



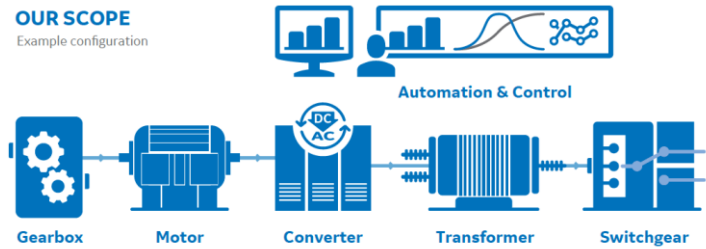
# DOE H2-PACE

## Commercial Systems Development & Qualification

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# Solution Overview & Industry We Serve

**OUR SCOPE**  
Example configuration



**+ Government  
(US DOD / US Navy)**

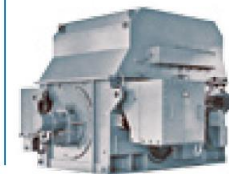
**Motor since 1900  
Power Electronics since 50's**



**Core Products**

**Rotating Machines for Motors and Generators**

- Motors**
- Induction and synchronous
  - Speed: up to 18,000 rpm
  - Power: up to 100 MW
  - Voltage: up to 15 kV (up to 22 kV on request)
- Generators**
- Induction and synchronous
  - Speed: up to 18,000 rpm fixed or variable
  - Power: up to 80,000 kVA
  - Voltage: up to 15 kV (up to 22 kV on request)



**Power Electronics for MV and LV Drives**

- MV Drives**
- Output Power: 3-100 MW
  - Output Voltage: up to 15 kV
  - Output Frequency: up to 300 Hz
  - Input Frequency: 50 or 60 Hz
- LV Drives**
- Output Power: from 0.5-8 MW
  - Output Voltage: 400-900 V
  - Output Frequency: up to 300 Hz
  - Input: up to 1500 V



**Control and Automation, and Digital Services**

- Drives and Systems C&A**
- High Performance Controller (HPCi)
  - Power Electronic Controller (PECe)
  - Visor
  - Vessel Control Systems, intelligent power management
- Digital Marine**
- SeaStream™ DP
  - SeaStream™ Insight
  - Remote monitoring and diagnostics
- Digital Services**
- Metals, Mining
  - Drives and rotating machines Asset Performance Management



**GE's Electrification business. Innovation is our DNA**



# Power Electronics for Electrolysis – Thyristor based

## Electrolysis Rectifier Building Block - Type 5MVA

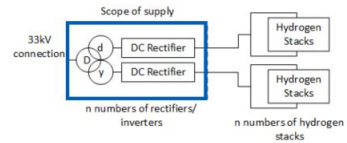
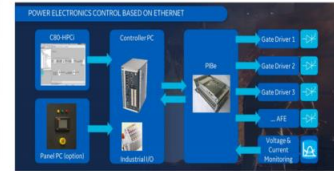


### Technical overview



Data 6 Pulse	
Voltage	0-1400 Vdc
Input frequency	50/60 Hz
DC current	2 – 17.6 kA
Transformer	6/11/20/33kV water cooled with tape changer
Trafo-rectifier Efficiency	98.5%
Control technology	HPCi (High Performance Controller)
Bus technology	Profibus / Optical

### Control



Scope of supply: Rectifier with Rectifier transformer 11 MVA

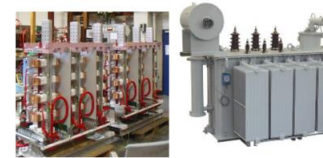
Air-cooled 5MVA building block

Main features	Benefits
Press-pack SCR (Thyristors or IGBT)	High power density
Well known design	Varied used for dc and synchronous drives
N-1 redundancy	High reliability as designed for n-1 operation with rated current
Multiple Pulse system	12/24/48 or higher
Air cooled or air/water heat exchanger	Ready for container installation

## Electrolysis Rectifier Building Block - Type 25MVA



### Technical overview

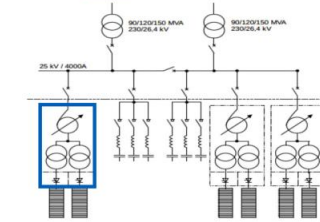


Data	
Voltage	0-1400 Vdc
Input frequency	50/60 Hz
DC current	up to 45 kA
Transformer	up to 66kV water cooled with tape changer
Trafo-rectifier Efficiency	98.5%
Control technology	HPCi (High Performance Controller)
Bus technology	Profibus / Optical

### Control



GE PC HC Powersemi Rectifier & Rectifier Transformer



Scope of supply: Rectifier with Rectifier transformer 50MVA

High-Current Water-cooled 25 MVA building block

Main features	Benefits
Press-pack SCR (Thyristors)	High power density
N-1 redundancy	High reliability as designed for n-1 operation with rated current
Multiple Pulse system	12/24/48 or higher
Water cooled	Ready for container installation

- Power System Study
- Installation Design
- Associated Power Electronic for Grid Power Quality
- E-House / Switchgear
- Automation as needed



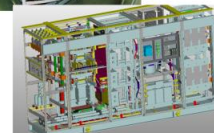
### Passive harmonic filters

- Specification & procurement of components
- erection



### TCR – thyristor-controlled filter

- PowerSemi product range



### STATCOM

- Standard VFD
- MMC



## Power Electronic System Integration & Engineering Expertise

# Future Power Electronics for Grid enabled H2 Plant

## LV8 High Performance Module Drive

### Technical description



LV8 Power Converter



	Range
<b>Voltage</b>	40-920 Vdc Higher with modularity
<b>Input</b>	50/60 Hz
<b>Frequency</b>	400-690Vac
<b>Power</b>	0.25 to 4MVA
<b>Load type</b>	AC (Grid or Motor) DC/DC
<b>Key features</b>	Air / Water Cooled Up to 12kHz

### References and applications

- First unit installed in '07
- 6 GW/20 000+ units installed including legacy model
- Used in many Industries (Test benches, Metals, Grid etc.)

Main features	Benefits
<b>Module IGBT</b>	High efficiency AFE drive 98%
<b>2-level VSI topology</b>	High reliability
<b>Front access</b>	Easy maintainability
<b>Modular</b>	500-750-1000A single unit and multi-unit >10,000A

## MV7 High Power Density Medium Voltage Drive

### Technical description



MV7 converter



MV7 Power module

	Range
<b>Voltage</b>	3.3 – 13.8 kV
<b>Frequency</b>	Up to 300 Hz
<b>Power</b>	3 – 100 MW
<b>Load</b>	AC (Grid or Motor) DC/DC
<b>Key options</b>	AFE configuration Transformer-less

### References and applications

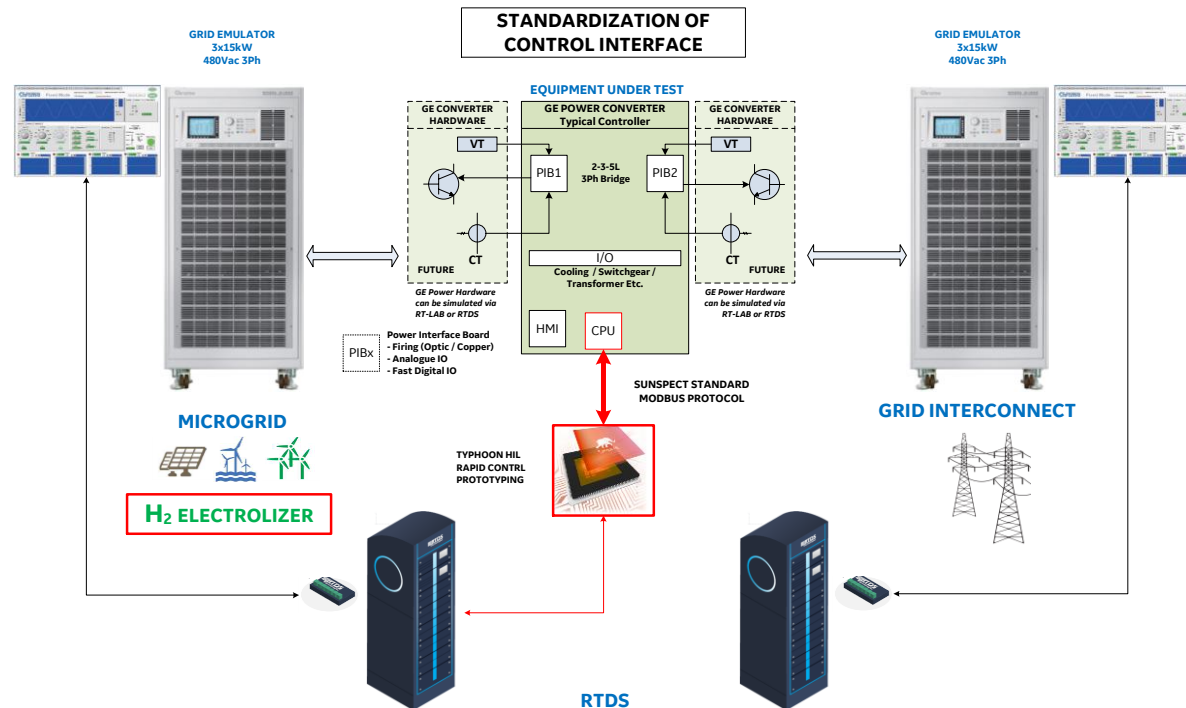
- First unit installed in '05
- 19+ GW/2000+ units installed
- 80+ million hours of operation
- Used in all sectors (Marine, O&G, Industry Power & Industry)
- Proven in various applications including Navy support vessels

Main features	Benefits
<b>Press-pack IGBT</b>	High power density 2.5 MW/m (HxD 2.5x1m) High efficiency 99%
<b>3-level and 5-level NPP topology</b>	High reliability
<b>Front access</b>	Easy maintainability
<b>Modular</b>	750 up to 3000A single unit and multi unit >9000A

- PMW based. AC/DC and DC/DC power converter.
- Use of IGBT, MOFSET and increase market penetration of SiC devices with lower cost
- Modular and Scalable from 1 to 100MW
- Use of Distributed Energy Resource (Wind, Solar, Battery Storage)
- AC or DC Microgrid. LV or MVDC. Seamless integration to MV Grid (Tranformerless)
- Grid flexibility & Interoperability
- Controller Interface to Utility / ISO / Energy Management system to participate in real time to macro economic

Complete AC/DC and DC/DC offering in LV and MV range

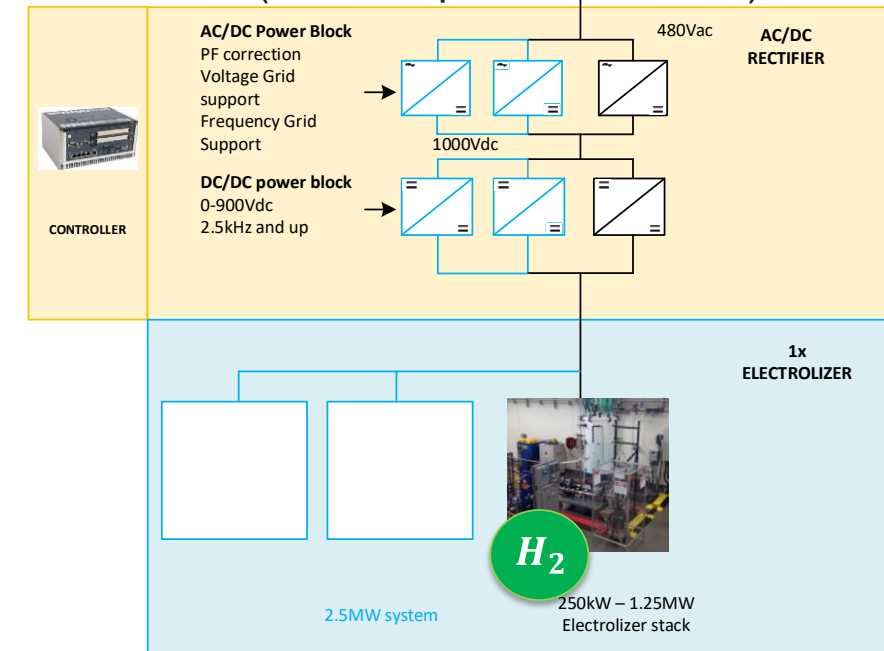
# Future Power Electronics for Grid enabled H2 Plant Scalability & Standardization



## Requirement

- Standardization of the power and control functions
- Standardization of the power converter testing

- Scalability for Electrolyzer Stack
- One Electrolyzer Block (250kW up to several MW)



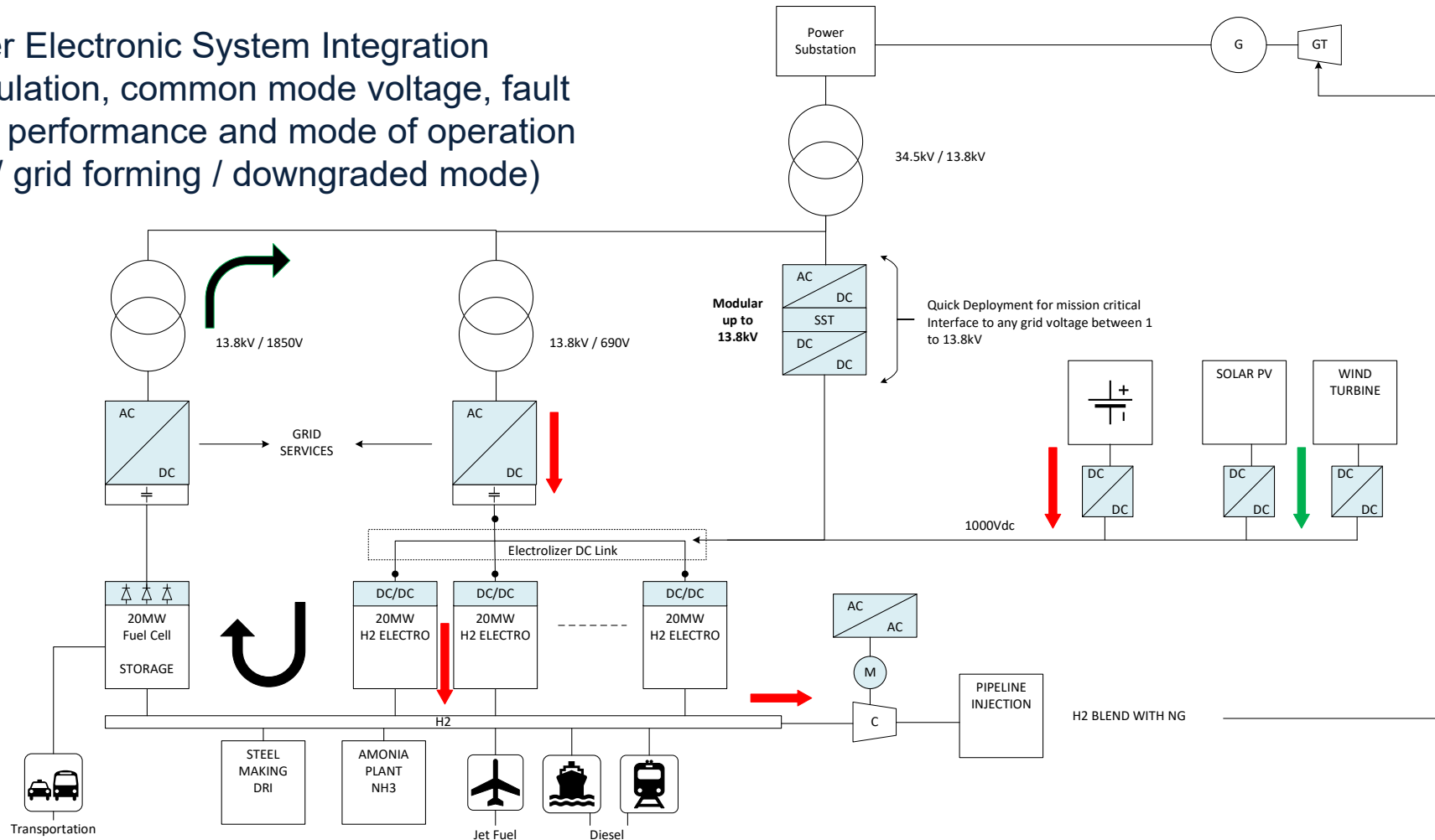
## Benefit

- Reduce the deployment cost and controls integration through standardization.
- Provide additional revenue source for electrolyzer through participation in grid services.

## SYSTEM ARCHITECTURE - PLANT INTEGRATION & MicroGrid

# Future Power Electronics for H2 Plant – MicroGrid

- Require Power Electronic System Integration Expertize (insulation, common mode voltage, fault management, performance and mode of operation (grid follower / grid forming / downgraded mode))



## Complete Power Electronic System Integration

## Smarter Electrolizer vs H2 cost

- PE supply ~ 15-20% of Electrolizer Cost (below 1MW)
- Grid Enabled Electrolizer -> Increase PE cost -> Increase CAPEX

**How to offset the cost for new power supply ?**



**Identify best revenue source for Grid Enabled Electrolizer (Demand response, Wholesale etc.)**  
**Identify major beneficiaries (Utility, Industrial and others)**  
**Identify potential benefit of Digitalization of large scale Electrolizer (100MW)**



**STANDARDIZATION + AT SCALE TESTING**

**COOPERATIVE AGREEMENT & PARTNERSHIP**



Building a world that works





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# Backup Slides

# We are Power Conversion... GE's electrification business

## Industry

### ACROSS MULTIPLE INDUSTRIES



Oil & Gas



Marine



Mining



Metals



Power Gen



Power Quality & Supply



Pumped Storage



Test Systems



Water



Wind Services

### CORE OFFERING



Rotating Machines



Power Electronics



Services



System Integration & Engineering expertise



High tech system & Digital Solutions

### GLOBAL & LOCAL PARTNER



3,500+ people, 160+ countries





# Innovation is our DNA

ELECTRIFICATION



SUSTAINABILITY



DIGITAL




World-Scale Electric Liquefied Natural Gas (eLNG) Plant in North America

eLNG



Electrifying the World's First Tidal Projects

Tidal Power



World's Largest Offshore PMG Wind Turbine

6 MW

WIND PMG



VSI Uwave

Largest VSI drive in the world

Ultimate Waveform Drive



Optimize ship design for energy efficiency & opex

VesPA digital design tool




Mining World's only project in 2014 on dual pinion.

Grinding Mill Drives



Full electric propulsion & hybrid electrical systems

Next Generation Aircraft Carriers



N Series Highest Power Density

N37 Motor



MV6

MV7000

MV Series Drives



World's First 80 MW Induction Motor

High Power Induction Motor



SeaStream Insight Marine APM

Digital Marine

ecomagination™

