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Africa's Extraordinary Green Hydrogen Potential

Harnessing Africa's 50 Mt green hydrogen potential by 2035 with EUR 1-trillion investment can unlock competitive and decarbonized growth across the continent and beyond

Research and analysis by CVA Corporate Value Associates

Capturing a fraction of Africa's massive solar energy resource to produce cheap and abundant green hydrogen, delivering affordable energy, accelerating and decarbonising growth across the continent and beyond.

1,230 GWp
new solar energy generation

Tapping Africa's unparalleled solar potential in 4 hubs across Africa

50 Mt
green hydrogen per year

to unlock vast amounts of green hydrogen

140 Mt green steel
160 Mt green fertiliser

will decarbonise Africa's heavy industry (steel, fertilizer, mining, and transport) and strengthen its global competitiveness, saving an estimated 500 Mt in GHG emissions

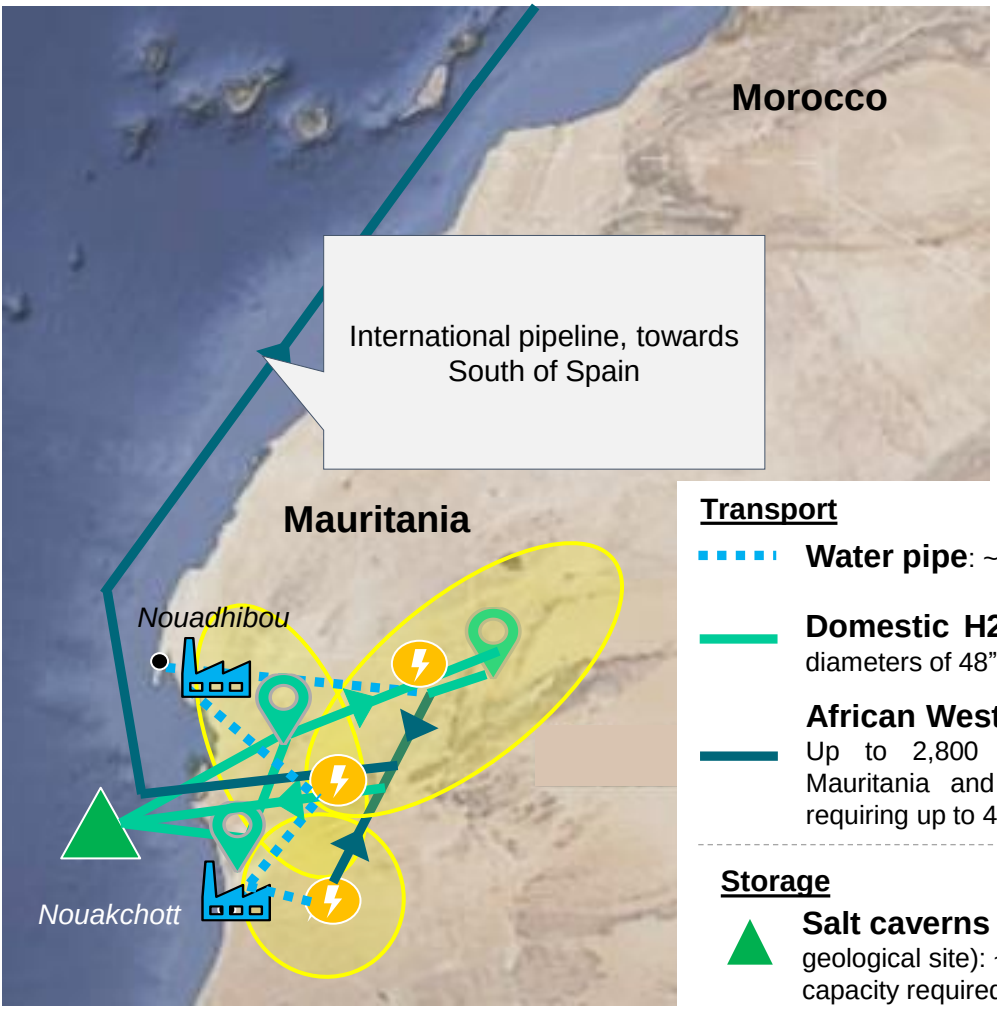
3,800 Mm3
of clean fresh water, each year

whilst producing and distributing huge volumes of clean water for needs of the sector and households – up to 5% of domestic needs

< 2€ / kg
Equivalent to 90€ / barrel oil

at a price which competes well with oil, meaning Africa becomes an important player in international energy markets as they evolve and decarbonize

Illustration with the Mauritanian hub of Solar to Hydrogen, 2035



Production

Solar2H2 production domains
- 210 GWp solar capacity in 3 areas
- Solar yield up to 2,400 kWh/kWp/y
- 315 kha in Mauritania dedicated to production sites (<0.5% of countries' area)

Desalination plants:
- 100 Mm3/y produced for electrolysis
- 400 Mm3/y for other usages

Electrolysis platforms:
- 3 electrolysis domains with a total capacity of 134 GW

Transport

Water pipe: ~1,300 km of water pipe (60 inches)

Domestic H2 pipeline: 1,200 km of H2 greenfield pipes; diameters of 48" and sections with up to 2 parallel pipes

African West Stream / International H2 backbone: Up to 2,800 km offshore international backbone along Mauritania and Morocco west coast to Spain – sections requiring up to 4 parallel 48 inches greenfield pipes

Storage

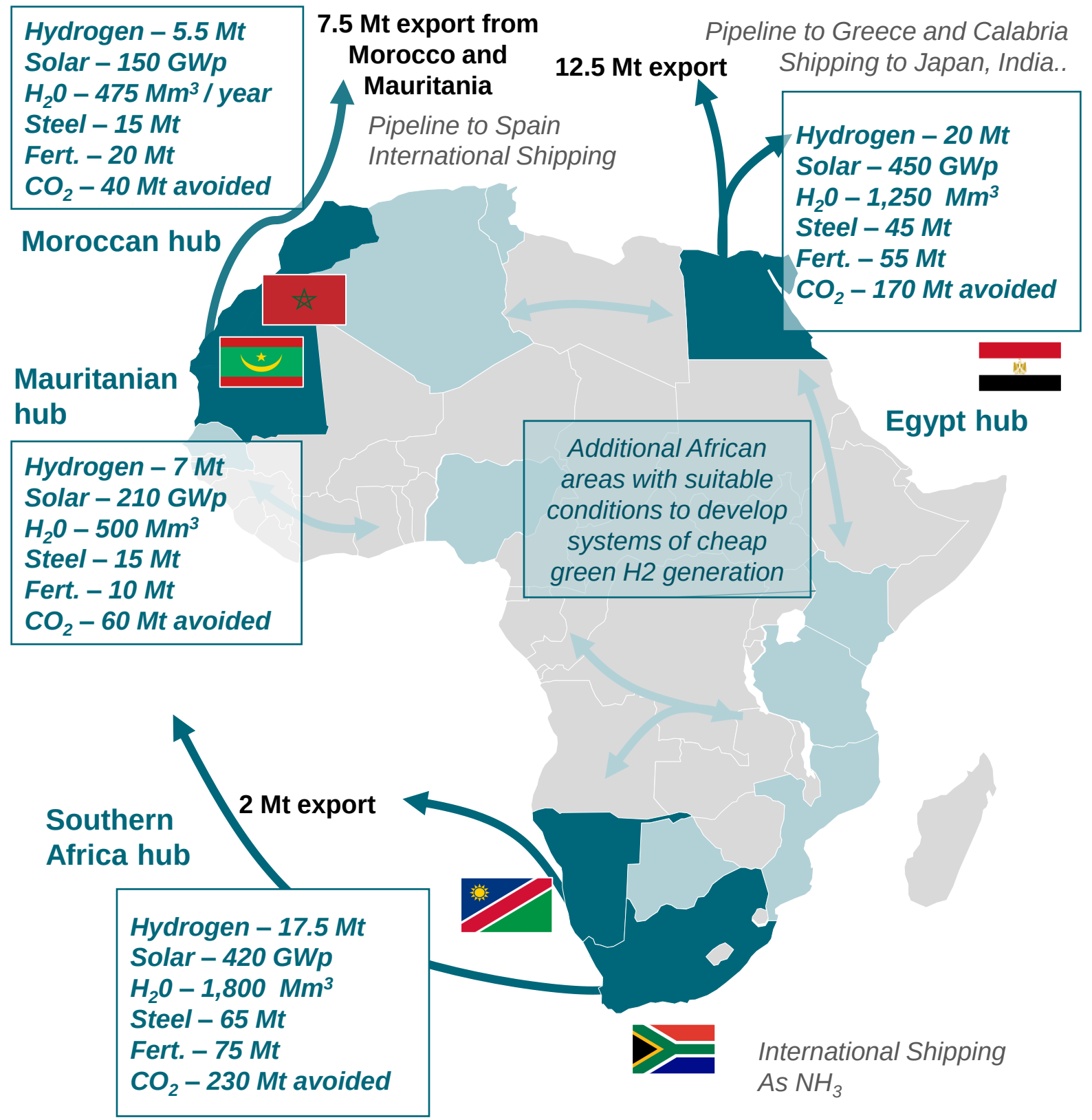
Salt caverns (existing or potential geological site): ~52 Mm3 storage capacity required

Off-takers

H2 Off-taker

By 2035, more than 50Mt / year of cost competitive green hydrogen can be produced to meet local demand, grow the domestic economy, support local communities, and for export to major international off-takers as hydrogen reshapes global energy integration.

This will mean the development of domestic green hydrogen production, storage and transport infrastructure and international networks of pipelines, ports and shipping.



4 hubs identified with qualified H2 production volumes of 50mt by 2035

Countries identified with additional production potential

Multiple value creation impacts both for local production countries and green H2 import countries – Vision at 50 Mt H2 production / year

Cost competitive energy

1.55-1.90 € / kg H2 at delivery points (equivalent to 79-96€ per Brent oil barrel, comparable to historical prices plus CO2)

Growth for local economies

An average of 40 Bn€ of direct GDP created / year all along the project lifetime corresponding to ~5% of the current considered countries' GDPs

Impact for local communities

Development of an at scale freshwater system: ~3,500 Mm3 production capacity available on the 5 different countries, i.e. more than 5% of the current volumes consumed locally

Direct employment

Massive creation of permanent quality jobs along the value chain

Global energy integration

Supply of ~25Mt H2 (equiv. ~70 Mtoe) to international markets.

~15% of the current EU gas demand

Domestic energy transformation

Massively increased generation and transmission capacity, skills and investment

Decarbonisation

~500 Mt CO2 / y avoided in 2035, either by direct usage of H2 or the supply of green commodities (~40% of African CO2 emissions in 2020)

Key success factors

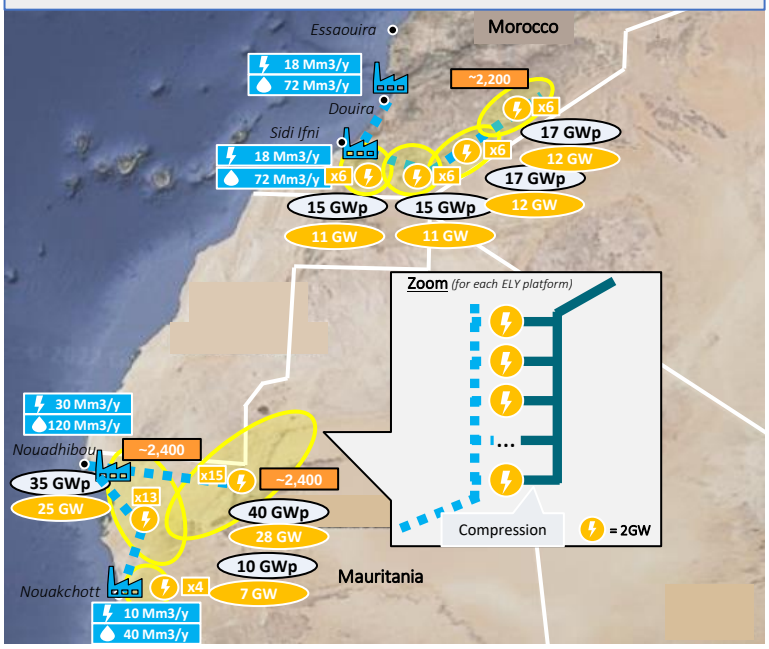
1. **Activate national planning and incentive schemes,** ensuring the development of domestic policy and regulatory frameworks which mobilise private sector investment and innovation to develop and integrate domestic value chains with international markets..
2. **Successful pilot projects at demonstration and commercial scale** involving key private and public sector stakeholders in all aspects of the green hydrogen value chain, from generation and storage, to distribution and application.
3. **Aggregate mass scale off-take and demand,** both domestically and internationally, working jointly to design, finance, build and operate the core storage and transport infrastructure.

Appendices – Detailed illustrations per Green H2 Hub

H2 Hubs designs – Illustrations: Morocco and Mauritania H2 hubs - 2030

Focus on Morocco / Mauritanian hubs – Upstream model by **2030**: 150 GWp of solar capacity and 105 GWe of electrolysis capacity to be installed

Link between desalination plants and green H2 plants managed through the **development of a large fresh water supply system**, opening development potentials for a part of the countries



Key

Production

- X — Solar Capacity to be installed by 2030 (GWp)
- Suitable area for solar development
- X — Solar yield (kWh/kWp/y)
- Desalination plant
- X GW — Electrolysis installed capacity
- X Mm3/y — Water volumes required for electrolysis (Mm3/y)
- X Mm3/y — Water volumes available for other usages (agriculture, drinking..)
- xX — Electrolysis platform (number of solar2H2 plants)

T&S

- Potential International H2 backbones
- Water pipe
- Cities

Design & sizing details

Solar generation

- **150 GWp in 7 areas**
- **25 MW** (representing 40 GWh a year) **of additional solar capacities to partially feed desalination plants** for water generation dedicated to electrolysis
- About **170 GWh a year of electricity** used from the **grid** to complement the sourcing (water generation for other usage)

Water desalination

- **76 Mm3/y of water required from desalination** for electrolysis
- **Up to 300 Mm3/y of fresh water available** for agriculture and drinking water: **53%** (160 Mm3) **in Mauritania** (covering **~66% of current Mauritanian needs for agriculture) and 47%** (140 Mm3) **in Morocco**

Water transportation

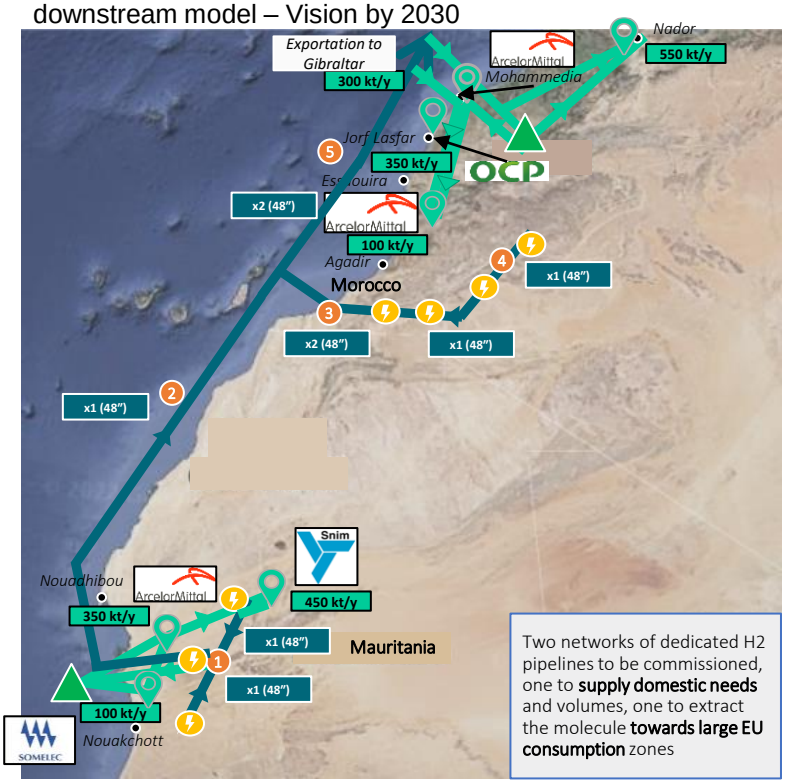
- **1,600 km of water pipe infrastructures** from desalination facilities to electrolysis platforms

Electrolysis

- **7 electrolysis domains** with a **total capacity of 105 GW**

Sources: ONNE, ArcelorMittal, Moroccan government H2 roadmap, Economics of hydrogen, MISO energy, CVA analysis

Focus on Morocco / Mauritanian hubs – Midstream and downstream model – Vision by 2030



Two networks of dedicated H2 pipelines to be commissioned, one to **supply domestic needs** and volumes, one to extract the molecule **towards large EU consumption** zones

Key

Production

- Electrolysis platform

T&S

- Domestic H2 pipeline to be built
- Potential International H2 backbone
- xX (X ") — Number of parallel pipelines (diameter of the pipe section, inches)
- 1 — International pipe length:
  1. 250 km
  2. 1,500 km
  3. 600 km
  4. 400 km
  5. 1,050 km

Off-takers

- ArcelorMittal — H2 Off-taker
- X kt/y — Domestic H2 volumes off-take (kt/y)

Storage

- Existing or potential salt cavern geological site

Design & sizing details

H2 generation

- **5 Mt H2 produced in 2030** to meet:
  - Domestic demand in 3 main areas (~2Mt)
  - International exportation (~3Mt)

H2 storage

- **2 national storage sites** (salt caverns) **to be sized for H2 dispatch management** with connections to off-take sites:
  - **23 Mm3 storage capacity in Mauritania**
  - **22 Mm3 in Morocco**

H2 transportation

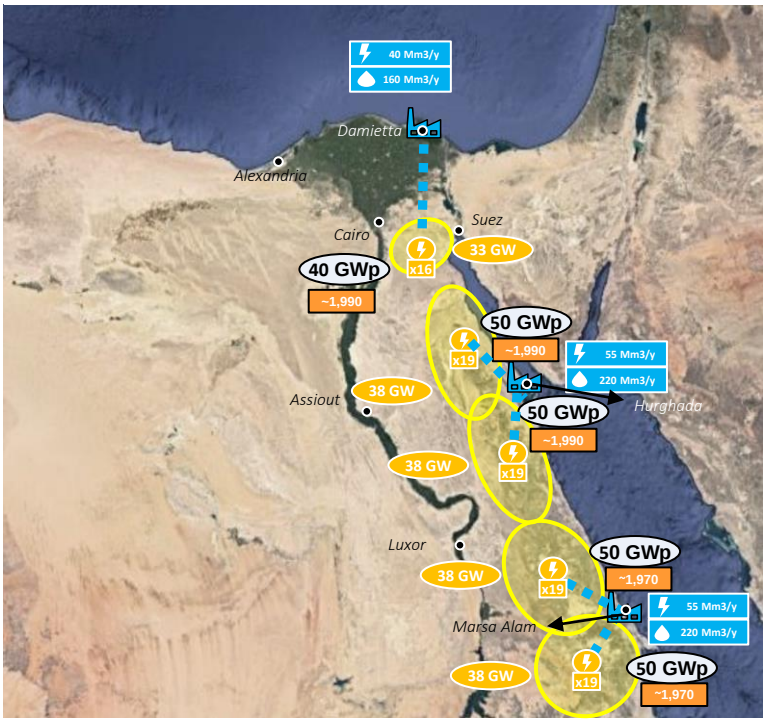
- **1,200 km of H2 simple 48 inches greenfield** pipes for **domestic** use in **Mauritania** and **1,900 km in Morocco,** connected with **2 storage sites.**
- Up to **2,800 km offshore backbone** along Mauritania and Morocco west coast to Gibraltar – sections requiring up to **2 parallel 48 inches** greenfield pipes

*When not detailed, the pipe is a simple 48" greenfield pipe

Sources: ONNE, ArcelorMittal, Moroccan government H2 roadmap, Economics of hydrogen, MISO energy, CVA analysis

H2 Hubs designs – Illustrations: Egypt H2 Hub - 2030

Focus on Egypt hub – Upstream model by **2030**: 240 GWp of solar capacity and 185 GWe of electrolysis capacity to be installed



Key

Production

- Solar Capacity to be installed by 2030 (GWp)
- Suitable area for solar development
- Solar yield (kWh/kWp/y)
- Desalination plant
- Electrolysis installed capacity
- Water volumes required for electrolysis (Mm3/y)
- Water volumes available for other usages (agriculture, drinking..)
- Electrolysis platform (number of solar2H2 plants)

T&S

- Water pipe
- Cities

Design & sizing details

Solar generation

- **240 GWp in 5 areas**
- **53 MW** (representing 84 GWh a year) **of additional solar capacities to partially feed desalination plants** for water generation dedicated to electrolysis
- About **335 GWh a year of electricity** used from the **grid** to complement the sourcing (water generation for other usage)

Water desalination

- **150 Mm3/y of water required from desalination** for electrolysis
- **Up to 600 Mm3/y of fresh water** available representing **1% of current agricultural water needs**

Water transportation

- **720 km of water pipe infrastructures** from desalination facilities to electrolysis platforms

Electrolysis

- **5 electrolysis domains** with a **total capacity of 185 GW**

Sources: Oxford Institute, Economics of hydrogen, NREL, CVA analysis

Focus on Egypt hub – Midstream and downstream model – Vision by 2030

Key

Production

- Electrolysis platform

T&S

- Domestic H2 pipeline to be built
- Existing gas pipeline
- Potential International H2 backbone
- Number of parallel pipelines (diameter of the pipe section, inches)
- International pipe length:
  1. 110 km
  2. 230 km
  3. 220 km
  4. 150 km
  5. 190 km

Off-takers

- H2 Off-taker
- Domestic H2 volumes off-take (kt/y)

Storage

- Existing or potential salt cavern geological site

Design & sizing details

H2 generation

- **10 Mt H2 produced in 2030** to meet:
  - Domestic demand in 4 main areas (~3Mt)
  - International exportation (~7Mt)

H2 storage

- **1 national storage site** (salt caverns) **to be sized for H2 dispatch management** with connections to off-take sites:
  - **56 Mm3 storage capacity**

H2 transportation

- **2,310 km of H2 48 inches greenfield** pipes for **domestic** use in Egypt, connected with **1 storage site.**
- Sections requiring up to **3 parallel 48 inches** greenfield pipes …

*When not detailed, the pipe is a simple 48" greenfield pipe

Sources: Oxford Institute, Economics of hydrogen, NREL, CVA analysis