“At Frames we encourage each other to stay curious. It helps us find new solutions for our clients.”

Jordi Zonneveld
Frames Group B.V.

- Integrator of process technology & instrumentation
- Design, Engineering & Assembly
- Alphen aan den Rijn, the Netherlands
- Since 1984
System integration

NextGenP2H2
Electrolyzer is the heart of the system

But you need a lot more to make a functional system
Water Treatment

Ultra pure water generation by reverse osmosis and De-ionization
Heat Management

Optimum stack temperature to be maintained
Oxygen Processing

Produced oxygen must be degassed from process water
Hydrogen Treatment

Produced hydrogen needs to be treated before it is a usable product
Power Supply

Available power to be made suitable for electrolyzer
AC/DC rectification
DC/DC conditioning
Shutdown & Purging

Automatic shutdown and blowdown with nitrogen in case of emergency
Safety & Control

PLC based Integration of all process & instrumentation control
Certification

- NEN-ISO 22734 hydrogen generators using water electrolysis process
- NEN-ISO 12100 Safety of Machinery – General principles
- IEC-60204 Safety of Machinery – Electrical equipment
- IEC-60079 Explosive atmospheres
- IEC-61000 Electromagnetic compatibility
- IEC-60364 Low-voltage electrical installations
- PED 97/23/EC Pressure Equipment Directive
- Local rules and regulations
Energy consumption
System efficiency

- System Efficiency vs. Hydrogen Production Rate [kg/h]
- Power Input vs. Hydrogen Production Rate [kg/h]

Graph showing the relationship between system efficiency and power input as a function of hydrogen production rate.
• Optimizing design will decrease CAPEX
• Increasing capacity of individual systems reduces Cost per kg H$_2$
• Fine balance between OPEX and CAPEX
• Scaling up quantities and volume will reduce cost
Next Steps

- Integration of water treatment
- Integration of Gas treatment to 99.999% purity
- Improved monitoring and control
- Reduced plotspace from 20ft container to 3m x 2m
- Modular design for accelerated assembly
Conclusion

- Integration of complex processes requires specific know-how
- Multi-disciplinary engineering asks for structured and iterative engineer
- Systematic approach to safety in all stages of engineering & design
- Cost need to come down to increase competitive advantage
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Thank you