

## Hydrogen Powering SKA, A precursor of renewable Energy Storage & Distribution

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ADVANCED BUSINESS  
& TECHNOLOGIES

Air Liquide Advanced Technologies:  
Innovation business unit  
[yan.pennec@airliquide.com](mailto:yan.pennec@airliquide.com)

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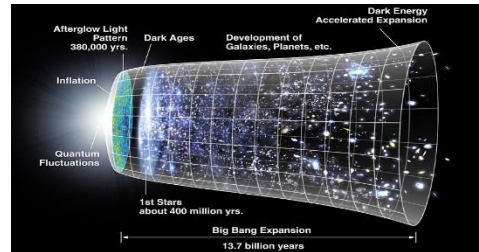


# From fundamental physics to Society

## Air Liquide & Space Exploration



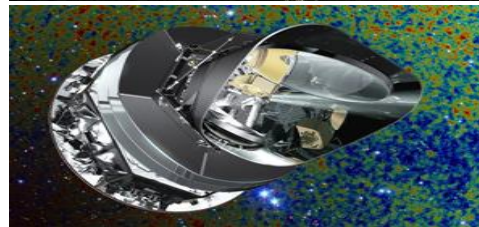
20K  
Pulse Tube



Cosmology & Space  
Early 19th.



Ariane Launcher  
Cryogenic tanks & lines  
1988

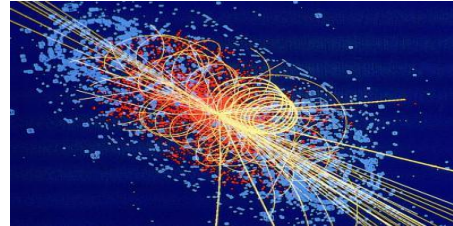


Planck/Herschel satellites  
On-board Refrigeration  
Launch 2009



Meteosat Third Generation  
Monitoring of climate  
On Board Refrigeration  
Launch 2020

# From fundamental physics to Society: Air Liquide & High Energy Physics



High Energy Physics  
Higgs Boson  
Inception 1960

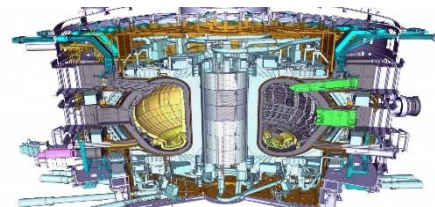


Large Hadron Collider CERN  
100 Tons Helium Liquefier  
Commissioning 2008



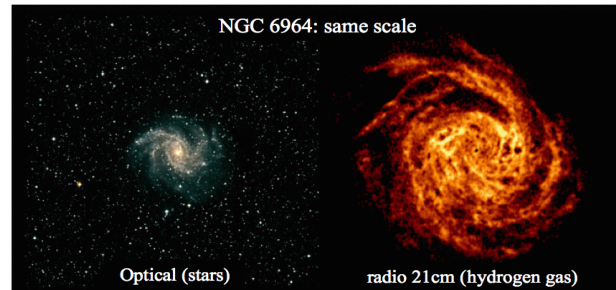
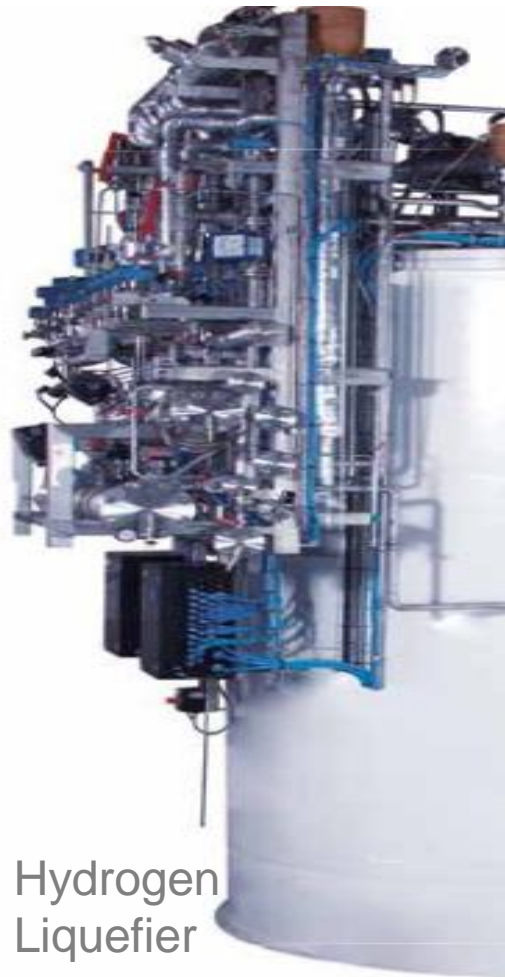
Qatar He production Plant  
8000 Liters/Hr. He Liquid

Commissioning 2013



ITER Fusion Reactor  
3 x 7500 Liters/Hr. He Liquid  
Delivery 2017

# From fundamental physics to Society: Air Liquide & Radio-Astronomy

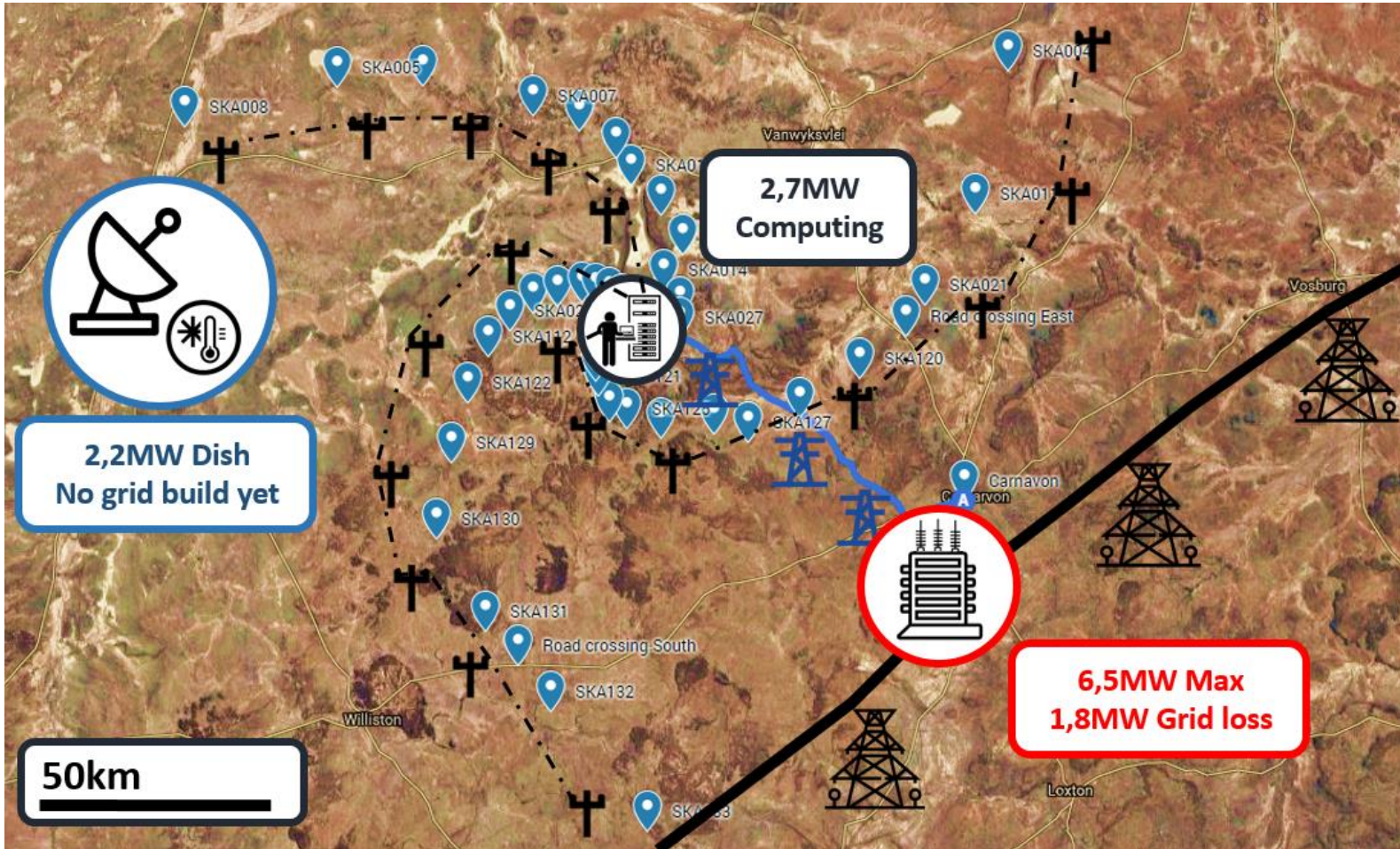


Cosmology  
Dark Energy  
ExoPlanets discovery  
Life emergence  
Early 2000

Square Kilometer Array  
Telescope.  
Integrated Cryogenics and  
distributed Power  
Early 2020

Renewable Energy Storage  
& Hydrogen Mobility  
Early 2030

# Grid Power Supply baseline of SKA-MID1



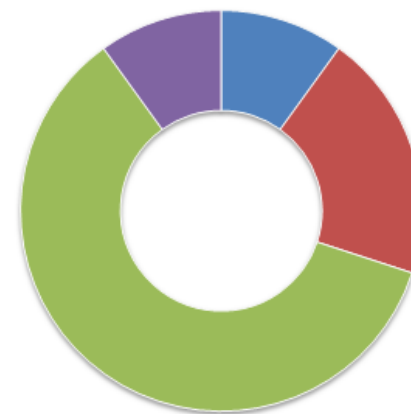
# Mechanical CryoCoolers for 20K Sensors drives Dish power



**2x 2W @ 20K**

Band 2-EMSS  
Band 3-5-TAYLOR

Balance of  
Power



**6 kW - Cryogenics**

**2 kW – Air Conditioning**

**1 kW - PC/COM**

**1 kW (10 kW pk)  
Antenna Motor**

# Solution for the central Antennas High Efficiency Pulse Tube Coolers

## GM Coolers

 baseline



## Pulse Tube Coolers

 proposal



<b>Cost</b>	\$	\$\$
<b>Efficiency</b>	~ 6 kW / 4W @ 20K	~ 3 kW / 4W @ 20K
<b>TRL</b>	TRL 9	TRL 5 Space
<b>Maintenance</b>	Yearly	> 10 Yrs.

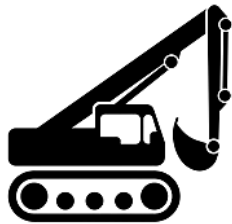
# Challenges when using mechanical Cryocoolers



Cooling power limited  
⇒ Reduced thermal margin



On site  
Electric  
consumption



Brand new secondary  
grid to be built



Grid EMI emissions

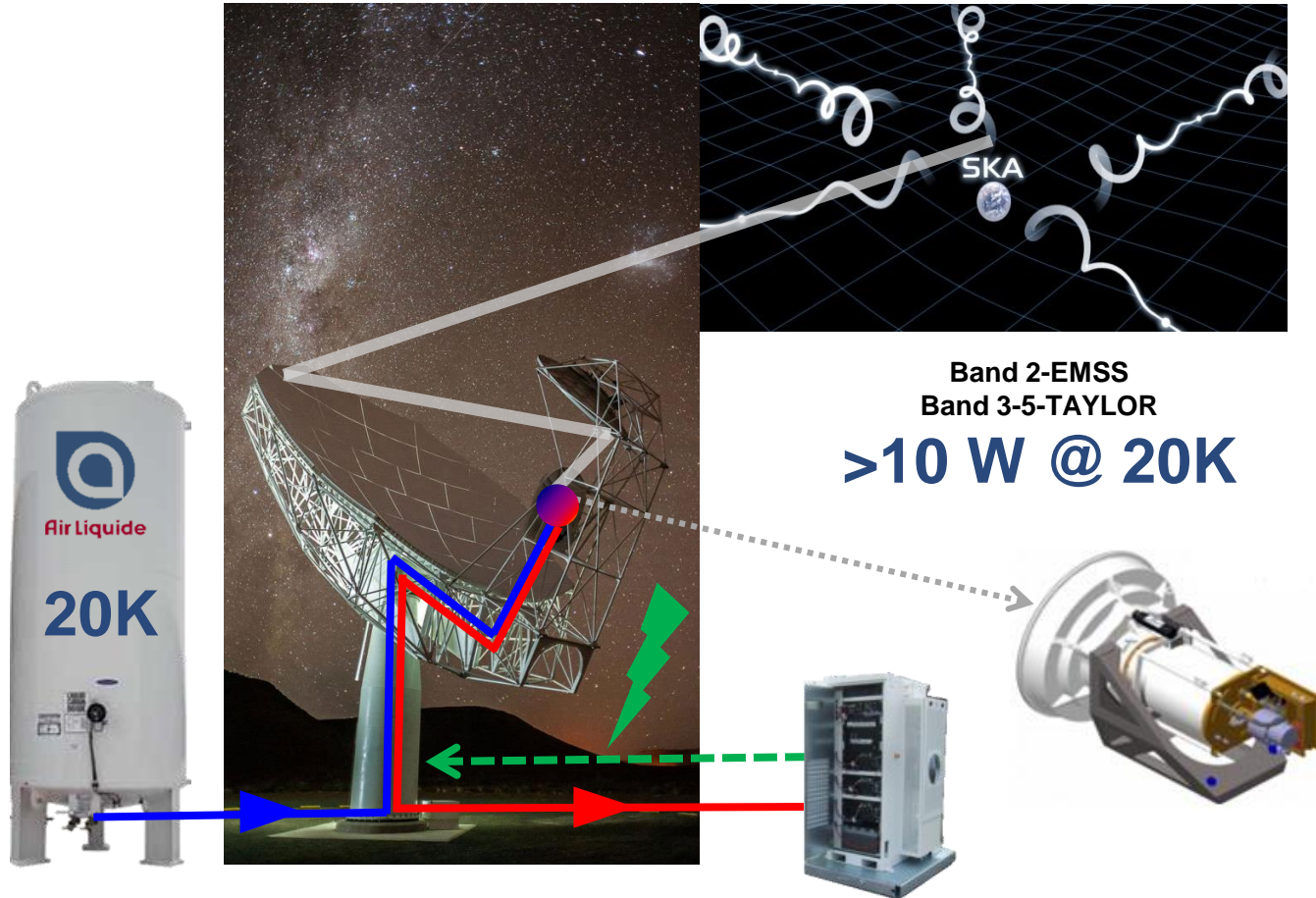


Spiraling cost  
With increasing size

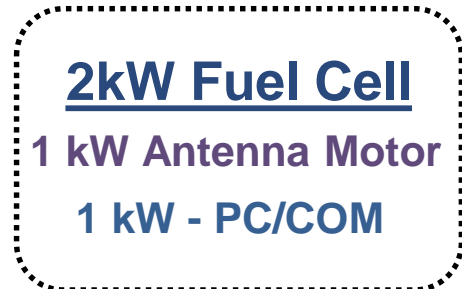
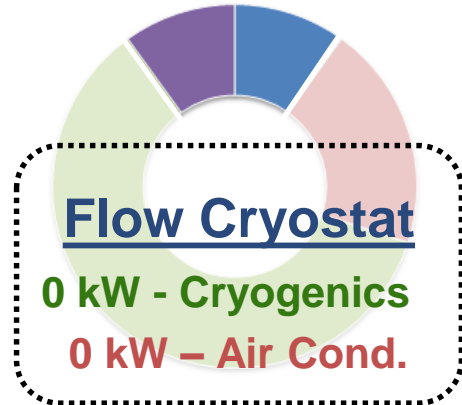




# Solution for the remote antennas Integrated Power and Cryogenics

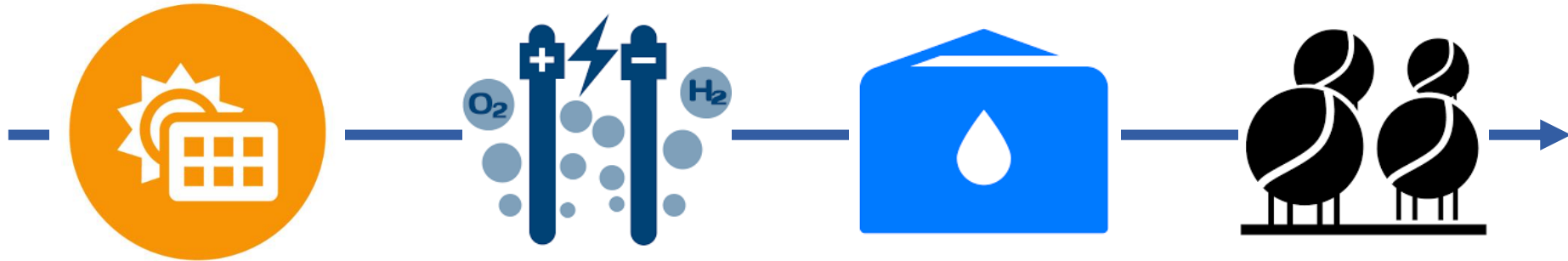


Remaining  
Balance of Power



## Autonomous antenna & Zero EMI

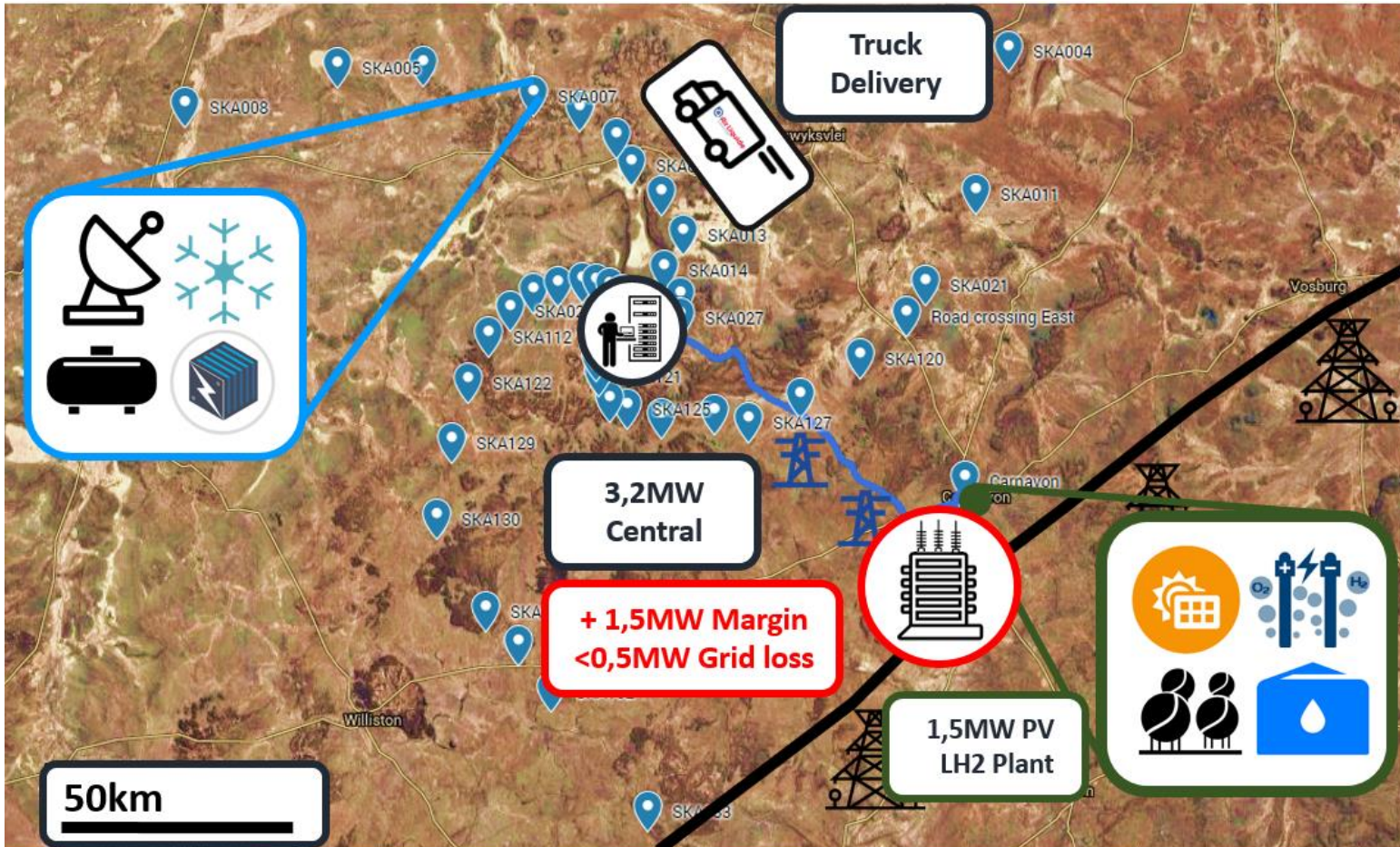
# Renewable Energy Vector Liquid Hydrogen Plant



HyBalance



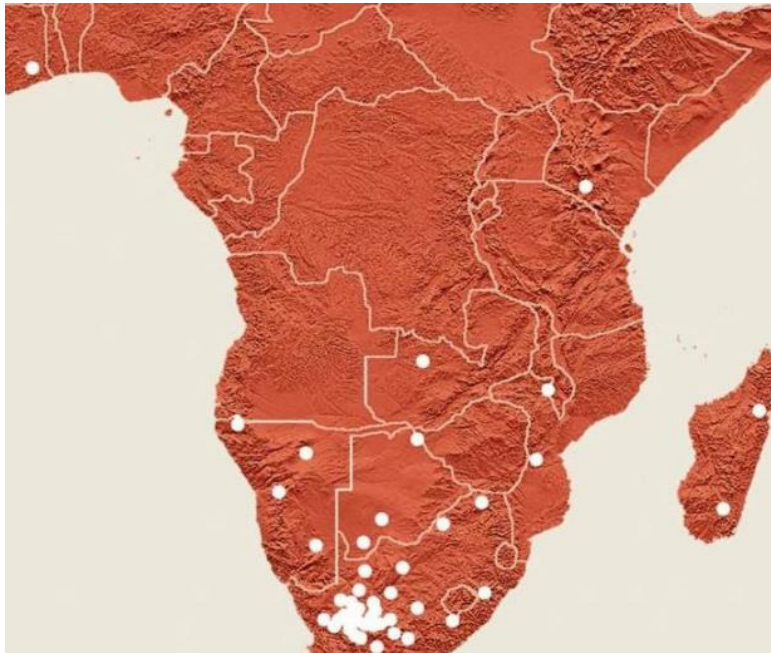
# H<sub>2</sub> Power Supply basis for SKA-MID1



**Solution is cost effective vs. Grid + Coolers**

# SKA Phase 2 and the future of H<sub>2</sub> mobility in Africa

Synergy between SKA and the transport industry



SKA Phase 2  
antennas location



Highway network  
and potential major  
"Blue" LH2 production site

# Pioneering innovative Gas H<sub>2</sub> mobility projects worldwide

141

Hydrogen Gas Stations already  
invested and operated by Air Liquide



America



Europe



Asia



# Paris COP 21 Commitment



Must reduce emissions  
of CO<sub>2</sub> and CH<sub>4</sub>

Regulation & Financing



PARIS2015  
UN CLIMATE CHANGE CONFERENCE  
COP21·CMP11

Europe

**-80%**

GHG emissions by 2050

South Africa

**-42 %**

by 2025

Air Liquide build **now** demonstrator  
projects using LH<sub>2</sub>

to **tomorrow** be able to  
deploy the technology to the mainstream.

# Concluding Statements

**SKA will pave the way to the deployment of industrial systems for the production and storage of renewable energies**

French breakthrough solutions proposed by Air Liquide can change the game :

- An innovative and competitive renewable energy storage system
- A cutting edge technology for the mechanical coolers



**A participation in SKA will put the French industry at the forefront in the worldwide energy transition market**