Advanced Electrochemical Hydrogen Compressor
Giner ELX Profile

- Giner has been a world leading innovator in electrochemical technologies for over 40 years
  - Life support in space and undersea
  - Implantable oxygenators to support cell therapies
- We span out GINER ELX in April 2017 to focus on multi-MW PEM electrolysis stacks and systems for commercial applications
  - Renewable energy storage

Synergy of Giner, Inc. Technologies
Overview

G5

Our next generation commercial electrolyzer stack. Designed specifically for our lab scale hydrogen generator OEMs using the latest technologies developed for our larger products. Also popular with academic institutions and for use in specialty water electrolysis applications.

Specifics
- 50 cm² nominal active area
- 450 A/cm² - 1600 A/cm²
- Higher flow rate stacks available
- Differential or balanced pressure
- CE Mark
- In stock

Overview

Pemi

Overview

Goderd

Overview

Merrimack

Overview

Allagash

Overview

Kennebec

Overview

Electrolyzer Systems

Giner ELX electrolyzer systems incorporate our world-leading PEM electrolyzer stack technology. They deliver pure hydrogen (99.999%) safely, cleanly, efficiently and reliably at pressures up to 40 bar or 500 psi.

Applications include:
- Energy storage of surplus electric energy—particularly of renewable solar or wind energy—by converting it to hydrogen for fuel use.
- To power fuel cell vehicles or hydrogen turbines
- As an industrial gas
- By blending into the natural gas supply network
- Hydrogen-fueling stations for fuel cell powered buses, cars, trains, trucks, forklifts...and beyond
- Chemical hydrogen production for industrial users:
  - Electrolysis on-site
  - Hydrogenation for food manufacturers
  - Steel industry processing
  - Gas chromatography and other laboratory devices

Specifics

- 3000 cm² (nominal) active area
- 40 years of satisfied customers
- To 2500 kg/day
- 0 to 225 bar (15.5 bar)
- Customizable

300 kW System
- 20 ft container
- 150 bar
- 1000 kg
- 1000 kg/hr

1 MW System
- 30 ft container
- 405 bar
- 2000 kg/hr
The Giner ELX Advantage

Highest performance and lowest cost

- Giner ELX’s commercial electrolyzer portfolio achieves industry leading specifications:
  - Current density: 3 A/cm²
  - Temperature: 70 C
  - Pressure: 40 bar diff standard
  - Highest efficiency
  - Lowest total cost of ownership

- Clear development roadmap to green hydrogen at a cost of $1.50 per kilogram (assuming power at 2 cents per kWh)
  - Based on technology advances already being demonstrated in our labs

Aerospace/Military Applications

Commercial/Industrial Applications
Emerging Designs for Future Applications

New Market Trends Require Larger Stacks

Giner ELX 5MW Stack Platform
- Active Area: 3,000+ cm²
- Current Density: 5A/cm²
- Operating temperature: 90 C
- Operating Pressure: 600 psig (40 Bar)

5 MW
25 kW/cell

1 MW+
3,750 Amp
>10kW/cell
**Wind to Hydrogen**

- Netherlands
- Centralized hydrogen production
- Hydrogen used for transportation applications
- 4 Allagash stacks directly coupled to each windmill
  - Elimination of rectifier in electrolyzer
    - Eliminates equipment redundancy
    - Improves system efficiency
    - Capital cost improvements

**Emerging Markets & Drivers**

- Power to Gas (P2G): Biogas
- Power to Mobility (P2M)
- Power to Hydrogen (P2H): Integration of Renewable Energy Sources
- Grid load shedding
Giner ELX PEM Electrolyzers have penetrated many of the hydrogen production utilization activities mentioned in H2@Scale.

**ELX Recent Activities**

- **UK**: Lab Hydrogen (30,000 units)
- **Netherlands**: Wind to Hydrogen/Mobility (Multi-MW)
- **Finland**: Synthetic Fuel w/CO₂
- **Belarus**: Industrial (200 kg/day)
- **France**: Major Utility company H₂ Generator Subsystem (200 kg/day)
- **Germany**: Bio-Methanization (240 kg/d)
- **Germany**: Supplying stacks to integrators - Industrial use. Follow up orders for 300 kg/day
- **India**: Mobile Refueling Unit, Follow up order 200 kg/day

- **Spain**: Hydrogen Refueling Station (65 kg/d) Follow up Projects Multi-MW
- **Portugal**: Emission Control
- **USA**: Onsite Hydrogen Generation HRS, CA (3x200 kg/d)
- **Brazil**: Industrial (200-kg/day)

Image Courtesy: Department of Energy, Office of EERE
Advanced Electrochemical Hydrogen Compression (EHC)

“Mechanical compressor reliability is a major concern in high pressure hydrogen systems and threatens the deployment of a hydrogen infrastructure”

- Giner ELX developing NEW solid state Electrochemical Hydrogen Compressor (EHC) technology to support FCEV penetration
- 900 bar hydrogen compression
- Reduce cost, improve reliability, and increase in efficiency of EHCs
EHC Cell Performance @ 350 bar (5,000 psi)

- Successful EHC Operation @ 5,000 psi (350 bar), ≤ 0.250V @ ≥ 1,000 mA/cm²
  - Single stage compression
  - Compression ratio 140:1
  - Performance: 0.217V @ 1000 mA/cm², 5,000 psi
- Back diffusion reduced by > 50% to < 3%
- Stack Efficiencies to 2.7 kWh/kg-H₂
- Highest Efficiency for EHC operating at 5,000 psi
EHC Stack Design & Development

875 bar Stack Design Features

- Proof pressure: 20,000 psi (1,400 bar)
- Active Area Scale-up: 50 to 300 cm²
- Utilizes low-cost materials: SS
- Enhanced bipolar plated design for reduced part count and dead-ended flow
- CE/UL Certification
  - Intertek review of ‘NEW’ H₂ compression technology

System Features

- System designed to be located in hazardous areas, zoned for Class 1, Div2, Grp B
  - UL Certified
Future Plans

Membrane/Stack/System
- Scale-up, Scale-up, Scale-up…
- Increase stack active-area to 300 cm², and then 1200 cm² +
  - Also requires scale-up of membranes
- Increased operating pressure
  - Currently operating at 5,000 psi. Increase to 12,688 psi
  - Maintaining seals of stacks at operating pressure of >12,688 psi
- Complete review of EHC System with Intertek
  - Established appropriated standards, component classifications, and operating requirements for certification
- Reduce Stack Costs
  - Unitize cell components (reducing parts/cell)
    - Combine cell components at the production level
    - Investigate techniques to reduce fabrication costs
Monjid Hamdan
VP of Engineering
mhamdan@GinerELX.com

Hector Maza
VP of Business Development
hmaza@GinerELX.com
+1 (781) 392-0307

Andrew Belt
CEO & President
abelt@GinerINC.com

Support for EHC provided by the
Department of Energy