The MYRTE project: implementing hydrogen energy storage through the 'GreEnergy Box'

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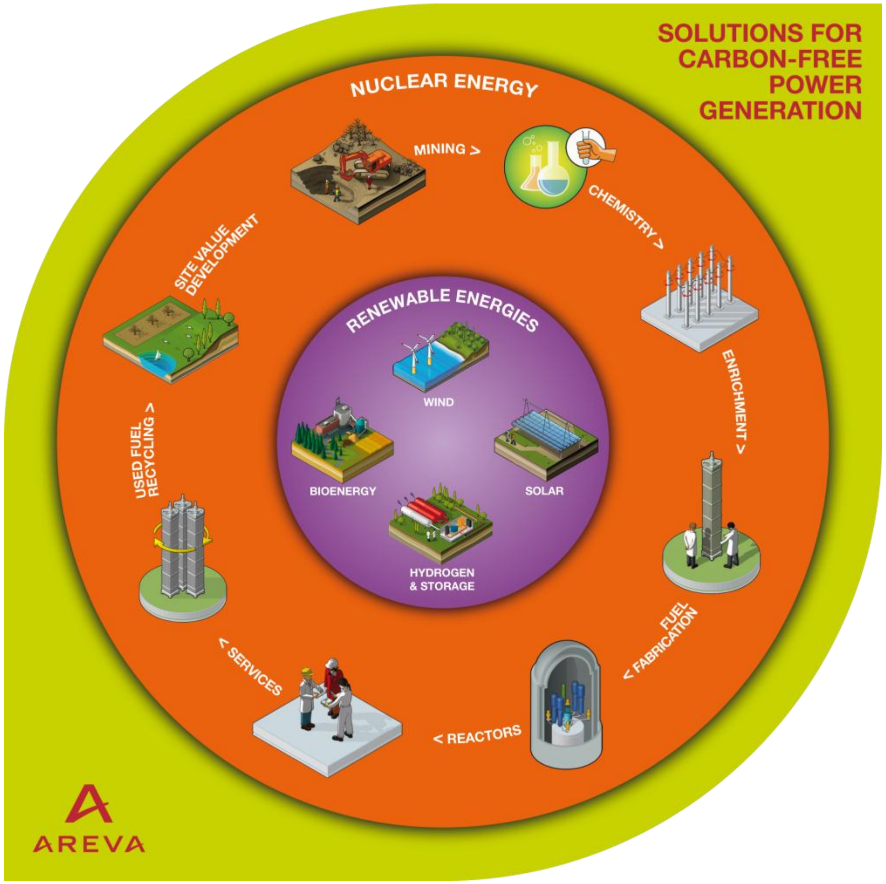
AREVA Fuel Cells activity



A Business unit dedicated to hydrogen and energy storage

- **Complete and competitive solutions:** Design, development and manufacturing of PEM* H_2 / O_2 fuel cell and electrolyzer systems, producing hydrogen by water electrolysis and electricity with fuel cells
- **Safe and reliable solutions:** Safe, reliable, clean and economical energy solutions for backup power and energy management applications in a power range from 5 kW to 2 MW

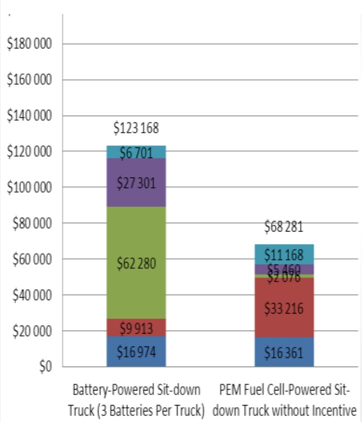
Creation	March, 2001
Headquarter	Aix en Provence, France
Headcount	60 employees
Shareholder	100 % AREVA Renewables
Certification	ICPE – ISO 9001 – ISO 14001

*(Proton Exchange Membrane)

Some H_2 based economic models are dominating

Powering ForkLifts

NPV TCO Batt Vs FC Powered Forklifts



- **Reduced down times**
- **Improved fleets productivity**

Telecom Back Up

- **Improved Reliability**
- **TCO reduced via lower OPEX**
- **Eco-friendly solutions**

Models related to Hydrogen Energy Storage can work

Relevant applications have to be targeted

From RTD to implementation

- **Achieve Scale 1 technology demonstrations**
- **Turn demonstrations into packaged product and focus on customer services issues**
- **Build the relevant supply chain to deliver the target cost to the costumer**
- **Demonstrate economic value proposition and identify target product costs**

MYRTE – The Scale 1 Technology Demonstration
General view

l'Europe s'engage en Corse

Collectivité Territoriale de Corse

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
Préfecture de Corse

Università di Corsica Pasquale Paoli

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Myrte Project Data Sheet

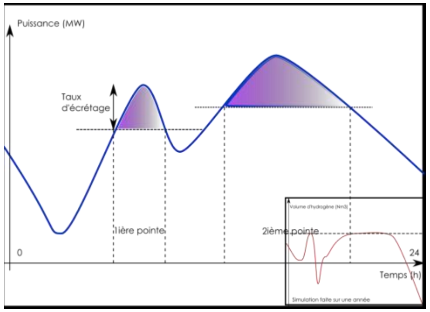
Project Key Figures

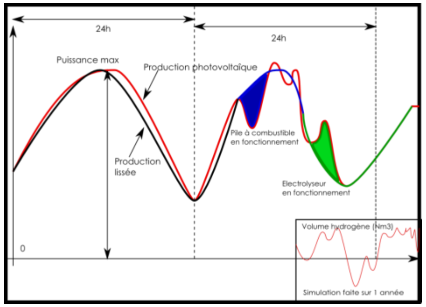
- **Project leader**
  - **University of Corsica**
- **Duration**
  - **6 years 2010- 2015**
- **Total Cost**
  - **21 M€**
  - **Phase 1 12.4 M€**
  - **Phase 2 5.9 M€**
  - **Operations 2.7 M€**
- **Funding**

EU	**7.4 M€**
CTCorsica	**4.6 M€**
French State	**3.0 M€**
Partners	**6.0 M€**

Target Applications & Research works

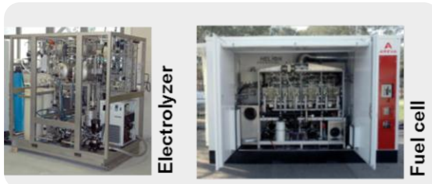
- **Improve energy management for electric grid stabilization**
  - **Peak shaving, PV load smoothing, achieving forecasted production**





- **Durability, tank material compatibility**
- **Thermal management**
- **System management optimization to improve efficiency**

MYRTE
Major Milestones Phase 1



Sept. 2009 – Contract signature and project kick-off

Nov. 2010 – Detailed design completed

March 2011 – HELION components manufactured

March 2011 – Site civil works completed

April 2011 – H_2 and O_2 vessels installed

May 2011 – Fuel cell and electrolyzer delivered

June 2011 – PV plant installed

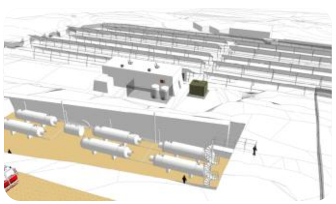
Aug. 2011 – HELION components commissioned

Oct. 2011 – Hydrogen energy storage sub-systems commissioning

Dec. 2011 – Grid connection completion

Jan. 2012 – 09/01/2012 MYRTE inauguration

Jan. 2012 – PV + energy storage final commissioning



Key figures for phase 1 – 2010-2011

PV Plant : 550 kW_p

Electrolyzer : 10 Nm^3/h H_2

Fuel Cell : 100 kW

Stored energy in H_2 : 1.75 MWh

MYRTE
Energy Conversion Unit

Phase 1: 100 kW / 1,75 MWh
Phase 2: 200 kW / 3,5 MWh

Electrolyser
10 Nm^3/h H_2

Fuel Cell
100 kVA

Water storage
Water circulates in a closed circuit

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Hydrogen storage

- **Taking into account constraints imposed by landscape protection requirements**

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Very limited environmental impact

- **The MYRTE project was developed with awareness of both:**
  - **Social acceptance**
  - **Protection of the environment (landscape and wildlife)**

On the verge of extinction in France, a population of **Hermann's Tortoise** was found on the project site and had to be accommodated

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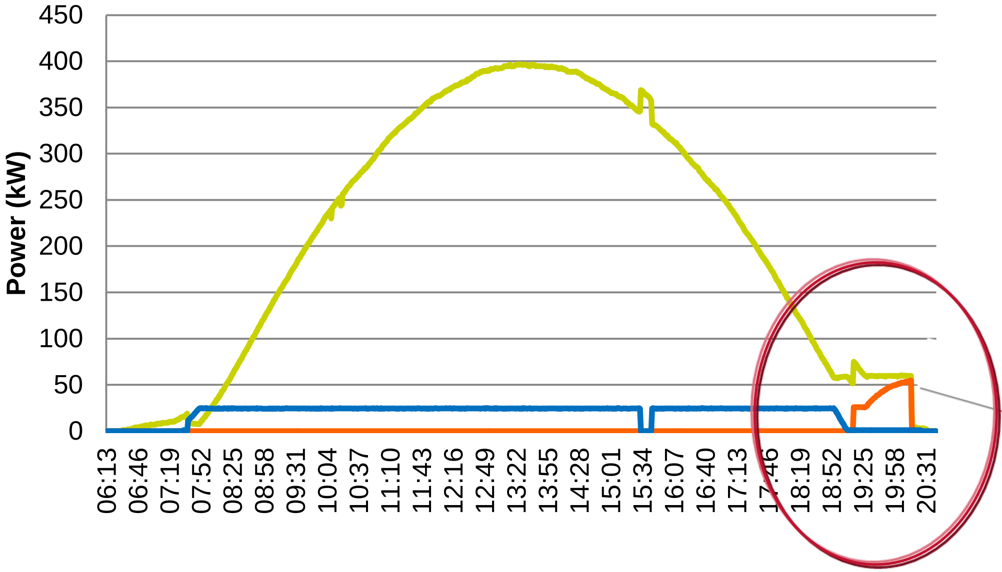
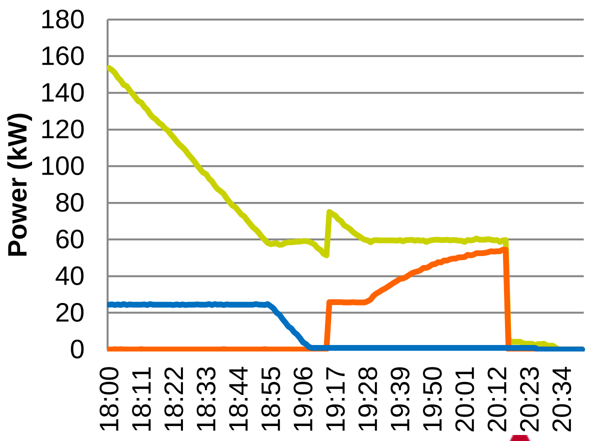
Demonstrating Evening Peak Contribution

Stored H_2/O_2 & Fuel Cell power contribution to the evening peak



Zoom from 18:00 to 20:34



- PV does not generate power in early evening hours
- H_2 & O_2 produced during the sunny hours is turned into power during the highest load hours in late afternoon

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Objectives Phase 2 - 2012 to 2015

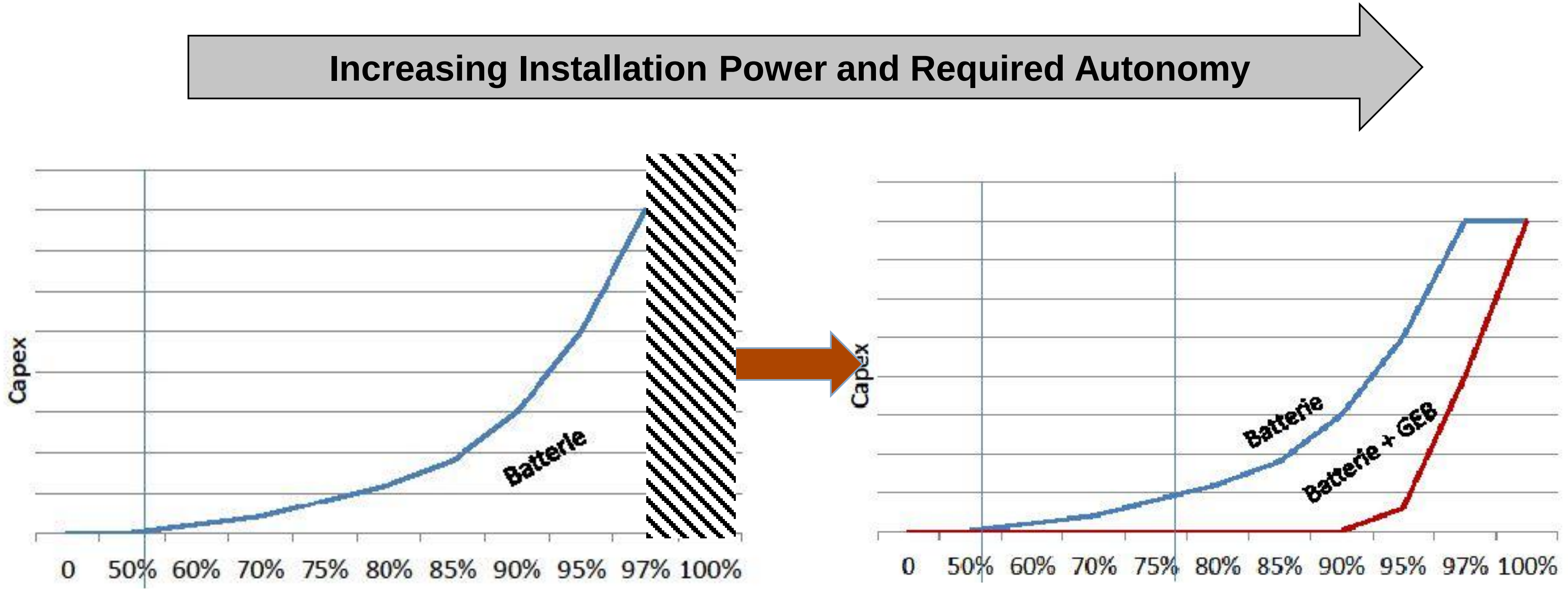
- **Objective**
  - **Operate Platform**
  - **Upscale Storage**
  - **Through installation of a Greenergy Box**

- **Mid 2013 Power increase of the hydrogen system**
  - **Fuel Cells total power**
    200 kW
  - **Electrolyzer flow rate**
    25 Nm^3/h H_2
  - **Stored Energy**
    3.5 MWh

Maximum charge power	75kW @ 15 Nm^3/h
Discharge power	20 to 100 kW
Gas production capacity (at 35 barg)	Hydrogen: 15 Nm^3/h Oxygen: 7,5 Nm^3/h
Round trip efficiency Electrical efficiency	70-80 % (heat included) 30-35%

- **Easy to transport, install and connect**
- **De-correlation between power and autonomy**
- **High pressure electrolysis to minimize footprint**
- **No gas or consumable logistics required**

Economics of an Autonomous Energy Station



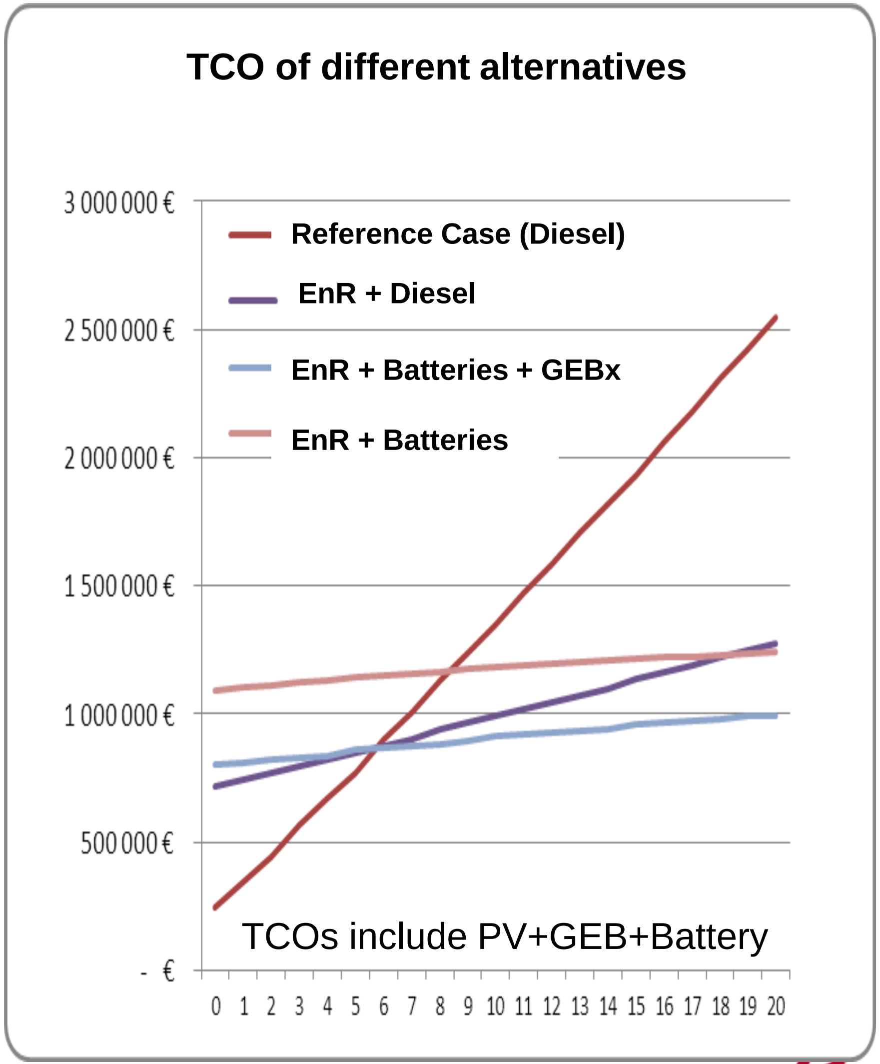
No Storage Short Term Storage Long Term storage

No Storage Short Term Storage Long Term storage

The requirement for autonomy drives the need for short and long term storage

Economics of an Autonomous Energy Station

- **Assumptions**
  - **Diesel: 2 €/l, 5%/yr increase**
  - **Actualization 4%**
  - **Costs GEB « target 2015»**
  - **VRLA Batteries at 120 €/kWh**
- **Key economics drivers**
  - **Cost of Diesel delivered on site**
  - **Target Costs of the GEBx and in particular of storage technologies**
  - **Batteries costs**
- **Drivers to be assessed**
  - **Impact of regulations on CO_2 and other gases (SOx, NOx, etc)**
  - **Ability to continue service under extreme conditions**



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Pursuing a Carbon Free Decentralized Energy Future

From RTD to implementation

Achieve Scale 1 technology demonstrations	Facilities and Programs like MYRTE are key in demonstrating the technology in real field environment
Turn demonstrations into packaged product and focus on customer services issues	Applying state of the art Manufacturing & Supply Chain practices we are confident such applications can be developed
Build the relevant supply chain to deliver the target cost to the costumer	
Demonstrate economic value proposition and identify target product costs	Early deployment programs will prove very useful to assess economic value Mutli country & Cross sector

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