Clean Energy and green-H2 for Space Transportation

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Space for Green Growth & Clean Energy | ESA e-WS

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Space Transportation Renewable Energies Objectives

Current ESA's Space Transportation main Renewable Energies objectives concern Europe's Spaceport[1]:

1) Reduce electrical consumption cost and CO_2 emissions by:

- implementing Renewable Energy Sources (e.g. **Photovoltaic solar fields**) within the CSG electrical grid for auto-consumption
- using **Biomass plants** *waste heat* to feed industrial processes
- implementing a smart electrical grid management

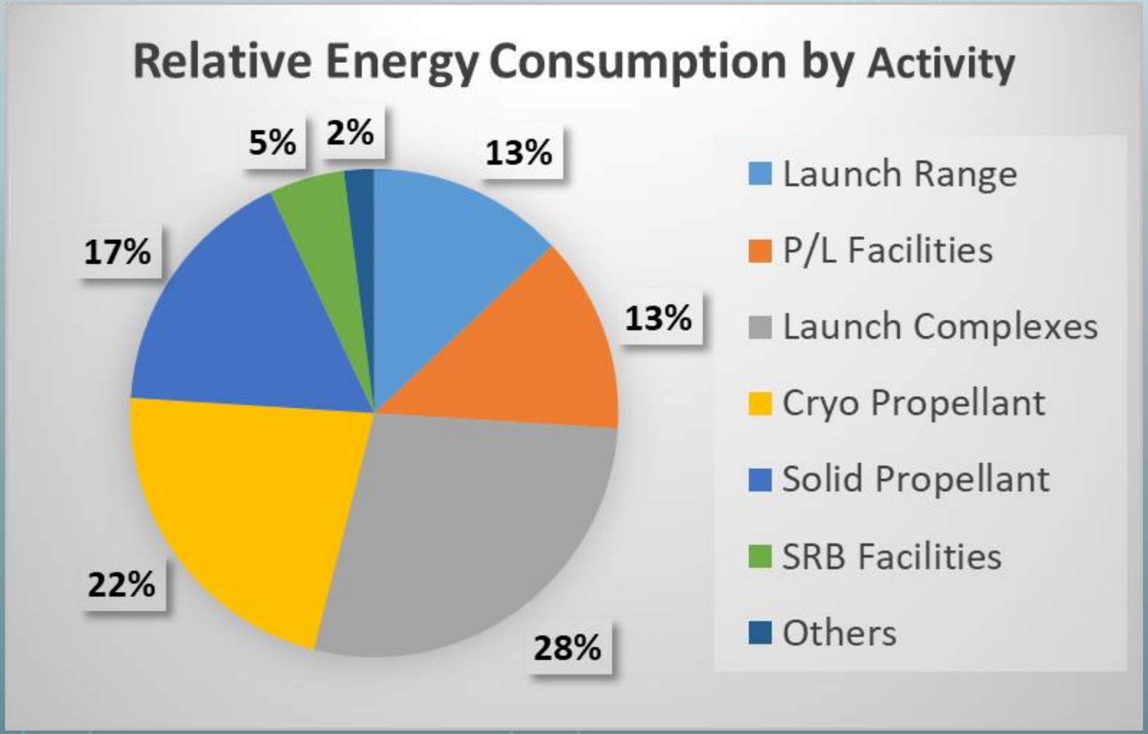
2) Improve dependability, reduce CO_2 emissions and stay competitive:

- introducing Water Electrolysis together with Renewable Energies (PV solar and wind turbines) to produce **green-Hydrogen** for both, fuel cells feeding and liquid hydrogen (launcher propellant) production
- introducing hydrogen Fuel Cells to supply uninterruptible electrical power

[1] Centre Spatial Guyanais (CSG) = Europe's Spaceport in French Guiana

Energy at Europe's Spaceport (CSG)

- CSG is the first consumer of electrical energy in French Guiana ≈ **20%** of the overall yearly production
- Very intensive energetic processes at **cryotechnic and solid propellants** production plants
- **50%** of the electricity is used for **air-conditioning**

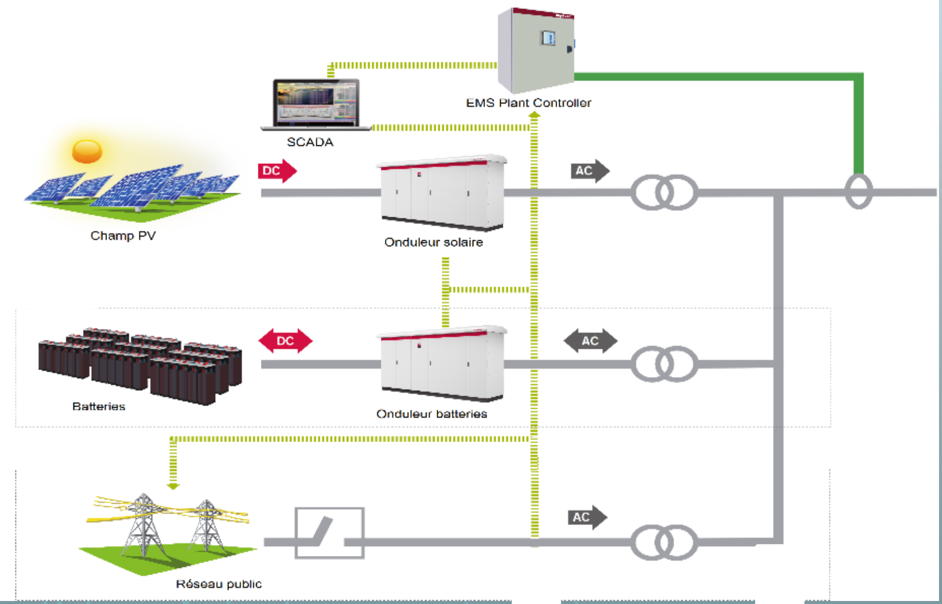


Some key figures:

- ✓ CSG power called on the grid: > **12MW**
- ✓ CSG yearly electrical energy consumption: ≈ **120 GWh**
- ✓ Electricity from the grid is not green enough today: ≈ **45%** from fossil fuel plants (45% hydro, 10% solar).

Renewable Self Production: Photovoltaic Solar Plant

- ✓ *Provides:*
  - ➢ Flexible & quick implementation
  - ➢ 100% green & renewable energy source
  - ➢ ≈ 1500 h/year **solar power** in French Guiana



- ✓ *Requires:*
  - ➢ Management of intermittent production
  - ➢ Avoiding disturbances on the grid

- ✓ Best balance between CGS energy needs and networks equilibrium & losses : **12MWp**
- ✓ *Key figures:*
  - ➢ CAPEX: ≈ 1M€ per MWp
  - ➢ OPEX: ≈ 20K€/MW/year
  - ➢ Lifetime: ≈ 30 years (Inverters 7 years)
  - ➢ ROI: ≈ 6 to 7 years
- ✓ *Stepped approach:*
  - ➢ **Step 1 (2019–2021) => 5MWp**

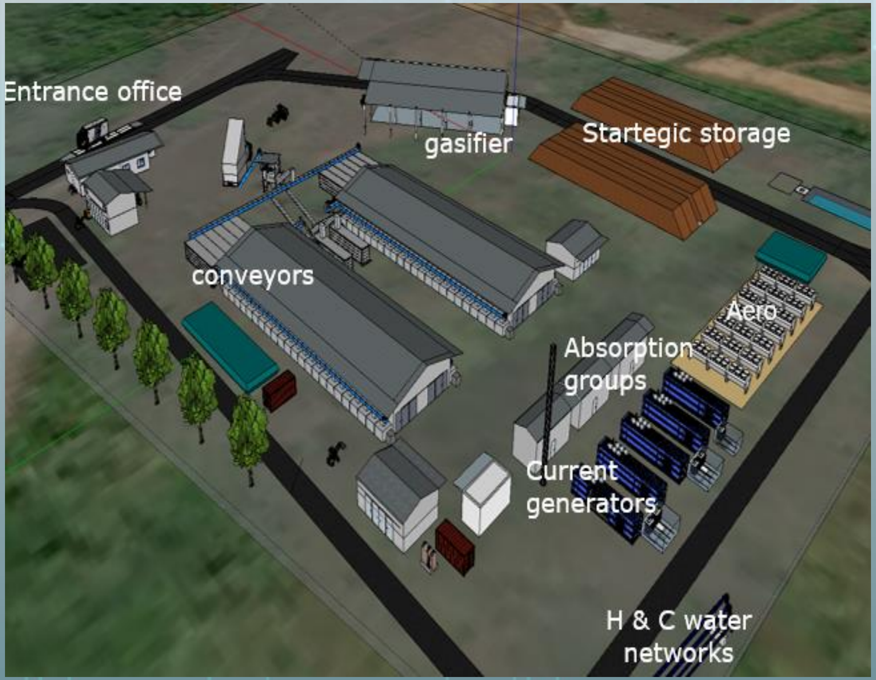


  - ➢ *Step 2 (2022-2025) additional power to reach the ideal balance*

=> Step 1 means: - 7% of energy from the grid & - 5000 CO2 eq tons/year

Renewable 3rd party Production: Biomass Power Plant

- ✓ *Provides:*
  - Flexible implementation: gasifier concept
  - “Green” electrical energy production
  - Local knowhow development for French Guiana



- ✓ *Requires:*
  - Important investment for plant implementation
  - Grid feeding (self-consumption not allowed)

Petit saut

MIA (Forest culture)

- ✓ *Investment will be done by an energy sector operator who will sell electricity to the grid.*
- ✓ *“Waste heat” (considered as lost in the biomass process) will be reused by CSG for air-conditioning of buildings and solid propellant production process.*

Green-LH2 Propellant: Water Electrolysis Plant & RE

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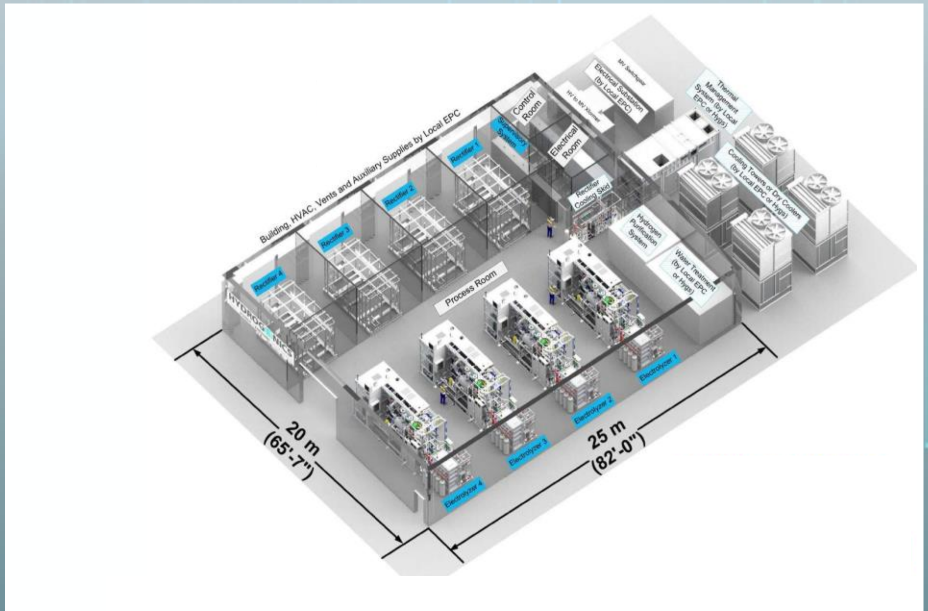
- ✓ *Provides:*
  - 0% CO_2 emission production process
  - Improved dependability: **use of local resources** (sun, wind and water)
  - Step by step modular implementation
  - Operational Flexibility



- ✓ *Requires:*
  - Significant Clean Energy power (≈ 6MW)
  - Electrical energy storage systems

- ✓ Available compact technology (PEM) allowing, with Renewable Energy Sources (PV solar and wind turbines), a high production rate (2.5 tpd) of green-H2: **≈ 6MW electrolyser plant (9±1 launches/year)**
- ✓ *Key figures:*
  - CAPEX: ≈ 1.5M€ per MW (decreasing)
  - OPEX: ≈ 220K€/MW/year (incl. infra, excl. utilities)
  - Lifetime: ≈ 20 years (major overhaul 10 years)
  - ROI: ≈ 8 to 9 years
- ✓ *Stepped approach:*
  - **Step 1 (2019-21) => Studies & Pre-design**
  - *Step 2 (2022-2025) => implementation of a Water Electrolysis pilot plan*
  - *Step 3 (2030) => switch to full Water Electrolysis green-H2 production at CSG*

=> Green-LH2 means: ≈ - 1000 CO2 tons/launch

Summary & way forward

Mid of 2020 building of the first photovoltaic plant & 2021 first Biomass plant

1) **Solar Plant 1st slice (5MWp)** for technology learning curve @ CSG (impact on grid, validation of model saving, consolidation of OPEX & life Cycle Cost…)

2) **Biomass** *waste heat* use for feeding CSG facilities

3) **Smart Grid** Implementation

2023 introduction of storage capabilities & green-LH2 Pilot Plant

1) **Solar Plant 2nd slice (7MWp)** to reach 12MWp

2) **Storage** of additional energy produced (fuel cells and/or Batteries)

3) **Start Fuel Cells** deployment for remote sites (based on LH2 boil-off valorisation)

4) LH2 propellant production via **Water Electrolysis Pilot Plant**

2025+ Fuel Cells & green-LH2

1) Potential increase of **photovoltaic plant, wind turbines** & storage

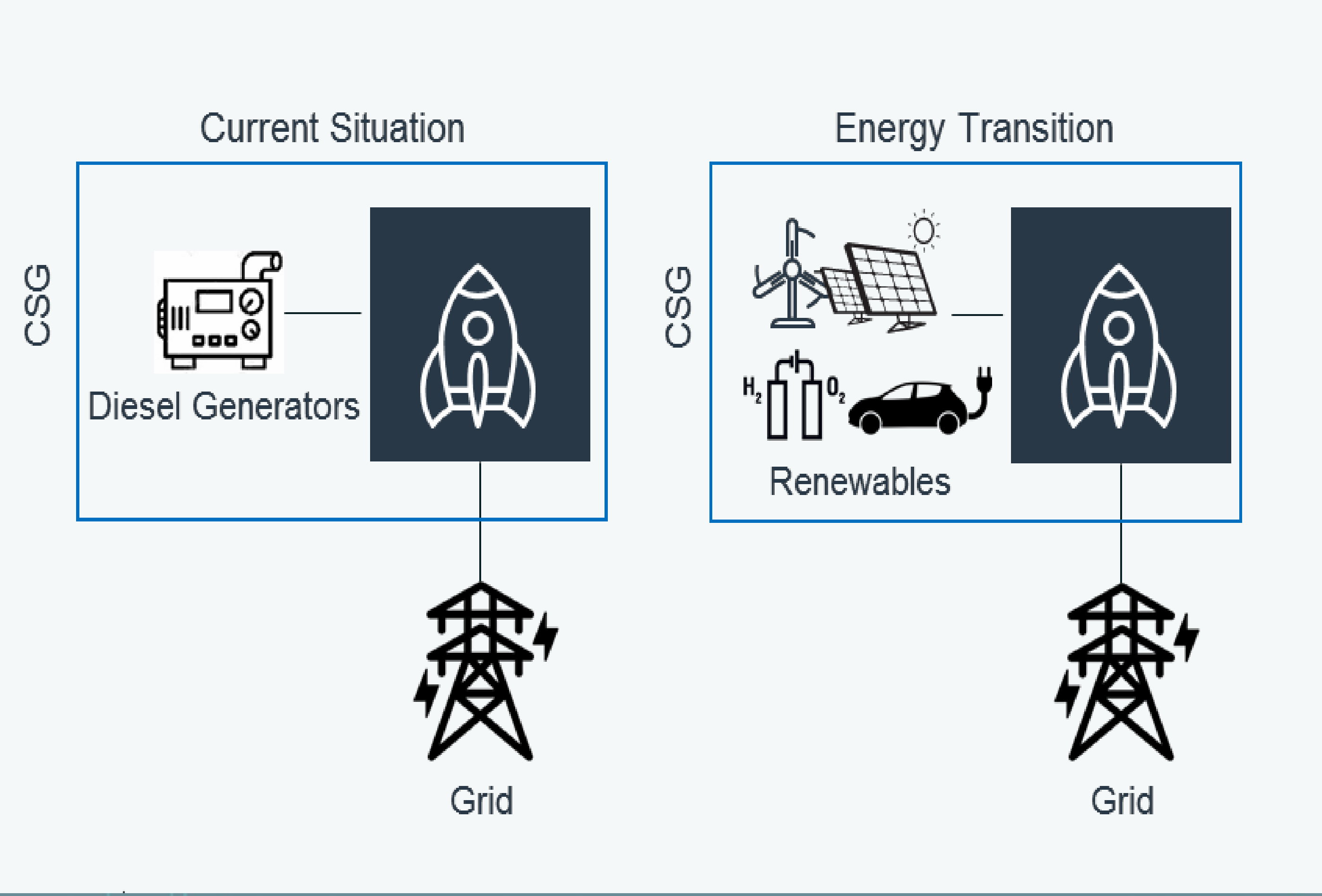
2) **Fuel Cells** in substitution of diesel generator

3) H2 mobility if economically viable

4) H2 storage (advanced technos) …

5) Step by step **transition to green-LH2 propellant production via Water Electrolysis**

Europe’s Spaceport Now and Then



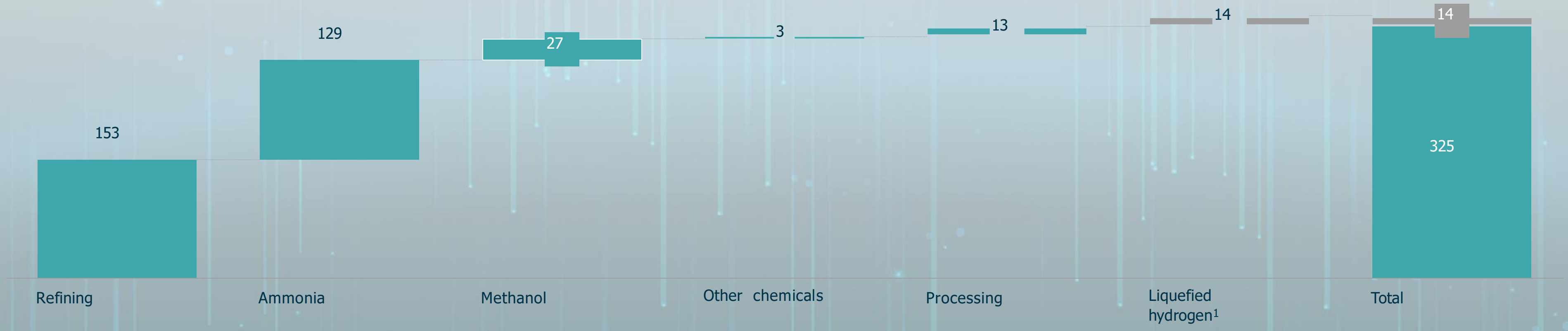
Any questions?

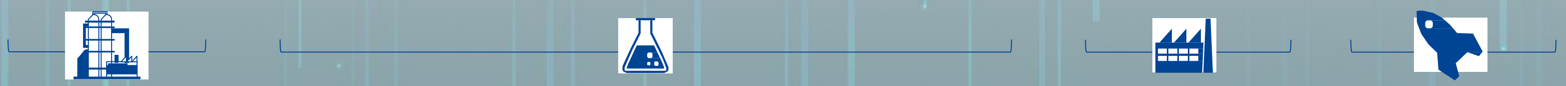
Back-up slides

Use of hydrogen in the EU (2018 data)

TOTAL USE OF HYDROGEN TODAY IN THE EU in TWh

Source: The Hydrogen Roadmap Europe, Fuel Cells and Hydrogen JU





- Hydro- cracking
- Hydro-treating (e.g., fuel desulfuri- zation)
- Biorefinery

- Production of ammonia (for urea and other fertilizers)

- Production of methanol and derivatives

- Other chemicals (e.g., polymers, polyurethanes, fatty acids)

- Heat treating of steel
- Welding of metals
- Forming and blanketing gas
- Glass production

- **Rocket fuel**
- Automotive fuel
- Semi- conductor industry

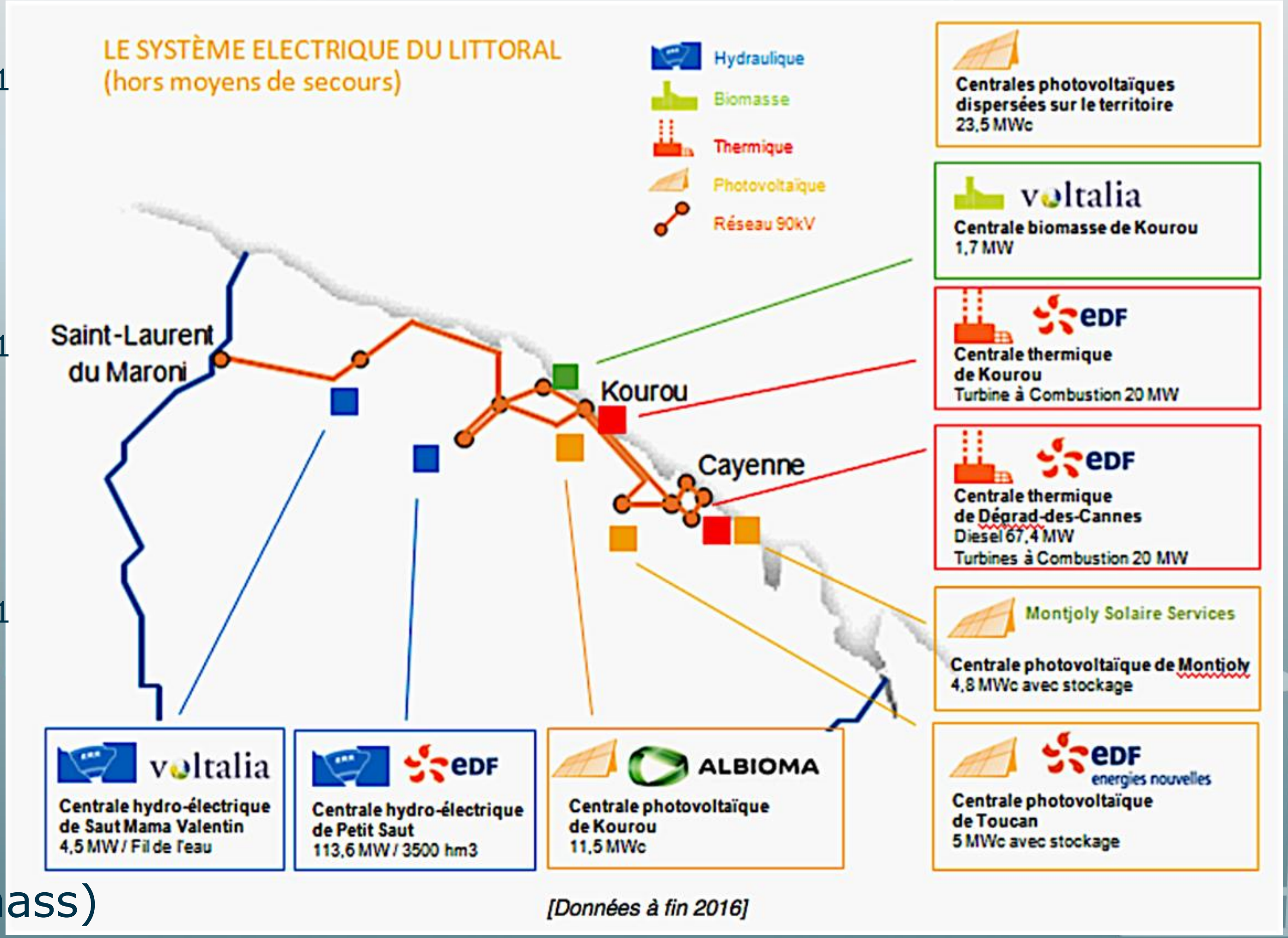
[1] **4,3% liquefied hydrogen** (counted in transportation segment)

French Guiana Electrical System (Grid)

Currently:
45% Thermic + 45% Hydro + 10% PV[1]

PPE by 2023:
35% Thermic + 35% Hydro + 30% PV[1]

PPE by 2030:
20% Thermic + 30% Hydro + 50% PV[1]



[1]Photovoltaic and other RES (incl. biomass)

PEM Water Electrolysers Industry

Several industrialists are currently offering WE systems for H2 production (cf. Industrialists consulted through ESA's RFI):

- Giner ELX (USA) working in Europe with **H2B2** of Spain (*)
- **Hydrogenics** (Canada) working in Europe in Belgium (*)
- **NELHydrogen** from Norway (*)
- Air Liquide (F)
- Areva H2gen (F)
- Erredue SpA (I) with i.TEC-S+V (F)
- Idroenergy Spa (I)
- Siemens (D)
- ELB Elektrolysetechnik GmbH (D)
- Linde (D)
- Air Products (NL)
- ITM Power (GB)

(*) at least these 3 are currently offering PEM WE in the MWs/stack power range.