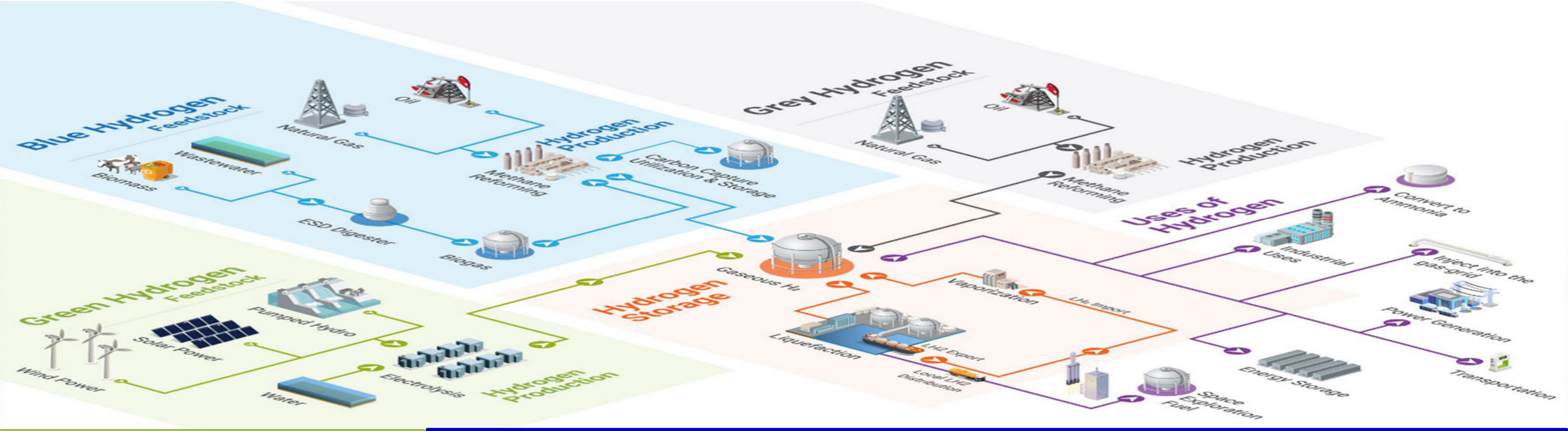


Energy Transition & Renewable Energy

Hydrogen Generation & Electrical Design Challenges

McDermott - NAP Studium Generale Energie Transitie

MCDERMOTT

24 March 2022

Preface

Energy transition are not new, they have been going for a long time and unfold over time. Previous energy transition have primarily been driven by technology, economics, environmental considerations & convenience and ease. The current one has politic, policy and activism more mixed in.

The European Union set a 2050 decarbonization target in the Paris Agreement to reduce carbon emissions by 90–95% relative to 1990 emission levels. The path toward achieving those deep decarbonization targets can take various shapes but will surely include a portfolio of economy-wide low-carbon energy technologies

Taking full advantage of renewable energy sources requires innovations in producing, storing and delivering electricity. That make the power grid the backbone of energy transition and bring further challenges of power grid balancing, operation, security and stability.

Energy challenge

Increasing population and energy demand

2015

2100

7+bn WORLD POPULATION

~500 EXAJOULES ENERGY CONSUMPTION PER YEAR

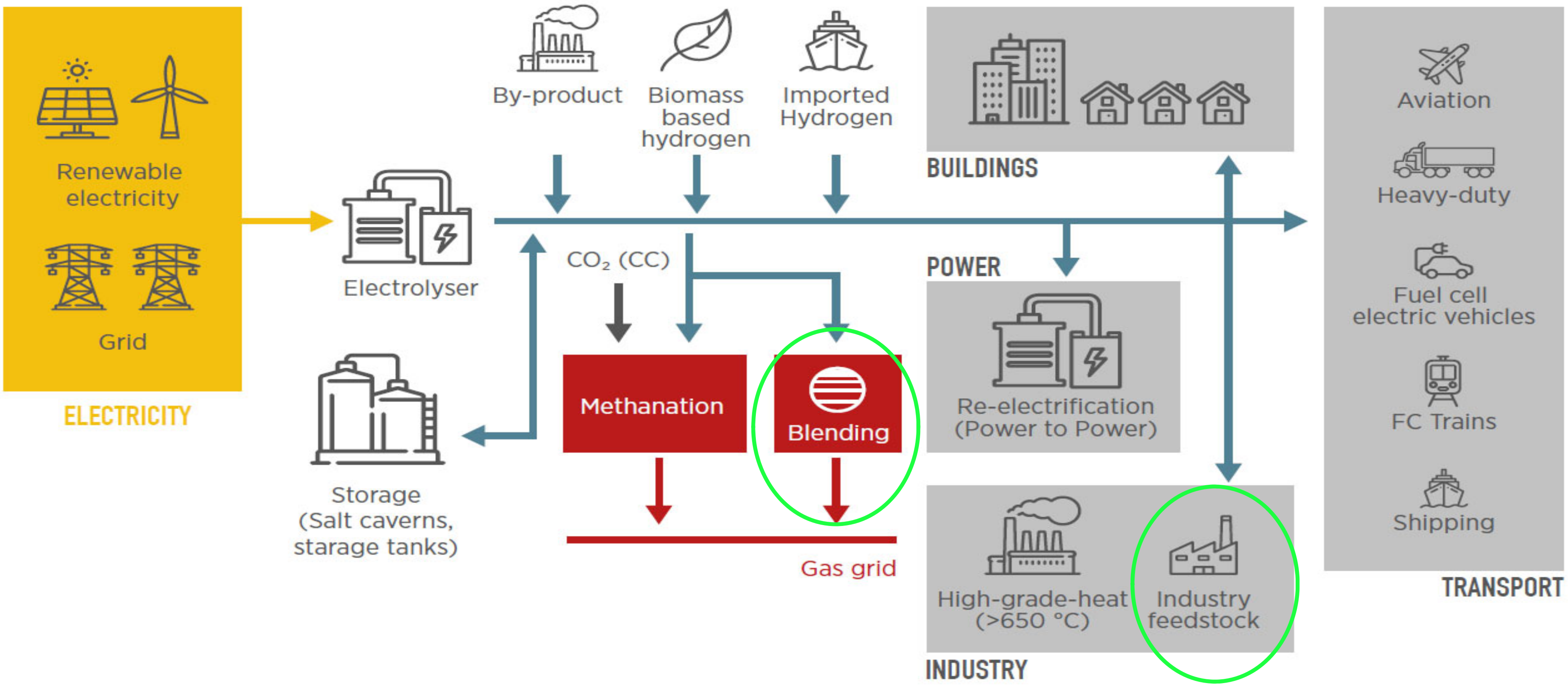
10bn WORLD POPULATION

~1.000 EXAJOULES ENERGY CONSUMPTION PER YEAR

Challenges of Electrification\ Decarbonization & using Existing Grid

- Firm and flexible renewable power generation resources
- Electricity storage (Power to gas, Hydrogen)
- Energy balancing (generation = demand)
- Power grid stability (reserve power resources)
- Power efficiency and quality

Future role of H2 : complementary to electricity for decarbonisation

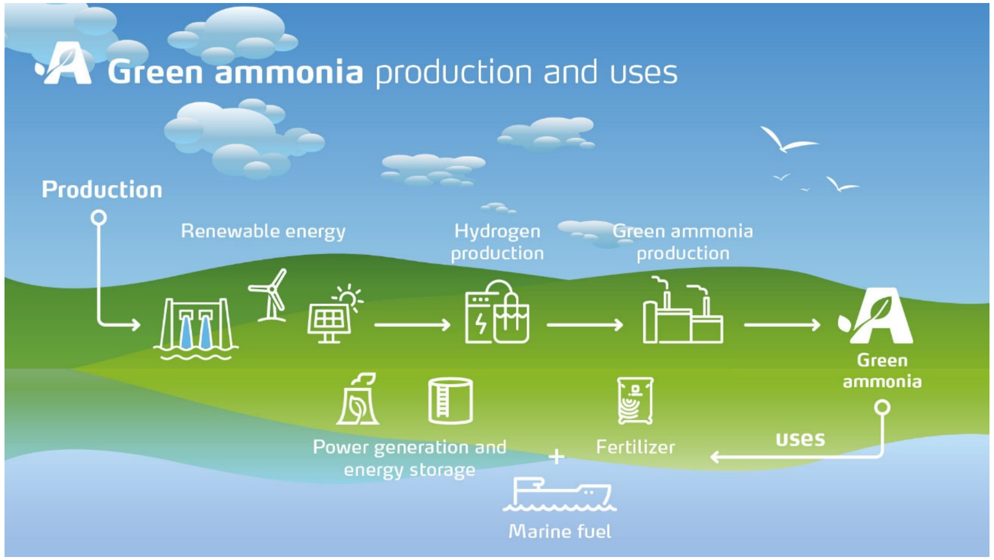


Generation – Transmission – Storage - Applications

Impact on power systems planning

- Location, type and operational mode of new electrolysers is a strategic system architecture question

Near to Consumers



For Example: Ammonia Feedstock

https://www.weforum.org/agenda/2021/01/green-ammonia-stop-fossil-fuels/

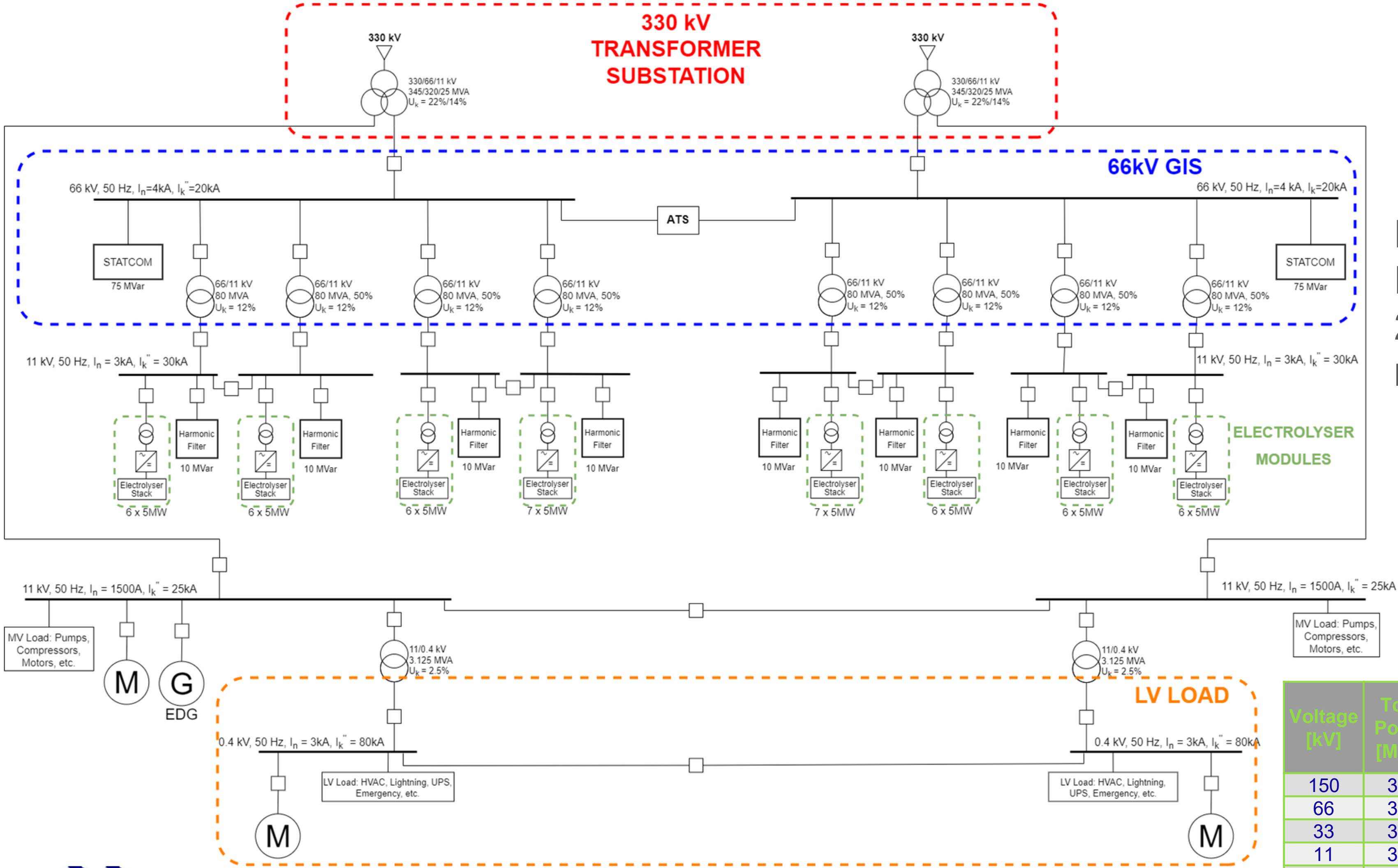
Near to renewable energy source

For Example: Offshore Wind \ HVDC

A rendering of an offshore green-hydrogen platform.Photo: Tractebel

Example: PEM Plant Typical Layout (1GW)

Challenge: Utility Grid – Power Connection

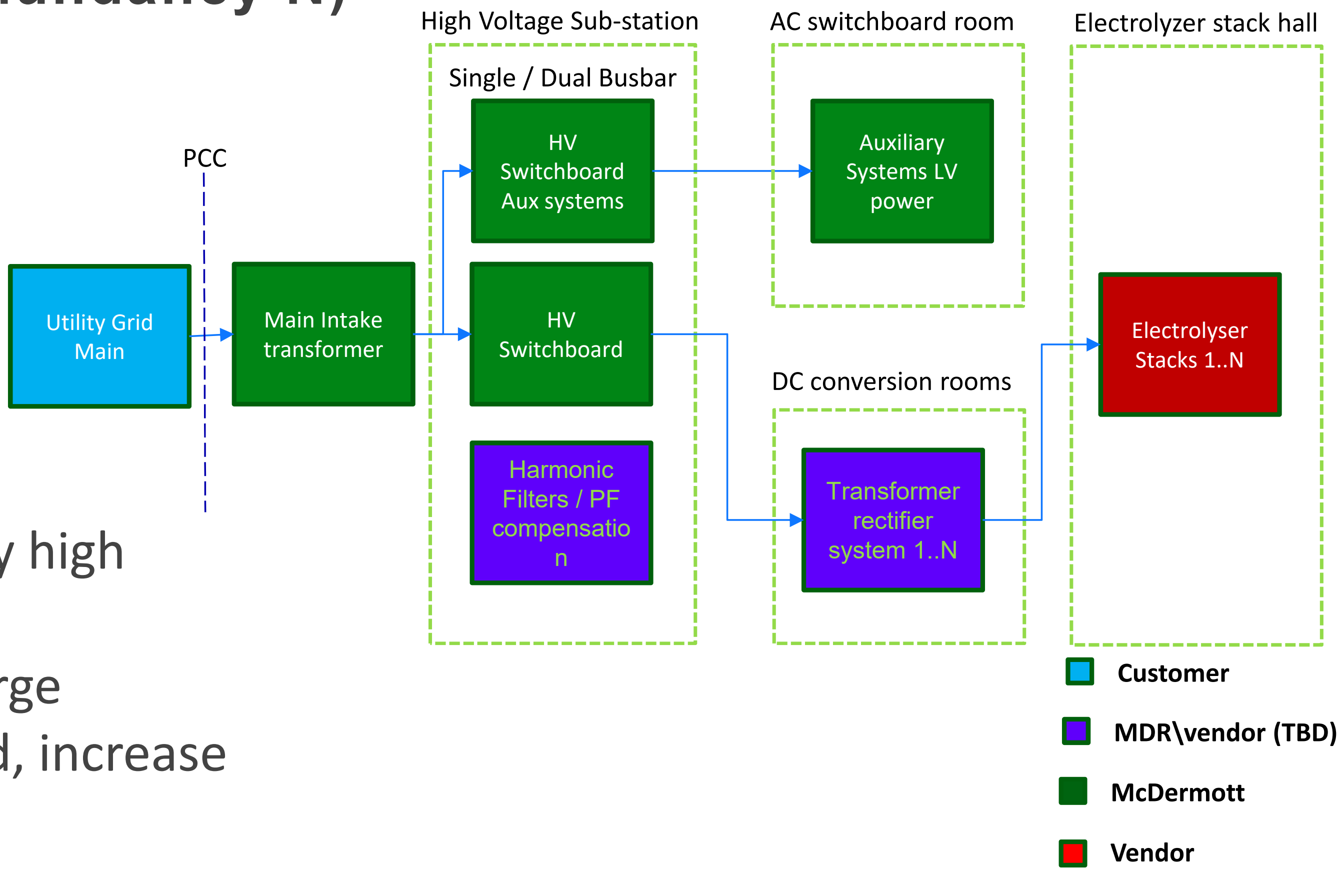


Example: 330/66/11 kV, Three-winding, 250 MWe, 5MW per module

Voltage [kV]	Total Power [MVA]	Bus Current [A]	Current Capacity per SWG [A]	Min. #Transformers
150	310	1431.83	4000	1
66	310	3254.16	4000	1
33	310	6508.31	3150	2
11	310	19524.94	3150	6
0.4	310	536935.75	10000	54

Challenge: Typical electrical configuration & redundancy depend on sizing of Plant

Electricity scheme A (Redundancy N)



Pros

- High over all efficiency due to higher equipment utilization.
- Lower CAPEX cost.

Cons

- Low redundancy, required very high reliability of equipment.
- Single point of failure cause large contingency for the power grid, increase grid security cost.

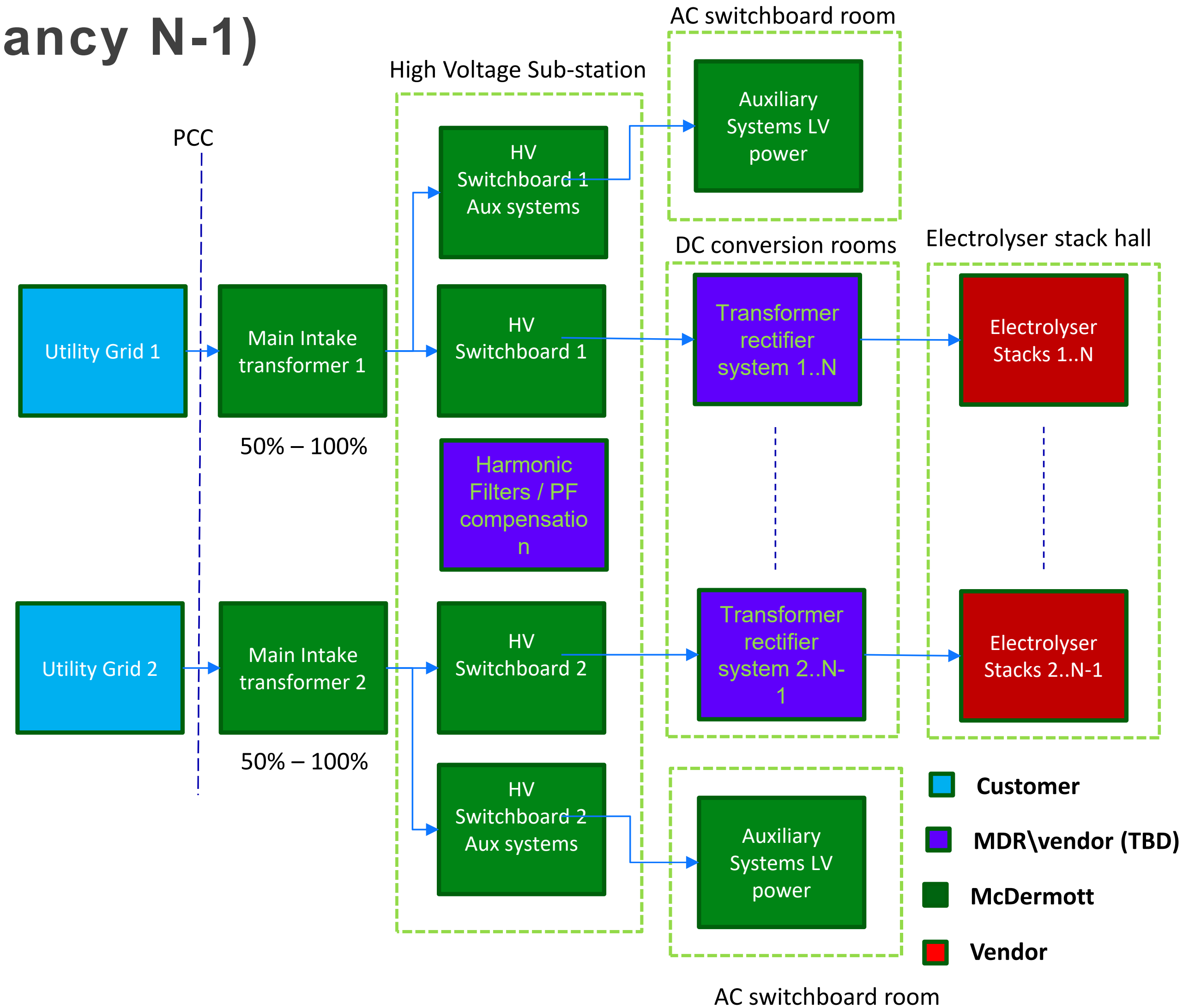
Electricity scheme B (Redundancy N-1)

Pros

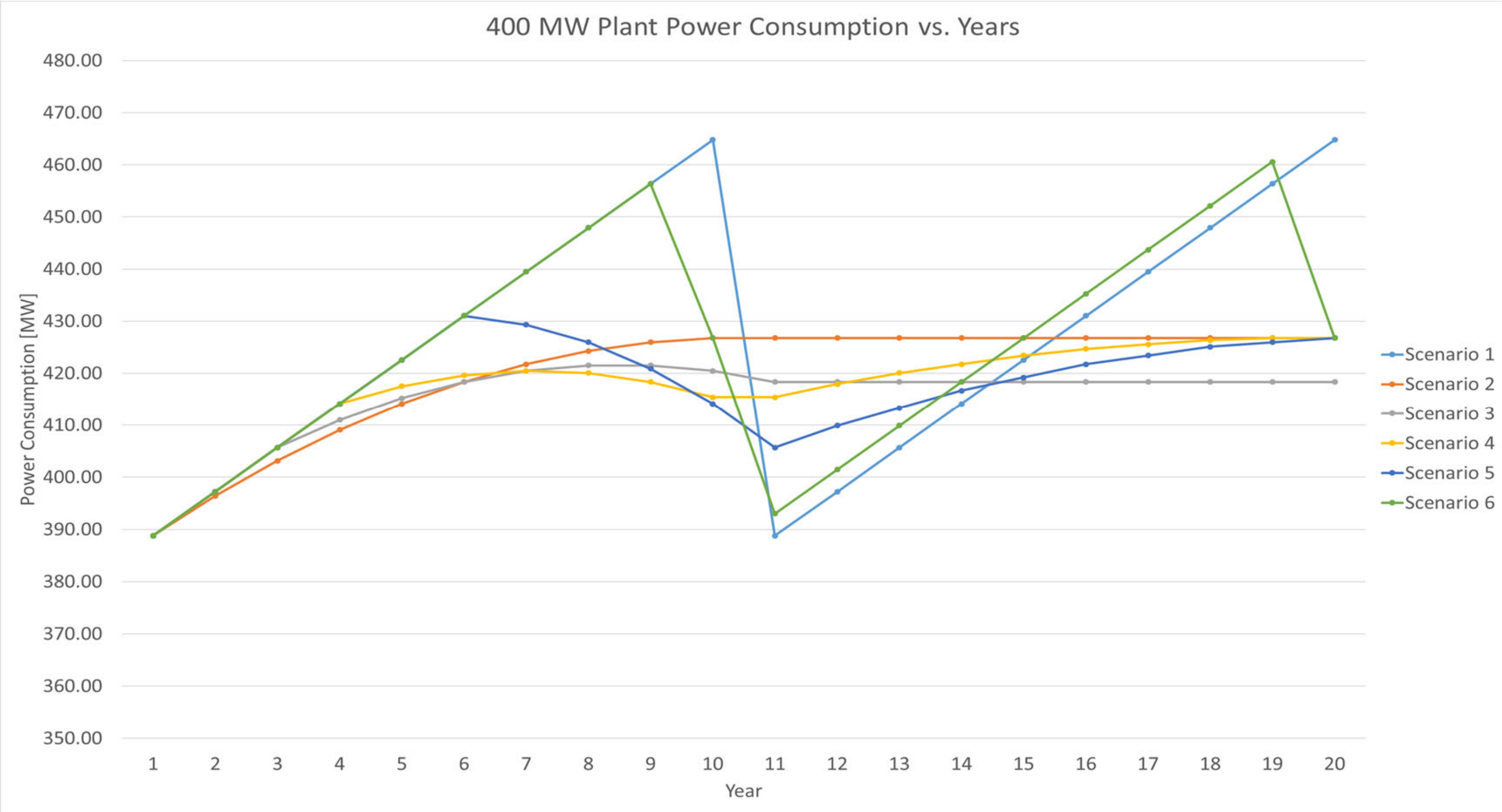
- Higher redundancy. No single point of failure.
- Flexible operation and maintenance capability.

Cons

- Higher CAPEX cost.
- Lower over all efficiency due to reduce equipment utilization.



Challenge: Sizing of Electrolyzer Stack & Monitoring power consumption @EOL



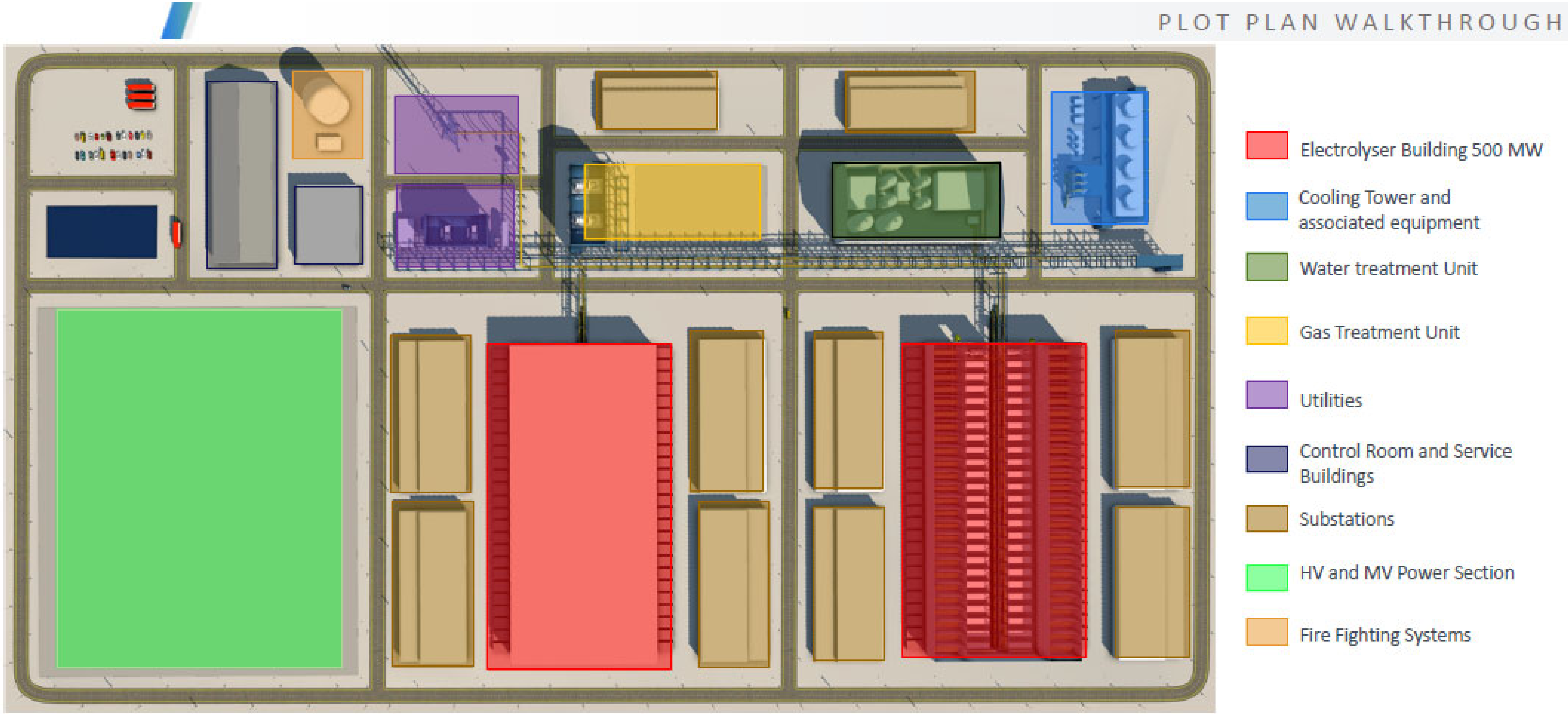
Scenario 1: replacing all at end of year 10
Scenario 2: replacing 4 arrays every year
Scenario 3: Start from end of year 3, replacing 5 arrays every year
Scenario 4: Start from end of year 5, replacing 6 arrays every year
Scenario 5: Start from end of year 6, replacing 8 arrays every year
Scenario 6: replacing 20 arrays at year 9 and 10

Example: 10MW array of PEM electrolyzer

Electrolyzer Array Replacement Scenarios

Power Consumption of 10MW Array per Year										
Year	1	2	3	4	5	6	7	8	9	10
1x10MW Array[MW]	9.72	9.93	10.14	10.35	10.56	10.78	10.99	11.20	11.41	11.62

Challenge: Balance of Plant (BOP) Vs Balance of system (BOS)



Example: PEM Plant Typical Layout (1GW)

Challenge: Emergency Power Supply (EDG vs Fuel Cell)

Nedstack PEM Fuel Cell

Fuel Cell

Emergency Power Supply

For further information on the content of this presentation, please get in contact:

Ahmed Labib, CEng MBA MSc Eng
ahmed.labib@mcdermott.com
MCDERMOTT

Thank you for listening…