



Addressing the Challenges in Hydrogen Infrastructure

5 Challenges <> 5 Solutions

Daryl Wilson
President & CEO Hydrogenics



Five Challenges of Fuelling Infrastructure

1. Challenge to innovate
2. Challenge to address funding & cost
3. Challenge to preserve green attributes
4. Challenge to find fresh business models
5. Challenge to think energy systems



Source: Pike Research, Markets and Markets, and Wall Street Research



There is a world of experience to harvest here!

**With more than 300 global fueling installations
More than 40 within Hydrogenics portfolio**

Some Lessons Learned Reflection is Timely





WaterstoNet, Brussels, Belgium
65kg/day, 350bar



Ruter/AL, Oslo, Norway
260kg/day, 350bar

Challenge: Innovation

The Problem: We use what we have rather than challenge what is needed

A positive approach: Linde Ionic Compression

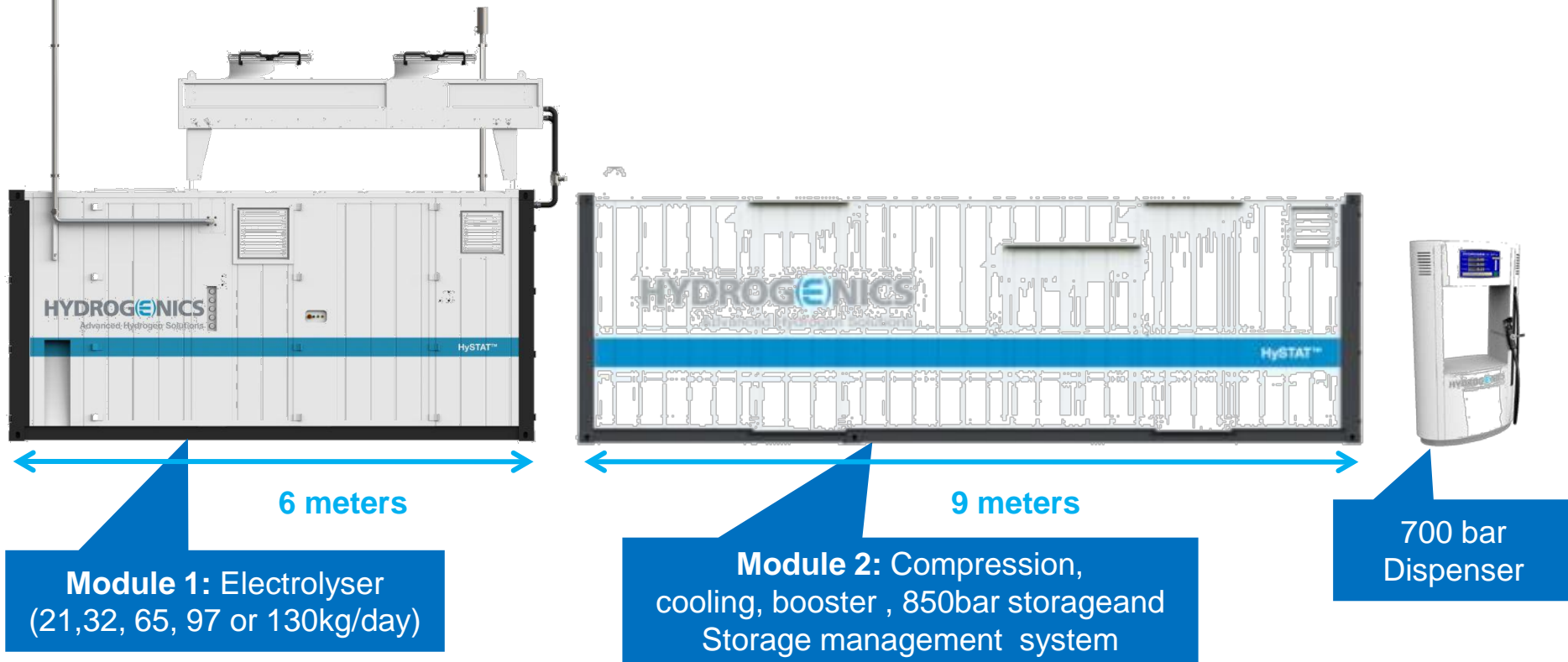
Hydrogenics Contribution:

Next Gen. MW Class PEM Water Electrolysis
6 x spatial improvement in onsite generation
 $2\text{MW} > 12\text{MW} = 5000\text{kg/d} = 1000 \text{ cars}$

Some recommendations:

1. Future JTI programs to reward innovation
2. Set targets to drive innovation
3. Ongoing Technology road mapping

700bar Fueling Station Setup



- Hydrogen quality: **Fuel Cell Grade (99,998%)**
- Fill type: **According to SAEJ 2601 requirements**
- Consumption: **68 kWh/kg H2 produced**
- **Fully interconnected and centrally controlled**



Vattenfall, Hamburg, Germany
Largest European H₂ Station owned by a utility
1 MW Hydrogenics Electrolyser – Project by Linde

Challenge: **Cost & Funding**

The Problem: After billions of vehicle R&D we are stuck on who pays for communal assets

A positive approach: Mitsui cost target challenge

Hydrogenics Contribution:

Scale merit of increased demand $n=100$ pricing

Cost reduction in balance of plant design “eliminate”

Energy system integration with storage & stabilization

Some recommendations:

1. Cost mapping of all costs followed by reduction challenge
2. Risk management, standards & safety best practices
3. Business model & energy systems approach has impact
4. Vehicle / infrastructure agreements which plan for funding



Postauto, Brugg, Switzerland
130kg/day, 350bar



Challenge: To Preserve Green Attributes

The Problem: After developing a power train capable of 90%+ GHG / CO2 emissions reduction we settle for just 55% (less than half)

A positive approach: California “Green H2 incentive”

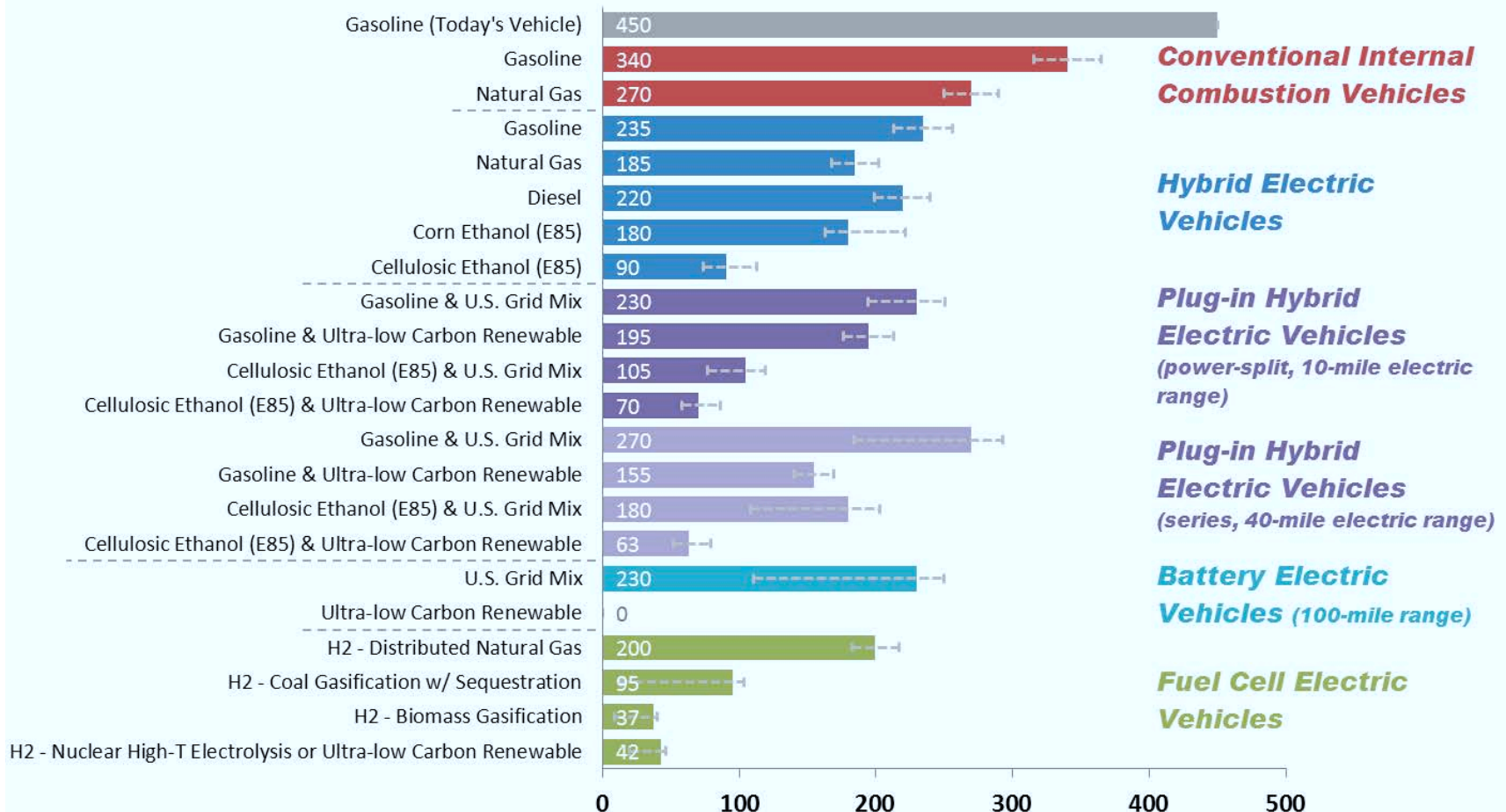
Hydrogenics Contribution:

Increased electrolysis current density and efficiency to 90%
Create total life cycle cost model which delivers on target

Some recommendations:

1. Incentivize green hydrogen pathway over alternatives
2. Allocate capacity in favour of green pathway

Electrolysis: $450 > 42 \text{ g CO}_2/\text{mile} = 90\% \text{ Reduction}$
NG: $450 > 200 \text{ g CO}_2/\text{mile} = 55\% \text{ Reduction}$



Challenge: To think of business models

The Problem: We are quickly trapped in the old paradigm of commodity delivery rather than thinking about the total business model

A positive approach: California station owner incentives

Hydrogenics Contribution:

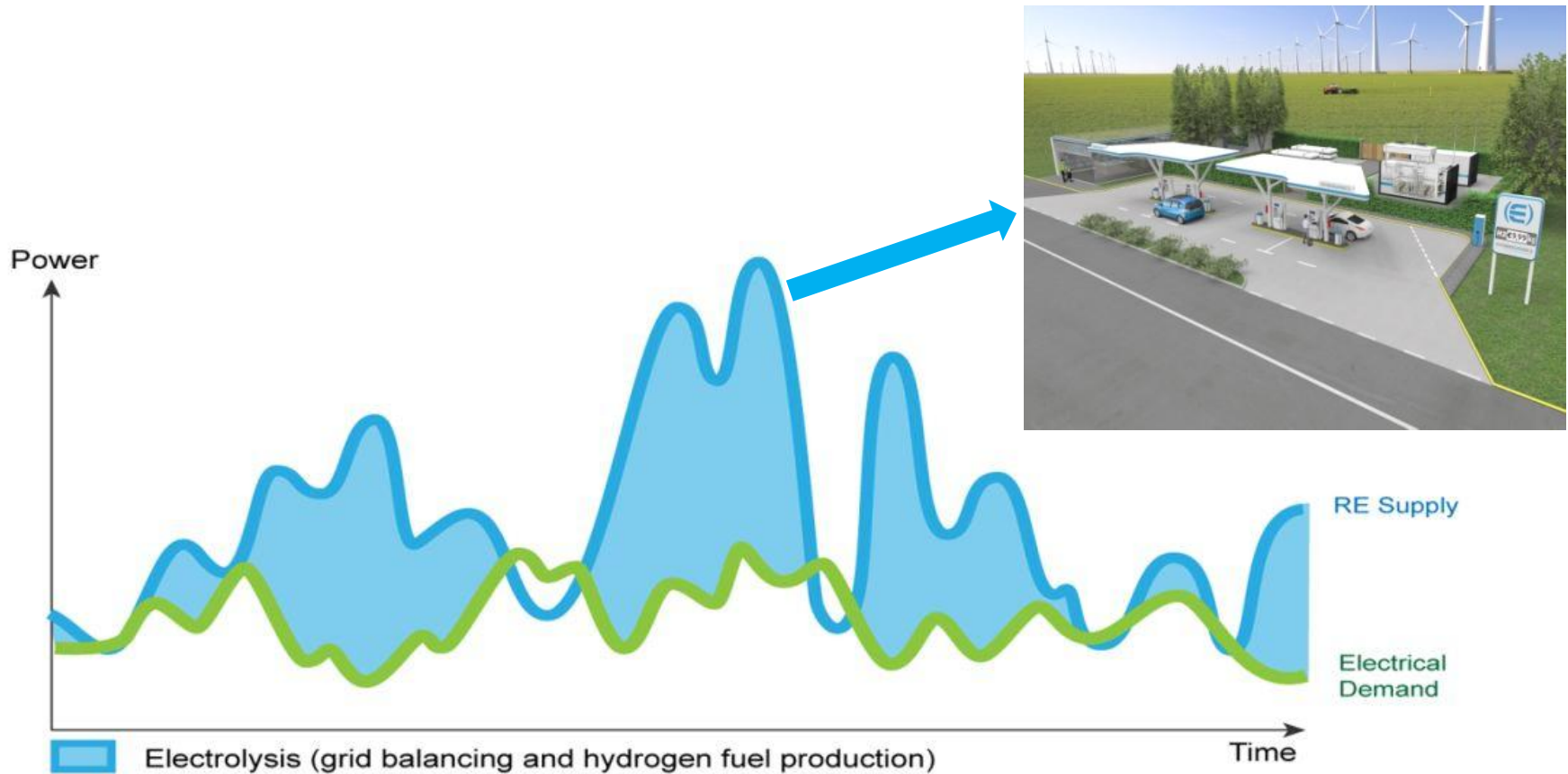
Energy storage and stabilization services (patented)

Create total life cycle cost model which delivers on target

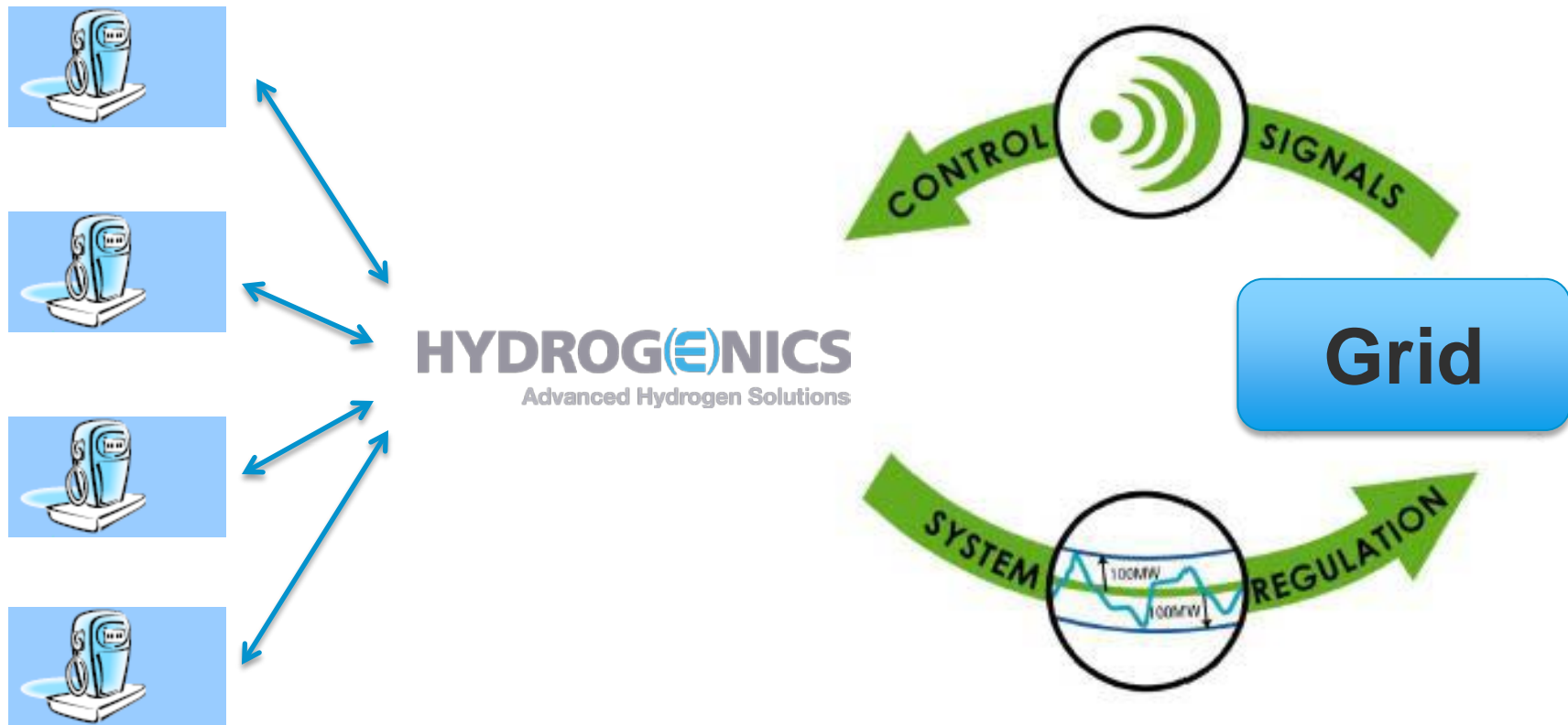
Some recommendations:

1. Consider the value of energy services for electrical grid
2. Consider local energy dynamics in time
3. Consider available or forecasted “surpluses”

Increasingly we have “excess” electricity



Hydrogen Fueling Station Control and Optimization



Challenge: To think of total energy systems

The Problem: We continue to see fueling infrastructure as an isolated element of the total energy system and fail to recognize synergies.

A positive approach: No one has done this yet!

Hydrogenics Contribution:

Energy storage and stabilization services (patented)

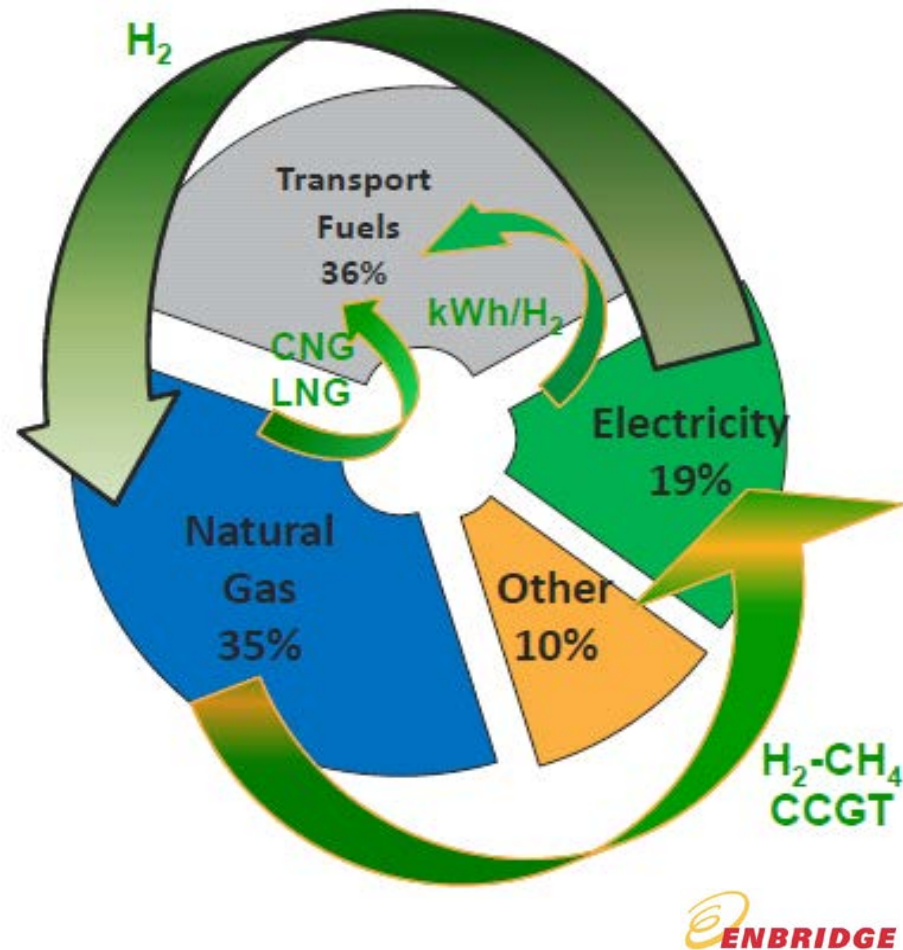
Flexible operating regime for electrolysis with “overdrive”

Some recommendations:

1. Integrate the shock absorbing attributes of electrolysis
2. Develop economic models for electricity price and services
3. Treat fueling as part of a whole system / operate as such

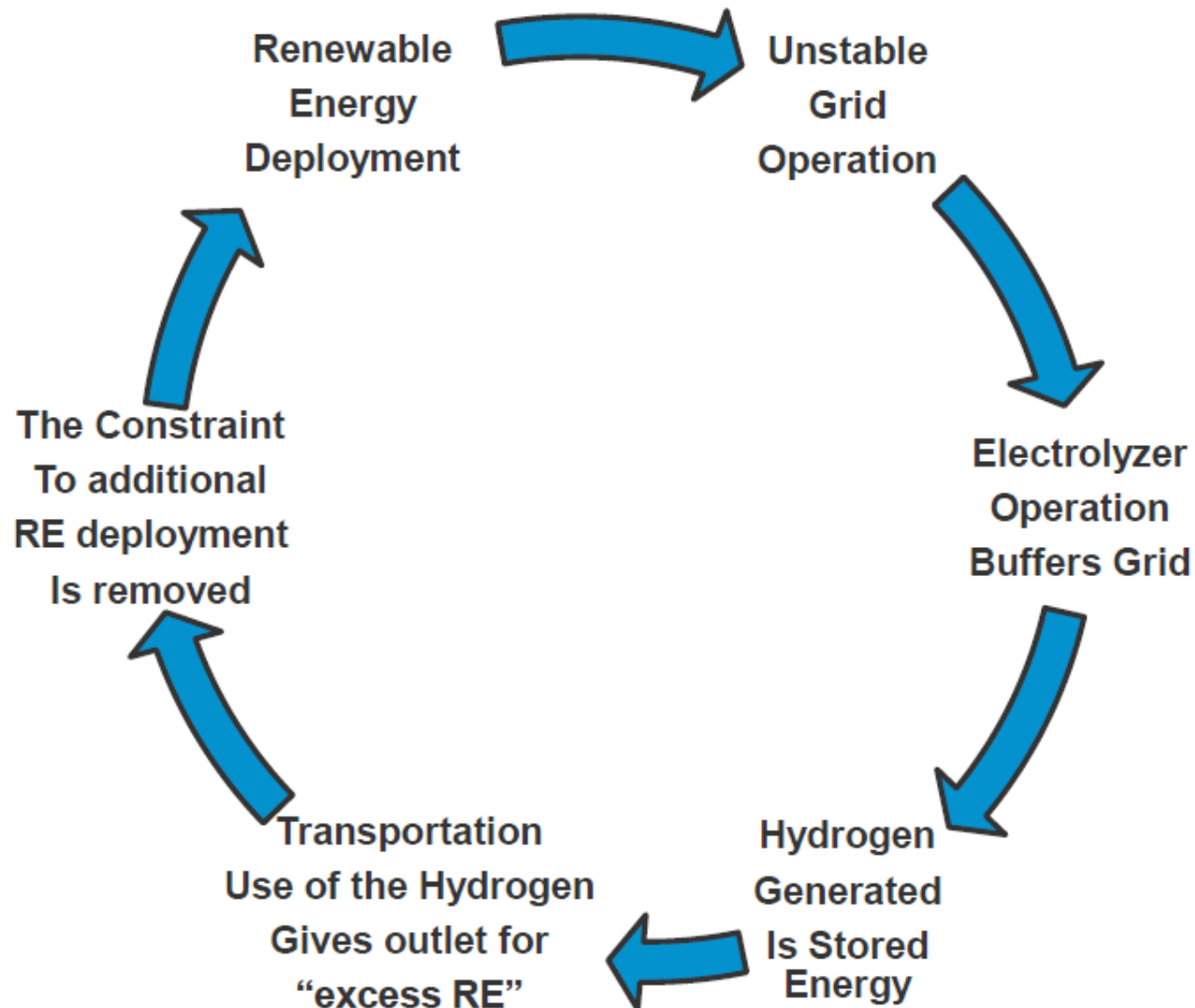
What is Power-to-Gas?

A Power-to-Gas Solution brings new economic and technology flexibility between the traditional energy silos of power grids, gas pipelines and transport



Source data: National Energy Board secondary energy demand forecast, Rethinking Energy Conservation in Ontario, May 2010 report

A Virtuous Cycle with electrolysis



Hydrogenics' team added value

- Direct contact with the manufacturer
- Dedicated Technology and R&D team
- 60 years of experience and professionalism
- Over 45 fueling stations delivered worldwide
- Safety and reliability is our main concern
- Design, production and startup by Hydrogenics
- Worldwide start-up and After-sales service
- Full maintenance contract possibility
- Recognized by major companies



