distribution tap-changer

2018
Transformer operating system

2021
DC transformer

2021
Strongest vacuum tap-changer

1978
Reactor with PolyGap technology

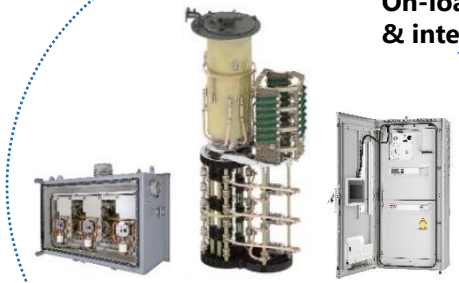


1990
Largest outdoor test system

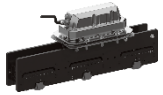
2020
Most power-ful resonant test system

Solutions for load flow and power quality

Transformer Accessories



On-load tap-changers & intelligent drives

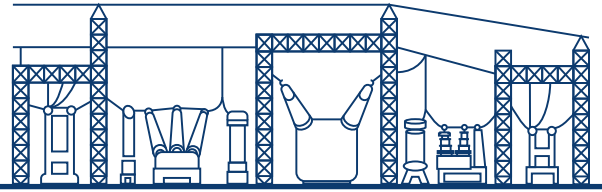


Control technology for distribution transformers

Services at the transformer station

Sensors, automation, digitalization

OEM & System Integrators



Network operator

Loads & feeders

High voltage Insulators

High voltage testing technology

Power Quality Solutions

Power Electronic Systems & Components

Reactors Medium & Low Voltage

Solutions & Portfolio of Power Quality

POCO-X
(arc proof up to 50kV)

Compensation Stations up to 36kV

Harmonic Filter Solutions up to 36kV

Harmonic Filter in E-Houses up to 36kV

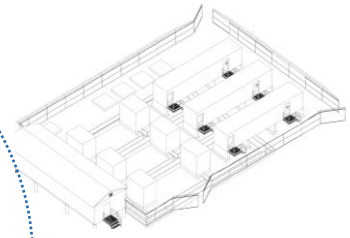
MSCDN
Mechanically Switched Capacitors with Damping Network up to 400kV

Static Solutions for PF Control and Harmonic Filtering

Dynamic Power Quality Solutions

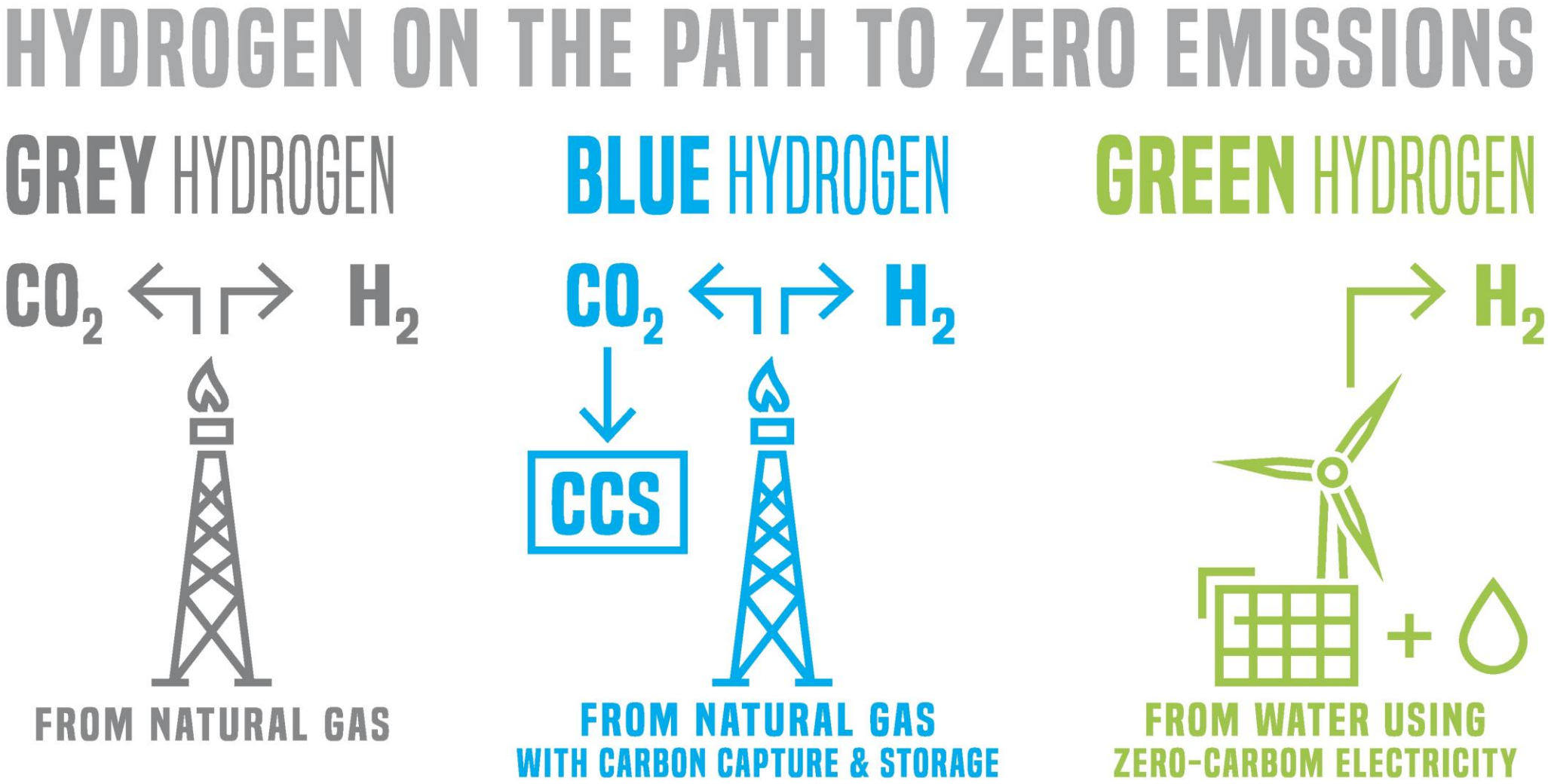
Active Filter & STATCOM up to 3,6Mvar

SVC & STATCOM upto +/- 50 Mvar

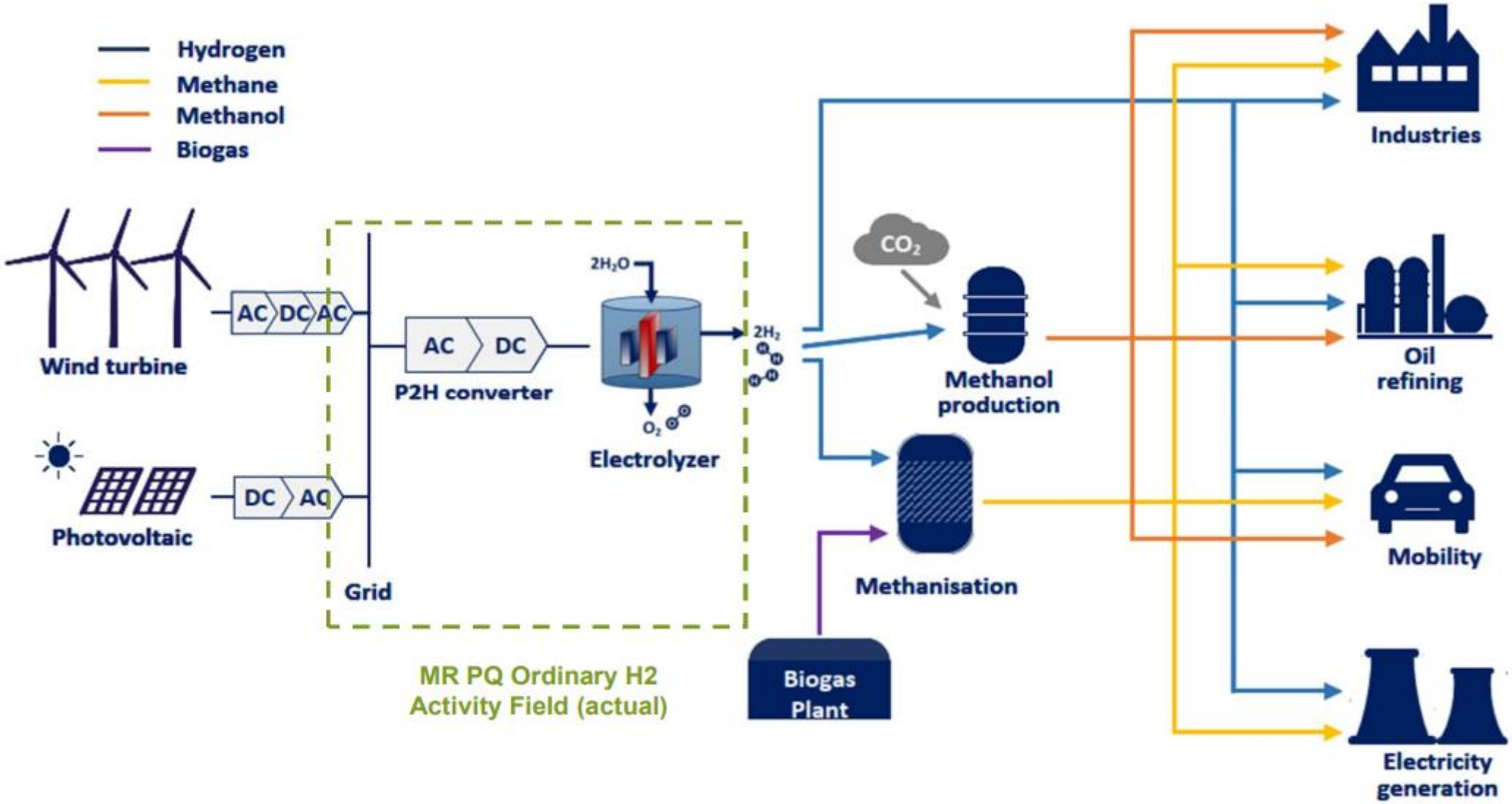


UUPS Systems upto 15 MWsec

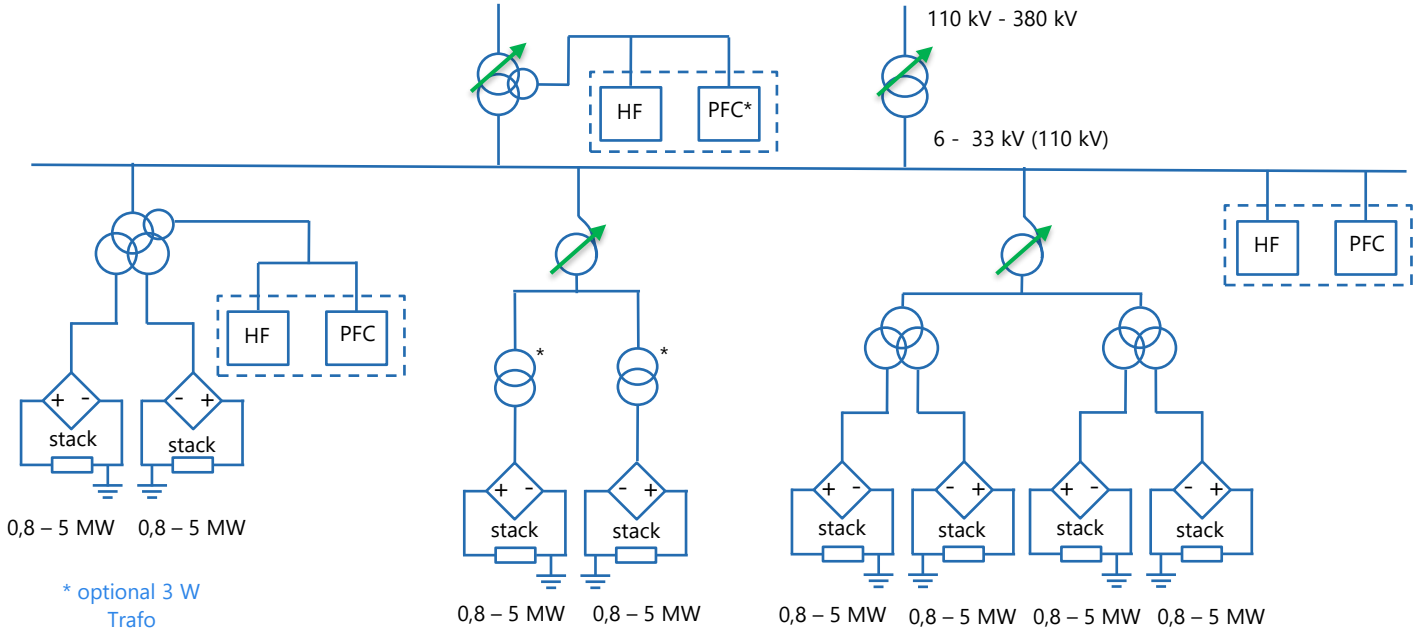
Grey, Blue and Green Hydrogen definition



Value chain of Hydrogen



Requirements of a MR for an Electrolyser Plant



+ Optimized solution planning with respect to reactive power and harmonics,

+ PQ solution design considering the voltage control by the transformer tap changers for reactive power compensation,

+ Compliance with the relevant parameters of connection guidelines and standards (IEC, IEEE, VDE-AR,...)

+ Transformer(s) to supply the rectifier (usually 12/24-pulse thyristor) for H2-electrolyzer stacks approx. 1 – 5 MW per Stack (17.5 – 20 MW Array)

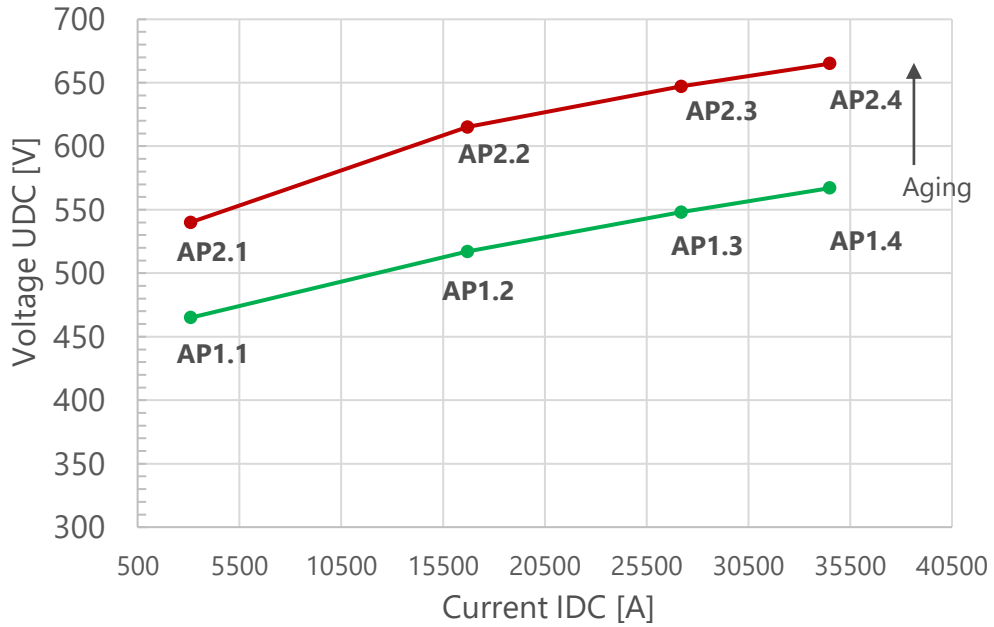
+ Harmonic filter and reactive power (Dynamic / Static) compensation as singular or hybrid function, single/group compensation

RE Power Fluctuations / Aging of Electrolysers / Voltage Control

Voltage Control – RE Fluctuations

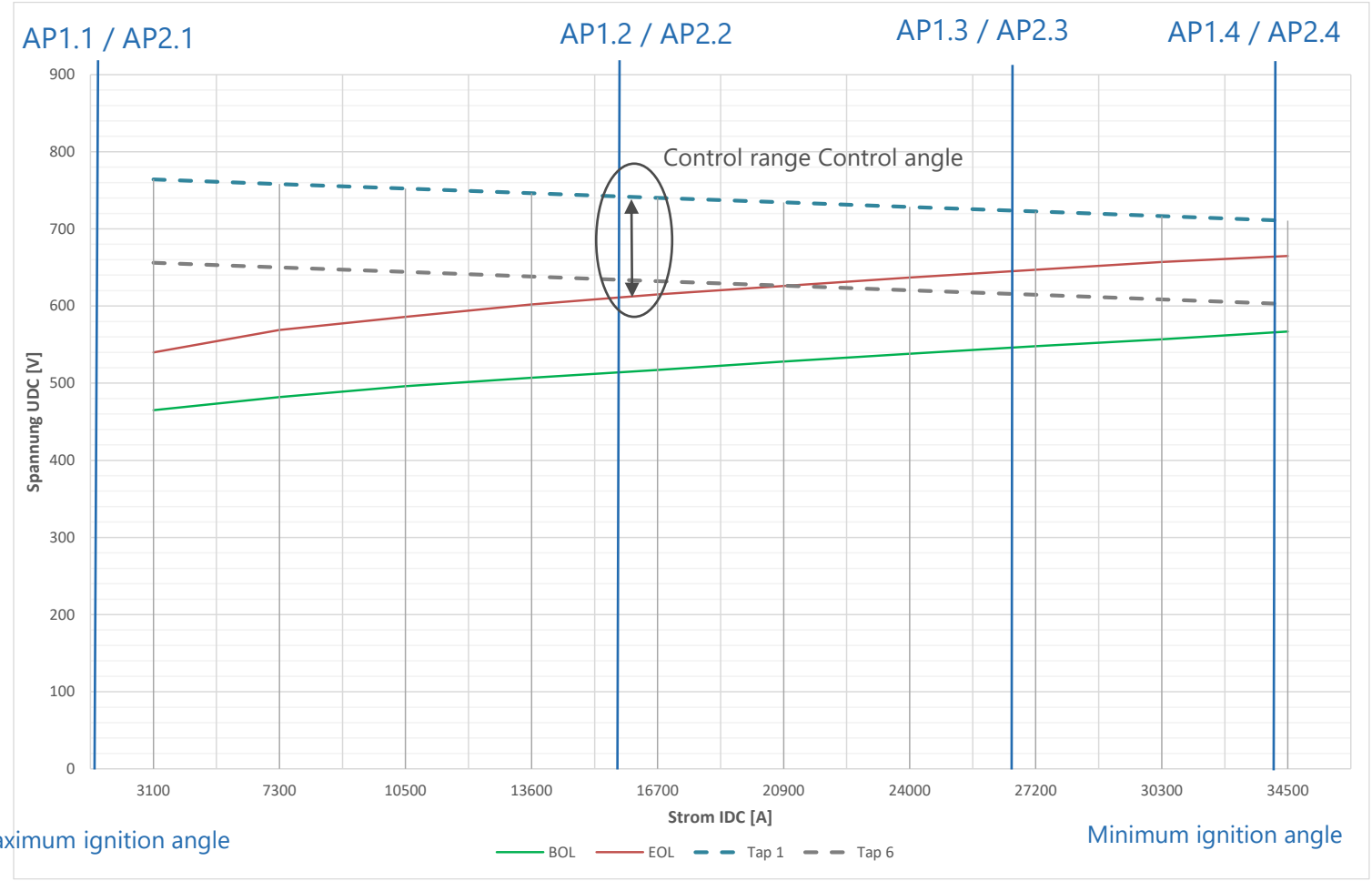
+ Adaptation of H2 production with the availability of renewable power generation,
+ Adaptation of H2 production leads to variation of thyristor bank firing angles,
+ Variation of transformer secondary input voltages necessary to achieve acceptable power factor and limited harmonic distortion,
+ Voltage control from OLTC in conjunction with renewable power generation.

Voltage Control – Electrolyser Aging



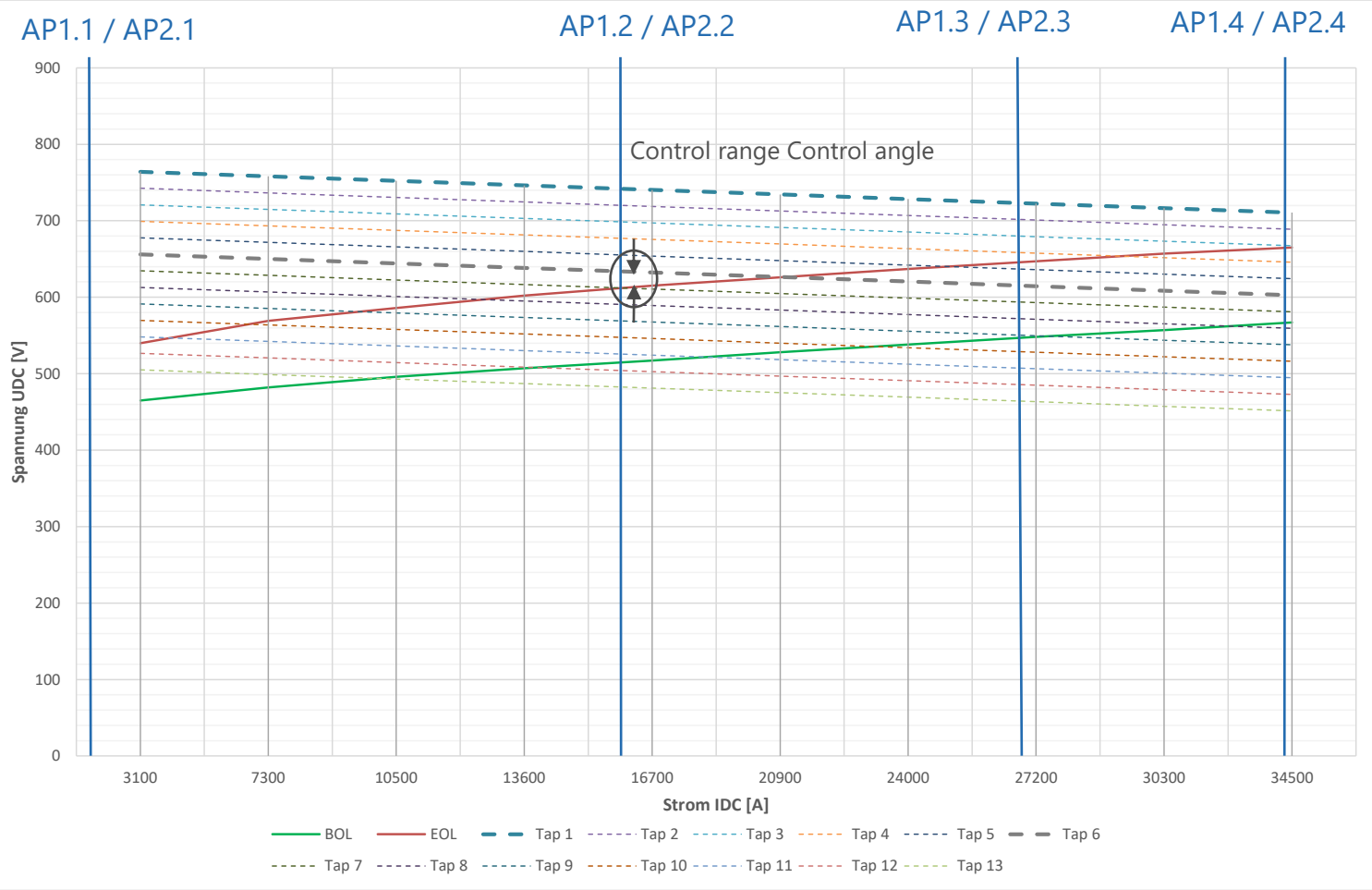
+ Exemplary characteristic curve of an electrolysis cell,
+ Aging (years) increases the voltage drop across the electrolytic cell, so that more electrical power is required for the same quantity of H2

RE Power Fluctuations / Aging of Electrolysers / Voltage Control



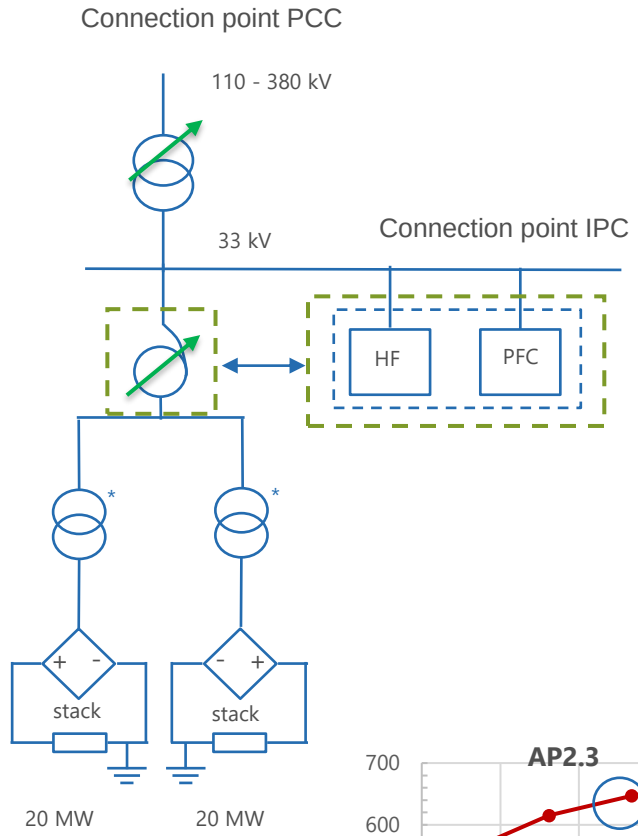
- **Transformer with 2 offload tappings**
- OCTC (1x SOL / 1x EOL) is set to EOL tapping at some point within the service life (changeover time may be critical)
- Transformer secondary voltage (GR input) must be selected so high that full current can still be started up in each case (if necessary, also with contractually assured undervoltage of e.g. 0.95 p.u.)
- Fine adjustment of the operating points via partly very large control angles of the thyristor rectifier, conditional:
  - High reactive power requirement
  - High harmonics
  - Possibly too high DC ripple

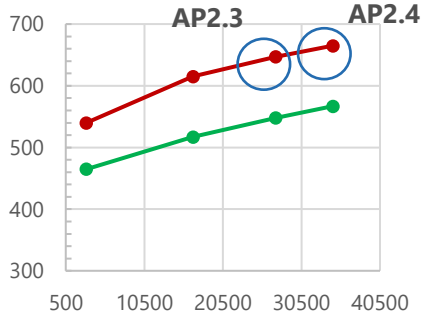
RE Power Fluctuations / Aging of Electrolysers / Voltage Control



- **Transformer with OLTC (13 tappings)**
- Transformer secondary voltage (GR input) can be selected better adapted over the entire service life of the electrolysis cell(s)
- Adjustment stages for mains undervoltage and overvoltage in operation only when necessary
- Fine adjustment of the operating points via significantly smaller control angles of the thyristor rectifier
  - Reactive power requirement ↓
  - Harmonics ↓
  - DC Ripple ↓

Advantages – Solutions with OLTC Theoretical Considerations





Simulation of a 40 MW electrolysis with an OLTC in an autotransformer (13 steps) from 374 V to 566 V in comparison to the version with a fixed offload transformer stage (EOL).

	Control angle	P [MW]	Q [MVar]	Qc [MVar] Cosphi 0.95
AP2.4 without OLTC	18,0 °	46,6	24,1	8,6
AP2.4 with OLTC	13,3 °	46,6	20,6	5,9
AP2.3 without OLTC	24,2 °	36,1	21,3	**9,6**
AP2.3 with OLTC	11 °	36,0	13,6	1,2

P/Q measured on HV side of auto-transformer

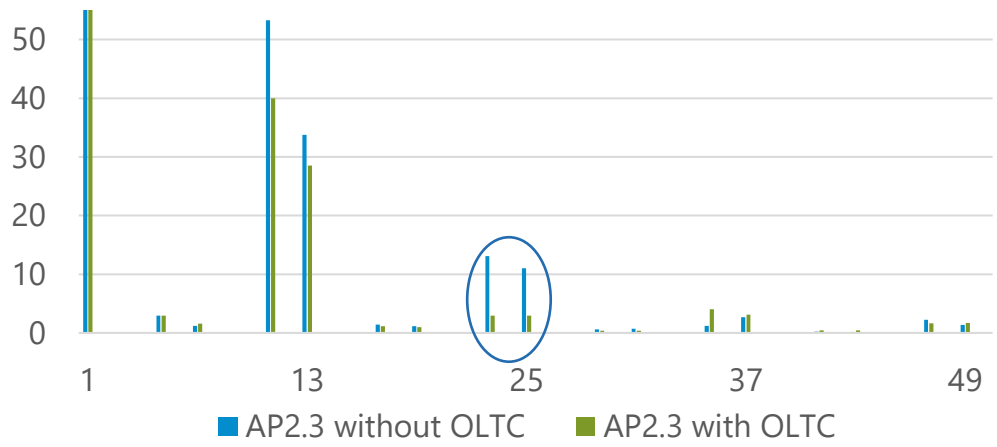
+ Maximum demand for compensation power at AP2.3
+ Design of the compensation (Qc) to 5.9 Mvar instead of 9.6 Mvar
+ **by using an OLTC, the need for compensation can be reduced by at least 40 %.**
+ Savings potential - Solution or Project Dependent (different ratios of fixed and variable costs in the compensation and filter solution).

Attention: The OLTC stages in the example are not optimized and are exemplary.

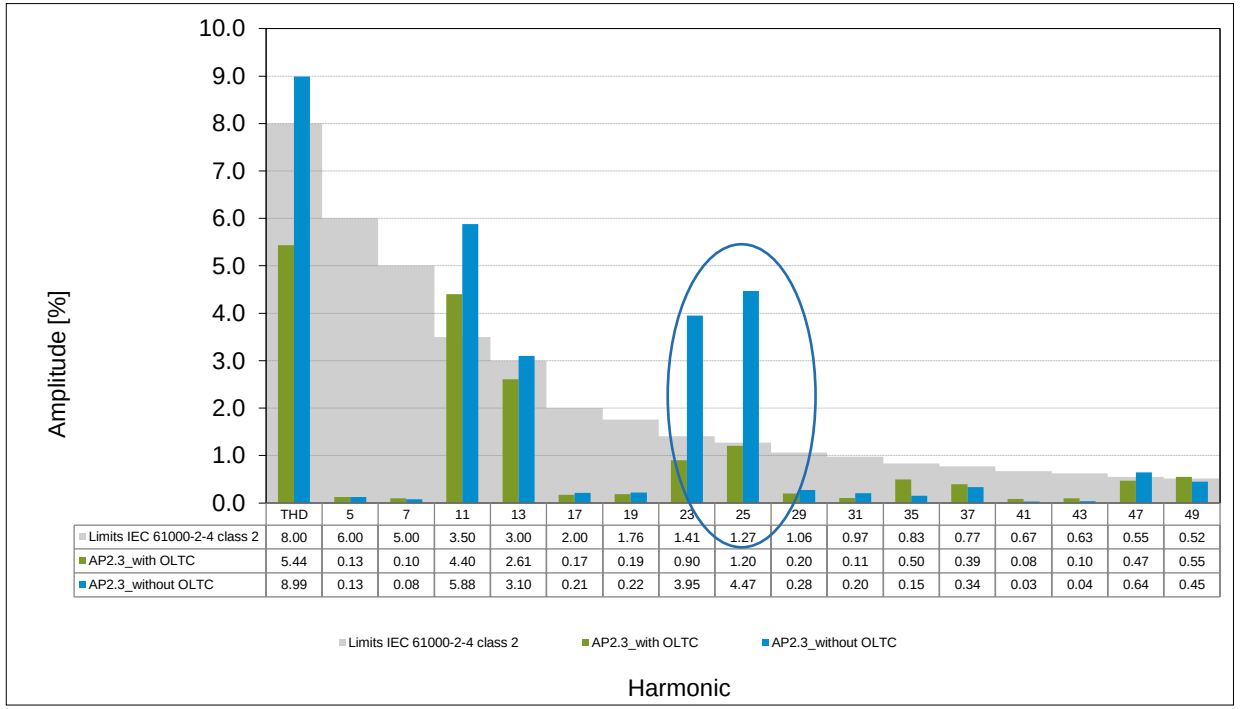
Advantages – Solutions with Tap Changers Theoretical Considerations

	1.	11.	13.	23.	25.	35.	37.	47.	49.	THD I
AP2.3 without OLTC	730 A	53,3 A	33,7 A	13,1 A	11,0 A	1,2 A	2,7 A	2,2 A	1,4 A	**8,9 %**
AP2.3 with OLTC	667 A	39,9 A	28,5 A	2,9 A	2,9 A	4,1 A	3,1 A	1,6 A	1,7 A	**7,4 %**

Current in [A] on the HV side of the three-winding transformer



Voltage spectrum at the connection point (33 kV IPC)



	THD	5	7	11	13	17	19	23	25	29	31	35	37	41	43	47	49
Limits IEC 61000-2-4 class 2	8.00	6.00	5.00	3.50	3.00	2.00	1.76	1.41	1.27	1.06	0.97	0.83	0.77	0.67	0.63	0.55	0.52
AP2.3_with OLTC	5.44	0.13	0.10	4.40	2.61	0.17	0.19	0.90	1.20	0.20	0.11	0.50	0.39	0.08	0.10	0.47	0.55
AP2.3_without OLTC	8.99	0.13	0.08	5.88	3.10	0.21	0.22	3.95	4.47	0.28	0.20	0.15	0.34	0.03	0.04	0.64	0.45

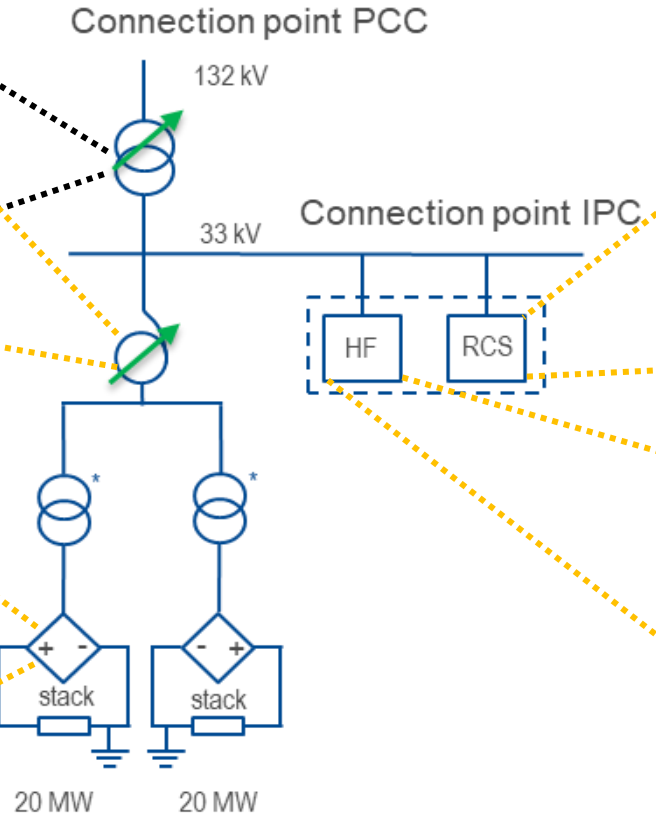
+ Reduction of harmonic currents on the HV side of the autotransformer when using an OLTC (reduction of THD I by approx. 17 %)
+ Very significant reduction in voltage harmonics (network-dependent)
  - Harmonic compensation can be designed lower

What does MR have to Offer Here? – The Complete Solution

MR offers a one stop complete system solution - optimized, highest quality, time saving, cost effective over its lifetime

Planning & Feasibility

Consulting

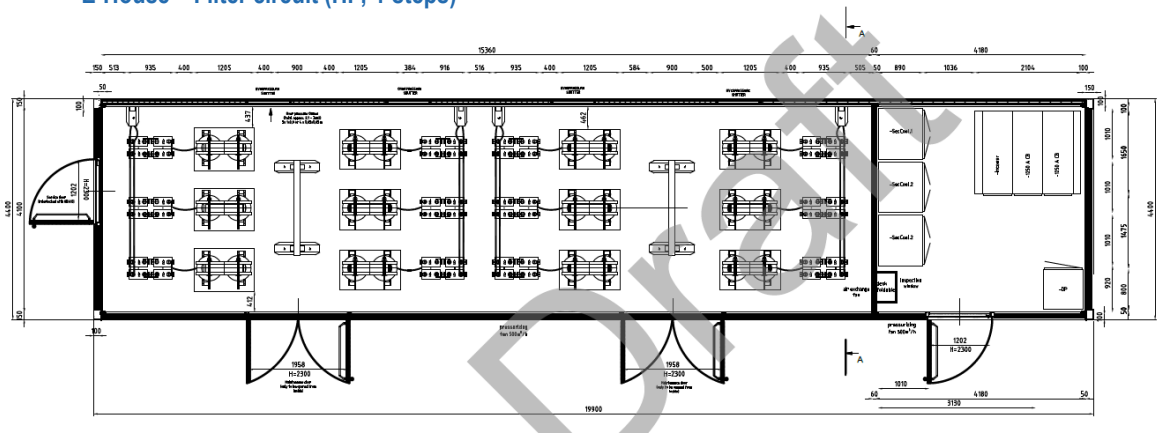


System design & Solutions

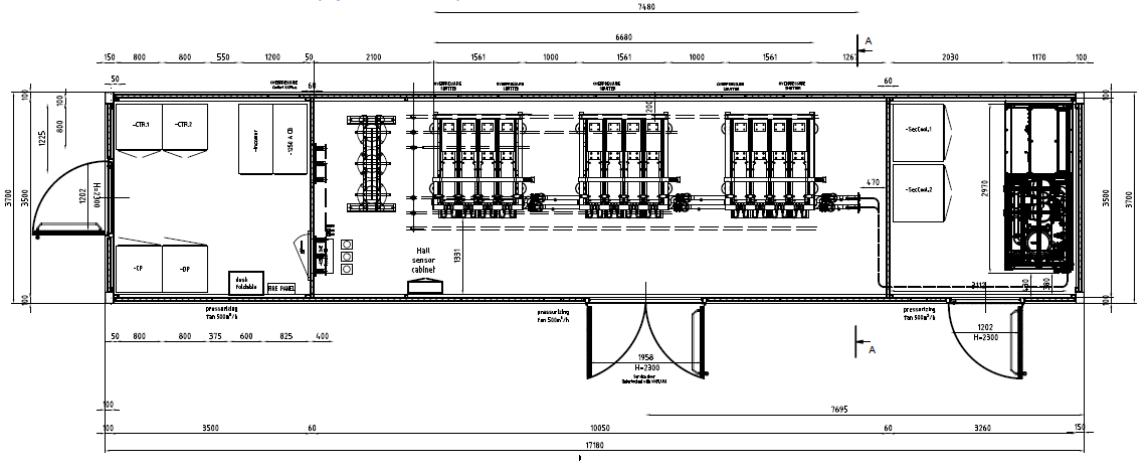
Product deliver and installation

Large systems 50 MW - >1GW ElectrolyseR (12 – 36 Pulse) project example: Passive filter and STATCOM for 2x100 MW

E-House – Filter circuit (HF, 4-steps)



E-House - STATCOM (upto 20 Mvar)

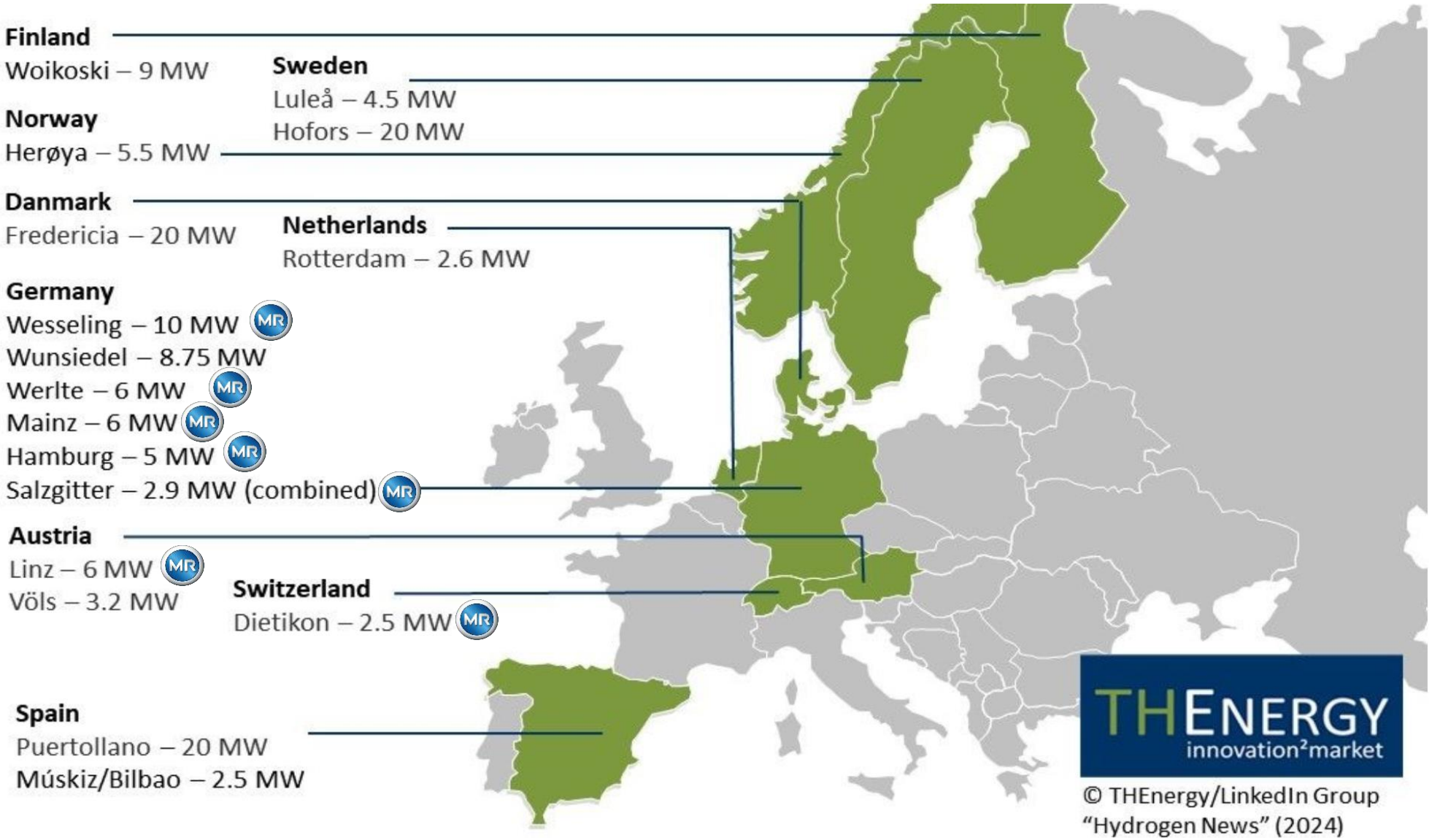


Mechanical Layout (E-House)

- Each prefabricated e-houses for minimal effort on the construction site (coastal environment)
- Often elevated on site
- Water cooling (without external attachments) or air conditioning units as wall/roof installation
- One E-House till approx. 20 m (4 step HF) / moreover 2-part approx. 27-28 m (6-stage HF)
- Protection and control from a walk-in control room during operation (primary system part locked)

Draft

Hydrogen in Europe (operational & 2.5MW+)



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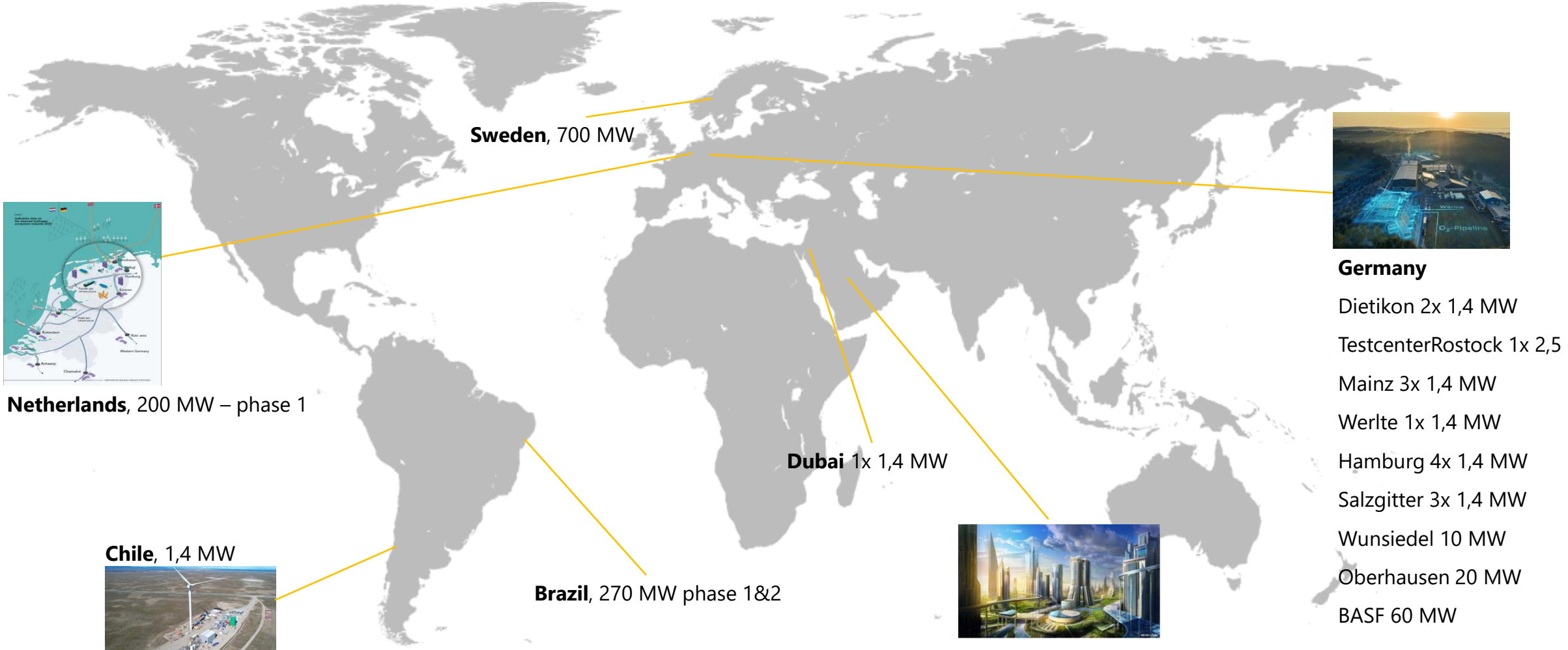
"Hydrogen News" (2024)

Worldwide Hydrogen Projects with MR Solutions



Sweden, 700 MW

Netherlands, 200 MW – phase 1

Germany

Dietikon 2x 1,4 MW

TestcenterRostock 1x 2,5 MW

Mainz 3x 1,4 MW

Werlte 1x 1,4 MW

Hamburg 4x 1,4 MW

Salzgitter 3x 1,4 MW

Wunsiedel 10 MW

Oberhausen 20 MW

BASF 60 MW

Dubai 1x 1,4 MW

Chile, 1,4 MW

Brazil, 270 MW phase 1&2

Saudi Arabia, 2 GW

Performance out of passion

+ 300 service heroes keep the global energy supply stable
+ Our software team drives the digitization of the products
+ In an international sales network we inspire our customers worldwide
+ 520 engineers working to shape a sustainable future

Grandfathering & Sustainability

We are aware of our special responsibility towards the environment, customers, employees and society and support the Sustainable Development Goals of the United Nations.

Sustainable Development Goals, SDGs | high impact 7/8/9/12, low impact 3/4/5/13

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