Net Zero Worx

Commercial and Technical Challenges of Green Hydrogen projects from a developer's perspective

IAIA, December 9th 2024

Net Zero Worx

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About us

- We support developers of utility-scale production and export facilities for renewable hydrogen and derivatives.
- Extensive project development, financing and engineering expertise in water treatment, renewables, electrolysis and ammonia synthesis.
- Our knowledge has been bundled in internally developed and proprietary modelling and optimisation software BrainWorx®.
- NetZeroWorx is mandated by SAHAMCO for its projects in the Atlantic Coastal Sahara region.

Setting the scene

- The Green Hydrogen (GH_2) did so far not live up to its promises for a variety of reasons:
  - Overpromising by the sector itself
    - GH_2 is not the silver bullet
    - The road to net zero will consist of a variety of technologies and measures
  - Overall economic constraints
  - Geopolitical unrest
  - Electrification is priority
    - E.g. in EU, renewables should first be used for electrification
  - Suboptimal locations leading to excessive costs
    - Onsite H_2 production is not to be compared with a utility scale export project e.g. through ammonia.
  - Delays in the implementation of regulatory frameworks and incentivising programs
  - Lobbying is always there
  - 2024 was the election year
  - 2025 – 2026 will lead to a further shoot-out
    - Suboptimal projects will be cancelled or pushed-back
- But the light still shines for GH_2:
  - Europe will largely rely on imports
  - The current hype around CCS is likely to come under pressure
    - Just as GH_2, 'blue' is only viable under very specific circumstances
    - Upstream methane emission accounting rules
    - Long term concerns about CO_2 storage
  - RED III and IMO regulations will stimulate the offtake from 2026 onwards
  - 2030 is tomorrow
    - Getting a large-scale GH2 online takes at least 6 years (3 years development + 3 years construction)

Key Success Factors for utility scale GH_2 export projects

- outstanding complementary wind and solar resources
- sea and seaport access
- proximity to EU demand centres
- proximity to bunkering capacities
- land availability with minimal societal impact
- serious positive social impact potential
- scale-up potential guaranteeing long term competitivity

The Importance of Solar and Wind Complementarity

- Intermittent Over-the-fence H_2 delivery is different from running an Ammonia Synthesis plant.
- The annual Capacity Factor is not all that matters.
- Traditional annual P50 – P75 – P90 scenarios used for Renewables fall short.

Capacity factors and complementarity between solar and wind	Renewables (MW)	Electrolysis (MW)	Ammonia Synthesis (TPD)	Ammonia Production (TPY)	Additional investment compared to high complementarity
low	4000 – 4500 (*)	2.200 – 2.500 (*)	3.500 (*)	ca. 1 mio	ca. 50 to 70%
medium	3.500 (*)	1.500 (*)	3.500 (*)	ca. 1 mio	ca. 10 to 20%
high	2.600 – 3.000	1.500	3.500	ca. 1 mio	Reference

Note* :Figures as reported on social media and press releases / projects (partially) running on hydro not considered for this comparison.

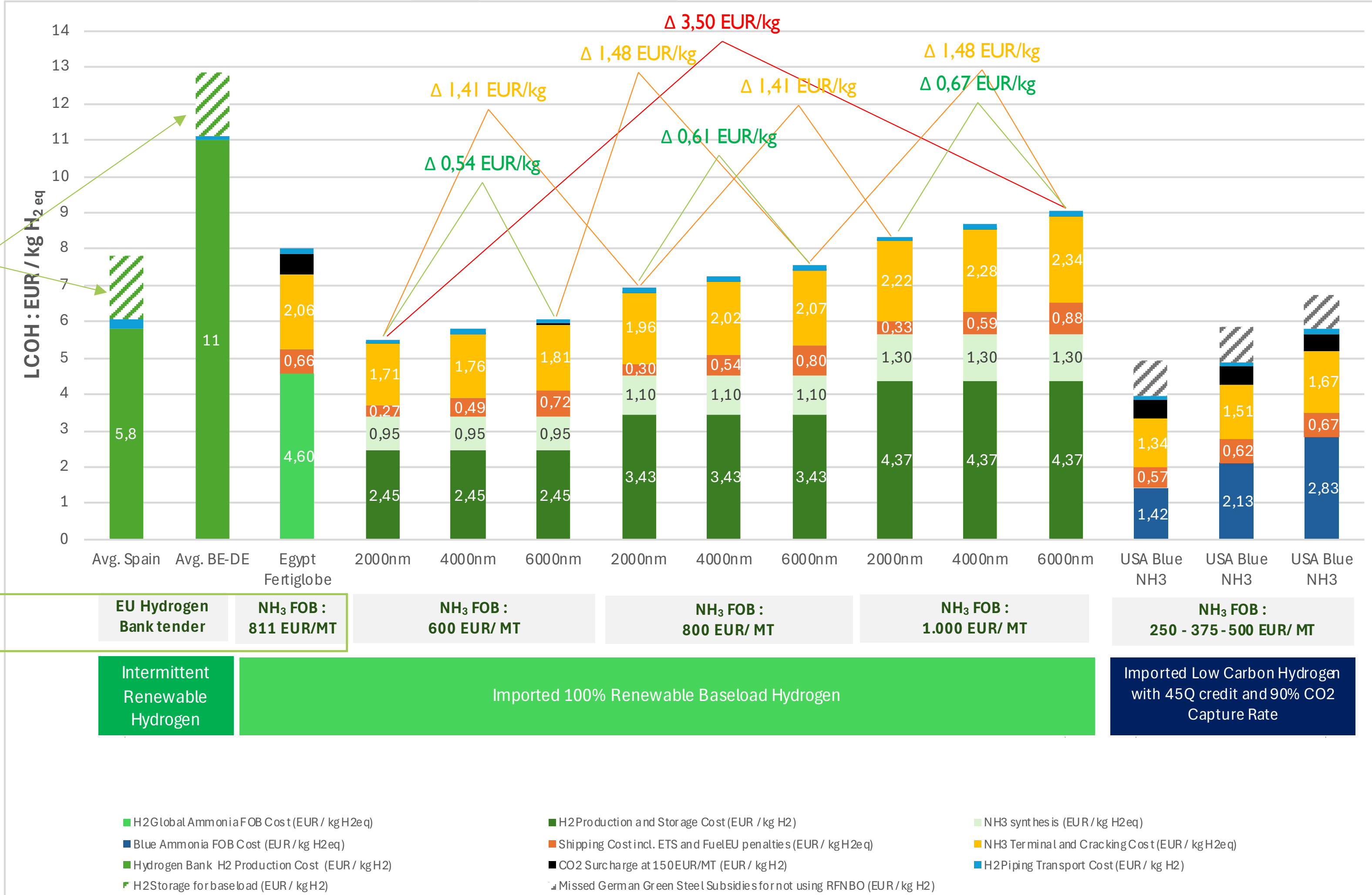
Lower Complementarity will require additional energy and hydrogen storage to sustain the ammonia synthesis loop.

Major Influencers of the Levelized Cost of Hydrogen (LOCH)

Most industries require baseload supply !

Import has storage built in the supply chain

Offtake tenor is a key driver of LCOH



Own ammonia used for sailing and cracking

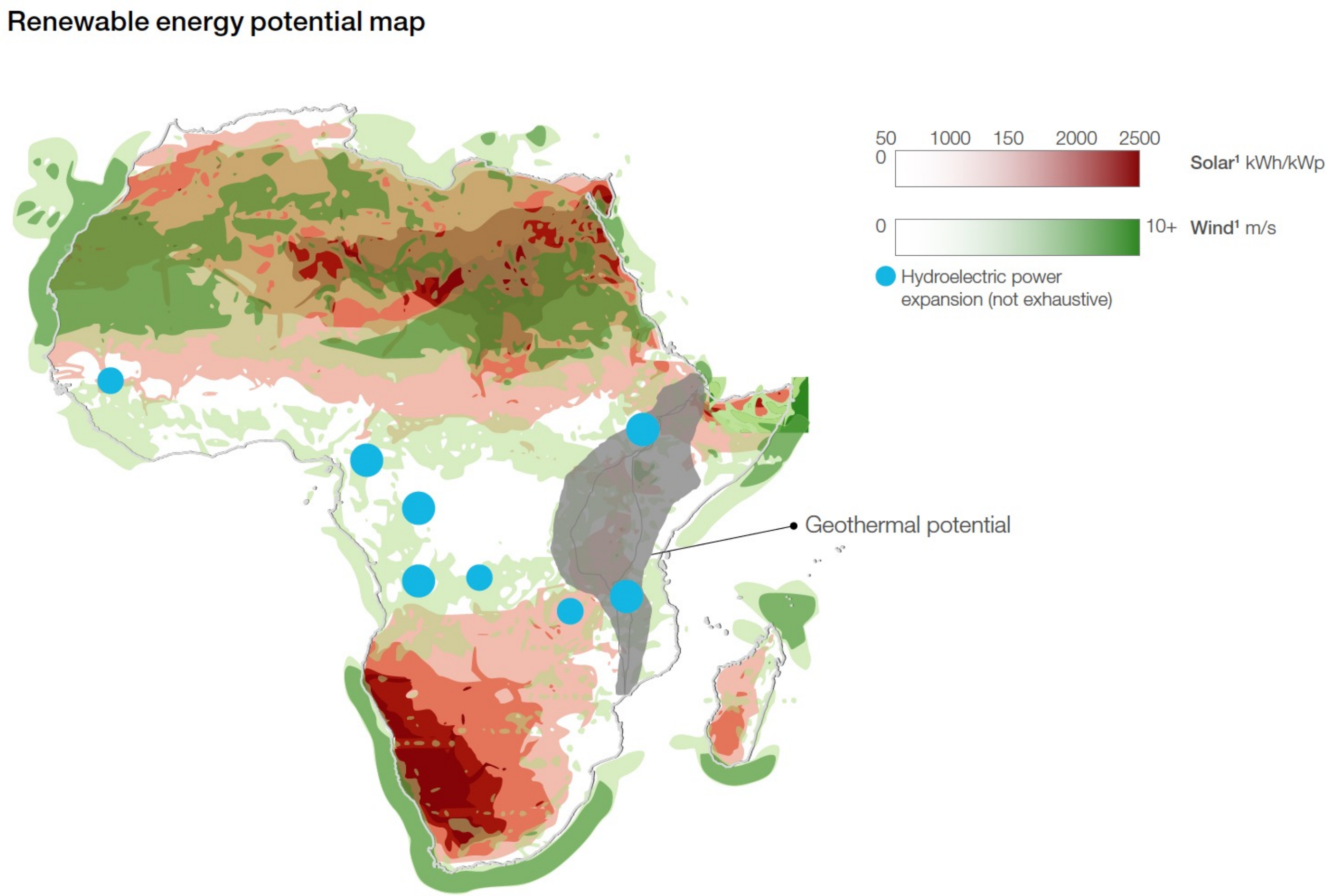
Project Highlights

- Atlantic Coastal Sahara
- NASSIM - Mauritania
- DAHAMCO - Morocco

Potential of the African Continent

- The wind and solar capacity factors of selected African countries could exceed those of many other aspiring producer regions around the globe, with only selected areas in Australia, Chile and China possessing higher wind and solar capacity factors.

- The capacity factors of Mauritania, Namibia, and Morocco (among the best African locations) are overall about 20% higher than those of Iberia, Canada, and the Middle East, which have established significant momentum in building hydrogen hubs.



In search of the perfect complementarity between wind and solar for the lowest possible LCOH, as a close as possible to NW-EU…

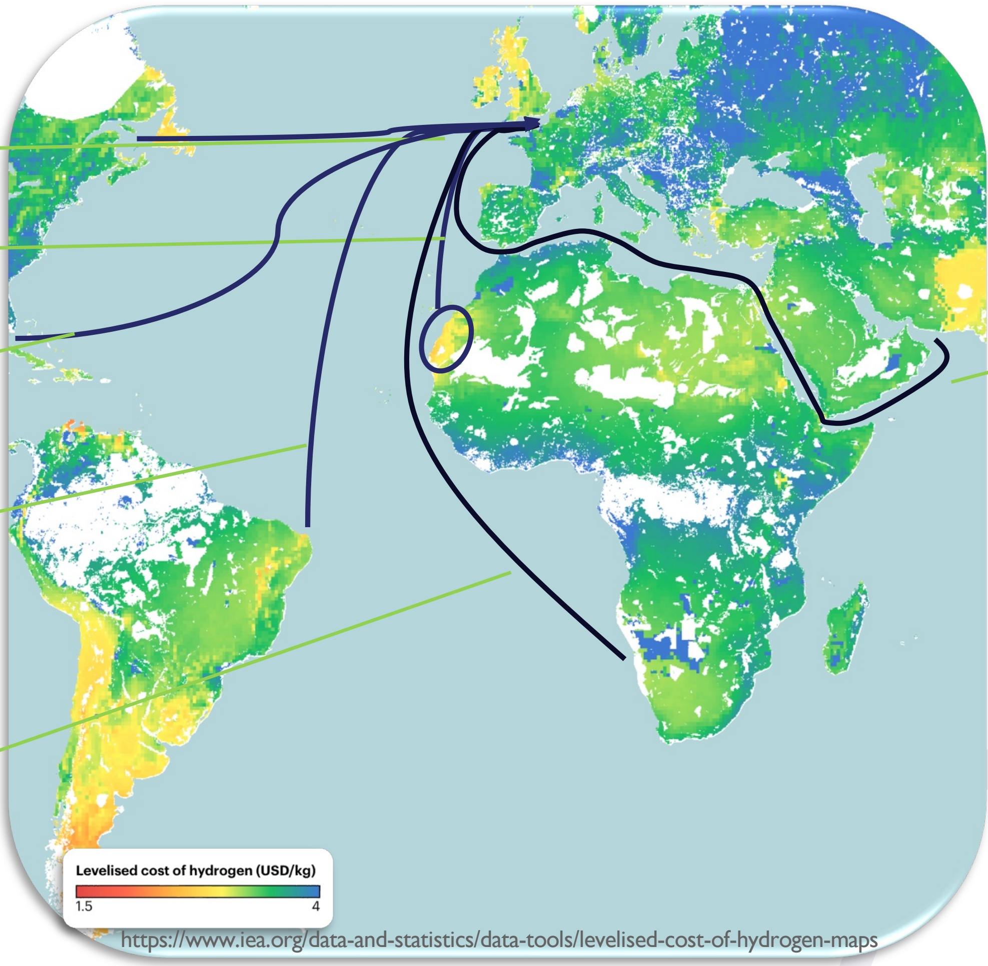
Ca. 2.800 nm

Ca. 2.200 to 2600 nm

Ca. 6.100 nm

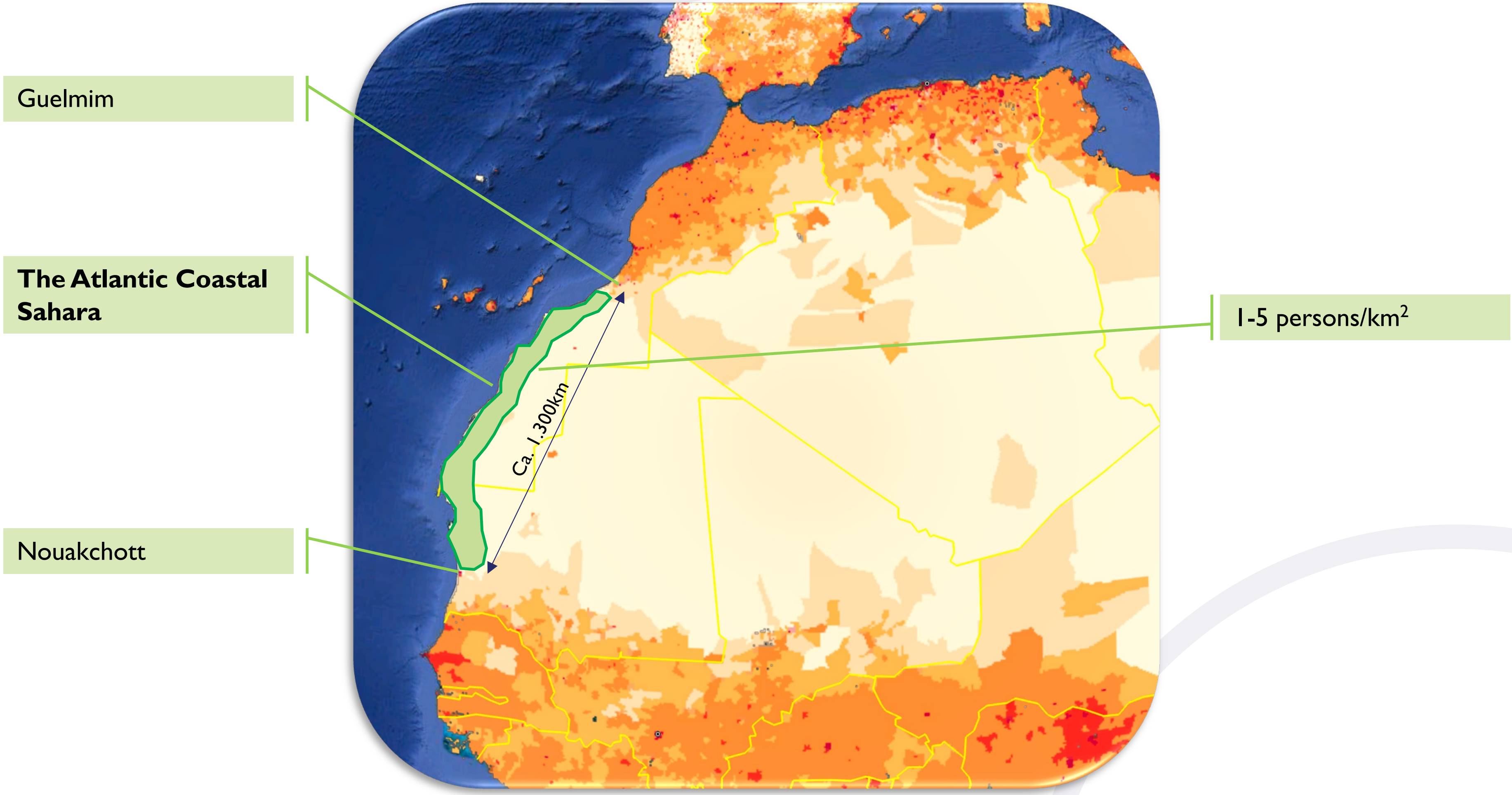
Ca. 5.200 nm

Ca. 6.500 nm



Ca. 6.300 nm
+ Suez Canal

...and with minimal societal impact.

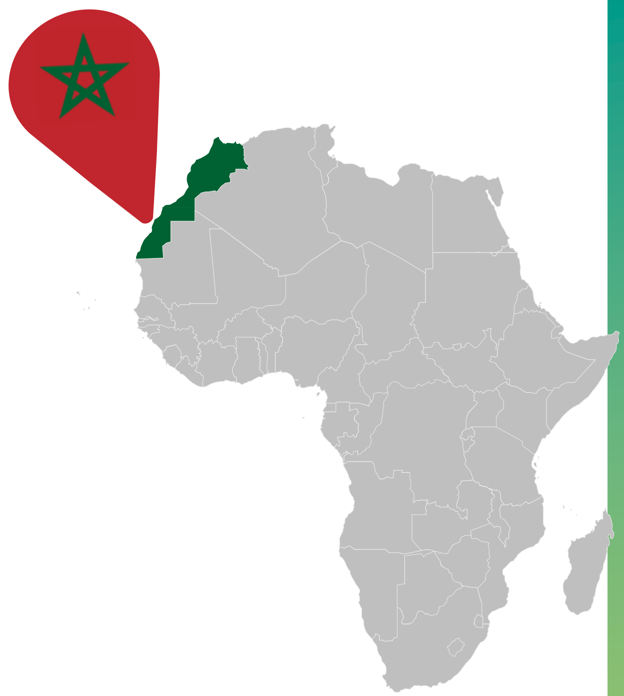


NASSIM - MAURITANIA

- Ca. 1,5 mio ha exploration zone secured – final site selection ongoing
- Fully integrated project
- First phase of ca. 1mio MTY 100% renewable ammonia
- Scale-up potential to ca. 3 a 4 mio MTY NH_3
- >1year on-site weather data collected
- ESIA, Geotechnical, Logistical and Port studies completed
- Pre-FEED under development
- COD Phase 1 targeted for 2031
- Transparent and Predictable Hydrogen Law

DAHAMCO - MOROCCO

- 553.000ha allocated by local authorities
- Fully integrated project
- First phase of ca. 1mio MTY 100% renewable ammonia
- Scale-up potential to ca. 4 to 5 mio MTY NH_3
- ISBL Pre-FEED phase 1 completed
- FID Phase 1 targeted for Q3/2027
- COD Phase 1 targeted for 2031
- Local Industrial Integration schedule
- 10.000ha agricultural zone



Challenges and Opportunities

Some Challenges and Opportunities

High potential during construction and operations	Employment	Lack of skilled labour
Governments and developers want to maximise	Local Manufacturing	Likely to increase cost and reduce bankability.
Enabler to build or improve basic infrastructure e.g. ports, roads, etc	Infrastructure	'Chicken and egg' Should be do-developed in PPP
GH_2 sector faces issues of affordability	Direct Financial Benefits	Governments want to monetize on their resources
Developers and investors need predictability	Legal Framework	Governments are in doubt on how to structure
Potential to supply excess energy. Potential to oversize water treatment plant and provide drinking water, irrigation water	CSR	Distribution and use is to be taken up by local community / government
Each developer runs its own ESIA	ESIA	Cumulative effects

Some Challenges and Opportunities

Limiting the wake losses in the wind farms is crucial

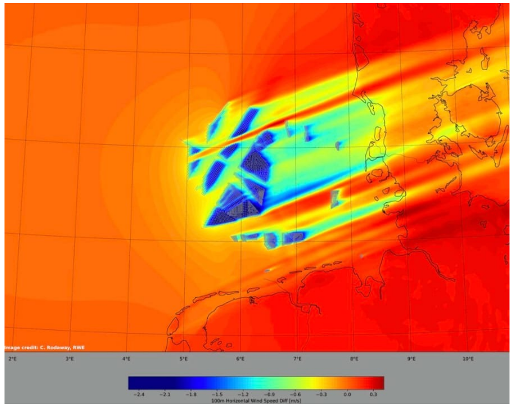
Wake losses

Large wind farms have higher wake losses.
Wind blockage from other wind farms.

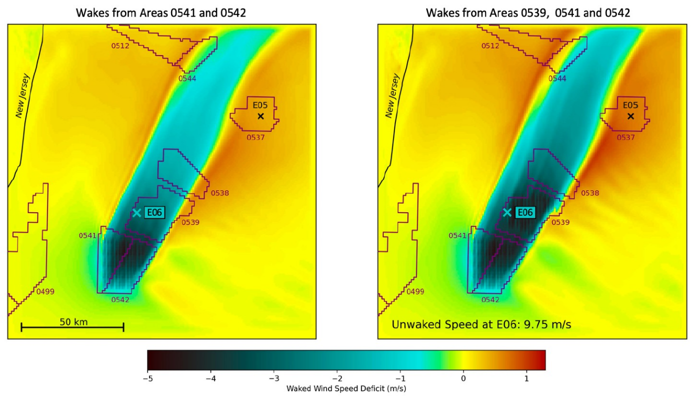
Each developer runs a separate wind measurement campaign

Wind Measurement Campaign

Wake Blockage effects are hard to estimate



- DNV reported that large groups of wind farms could have significant wind-shadowing impacts that would affect the wind yield of upcoming wind farms.
- Wake effects up to 200 kilometres away and diminish the energy yield by almost 10% in some circumstances.



- ArcVera Renewables carried out a study of long-range (> 50 rotor diameters) external wakes, with emphasis on the tendency of existing engineering wake models to greatly underpredict the strength and longevity of external wind farm wake losses on other projects.
- The simulations produced dramatic hub-height project-scale wake swaths that extended over 50 km downwind, with a specific example showing a waked wind speed deficit of 7% extending 100 km downwind from the array of turbines that produced it. When averaged over the selected 16 simulation days, the energy loss at the target lease area due to external wakes from arrays to its southwest was 28.9%.

Thank you!

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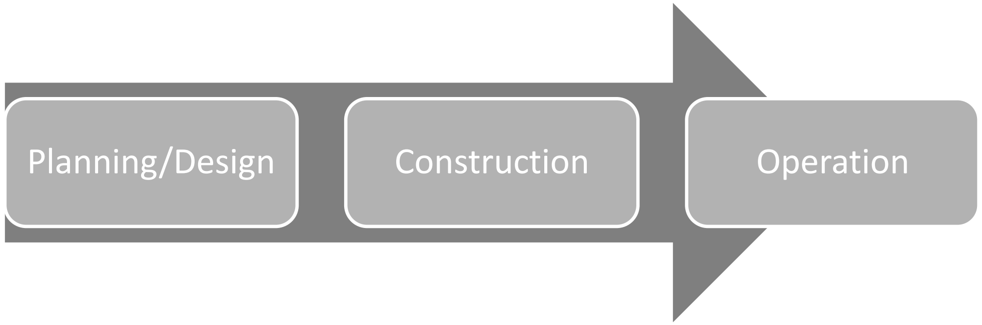
Environmental and Social Considerations Related to Green Hydrogen Project Development: Strengthening the decision-making process and its commercial and technical viability.

Experiences from over 20 traditional windfarms constructed in Patagonia, and 3 green hydrogen feasibility projects in Argentina

Dr. Ariel Cuschnir
AMDA Consultants LLC

Photos source: AMDA Consultants LLC (Left: National Park Monte Leon. Right: Cauquen bird species in Rio Gallegos Study Area)

The purpose of this presentation is to use our extensive local knowledge and experience of windfarms development in Patagonia, Argentina, and based on lessons-learned, provide suggestions on how to address the development of green-hydrogen projects in that region.

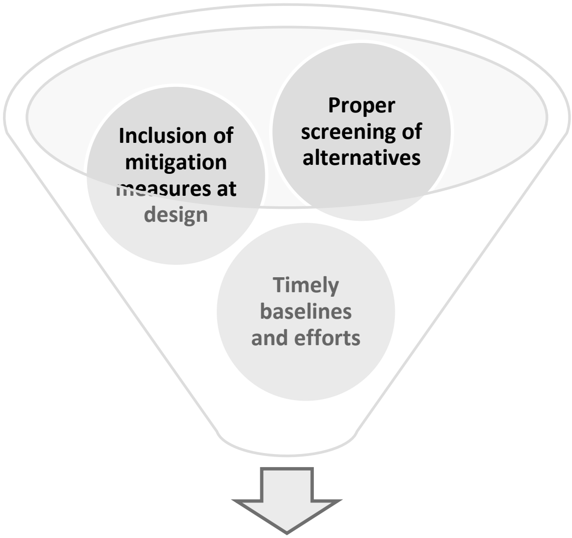


Windfarm development life-cycle

Green-hydrogen projects raise additional E&S challenges not only related to the much larger scale of these projects, but also to their complexity (multiple components) associated with hydrogen production, transport, storage, and export.

Examples of environmental and social Issues associated with traditional windfarm project development

- Proximity to support/associated infrastructure (i.e. roads, transmission lines)
- Workforce availability in remote areas (Patagonia)
- Biodiversity constraints
- Stakeholder acceptance
- International project financing and exclusion lists
- Legal regulatory framework and approvals



Successful implementation

Photo: AMDA Consultants LLC

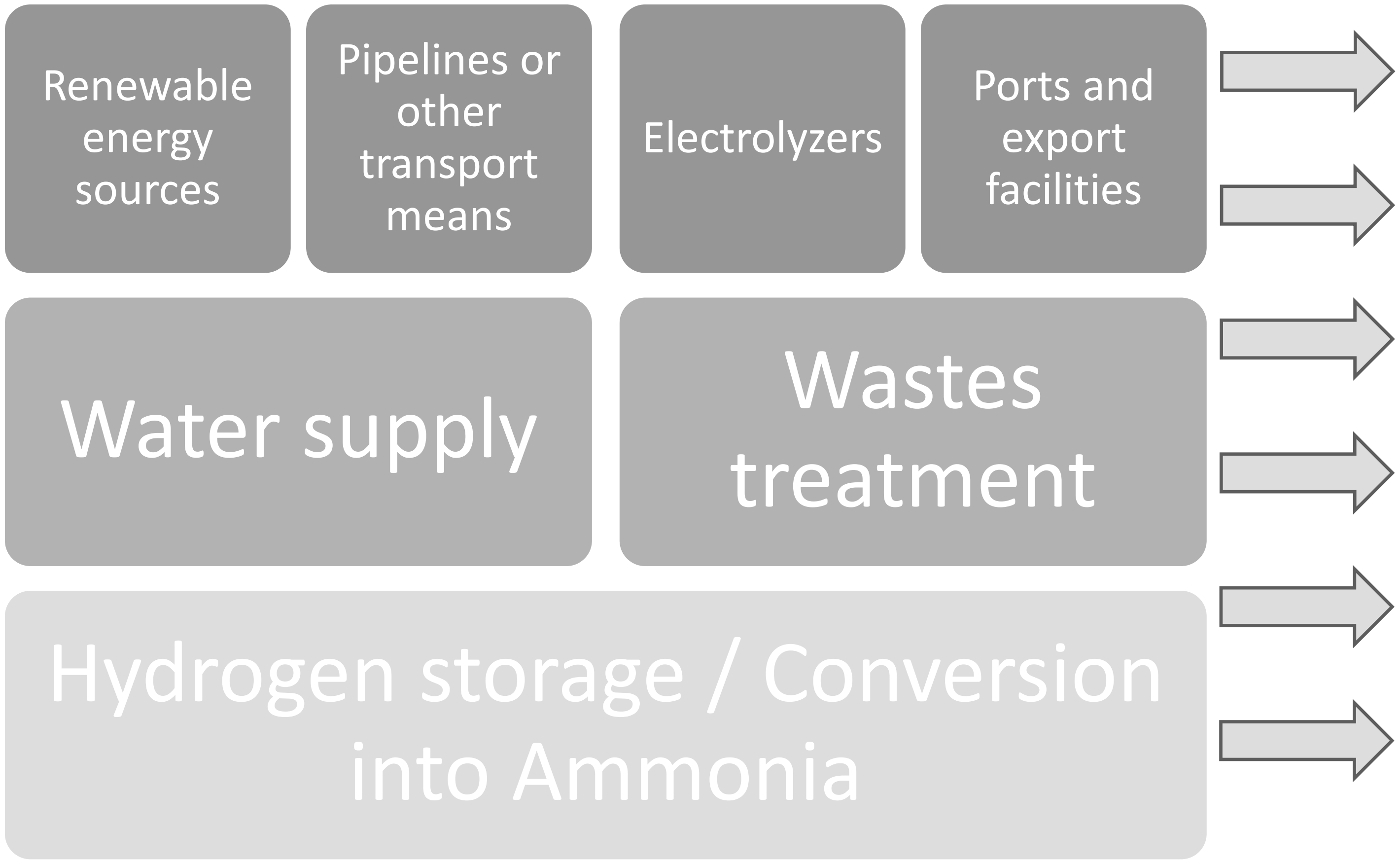
Examples of project components in green hydrogen production and distribution that generate additional environmental and social challenges

- Renewable energy sources
- Pipelines or other transport means
- Electrolyzers
- Ports and export facilities
- Water supply
- Wastes treatment
- Hydrogen storage / Conversion into Ammonia

Siting, construction, and operation of these components could generate E&S challenges beyond the project's footprint.

Successful project implementation requires environmental and social assessments at a larger scale, and with a comprehensive integration of cumulative impacts identification and management. The scale of the area of influence will depend on the nature of the project (green hydrogen projects for local energy consumption vs regional/global consumption).

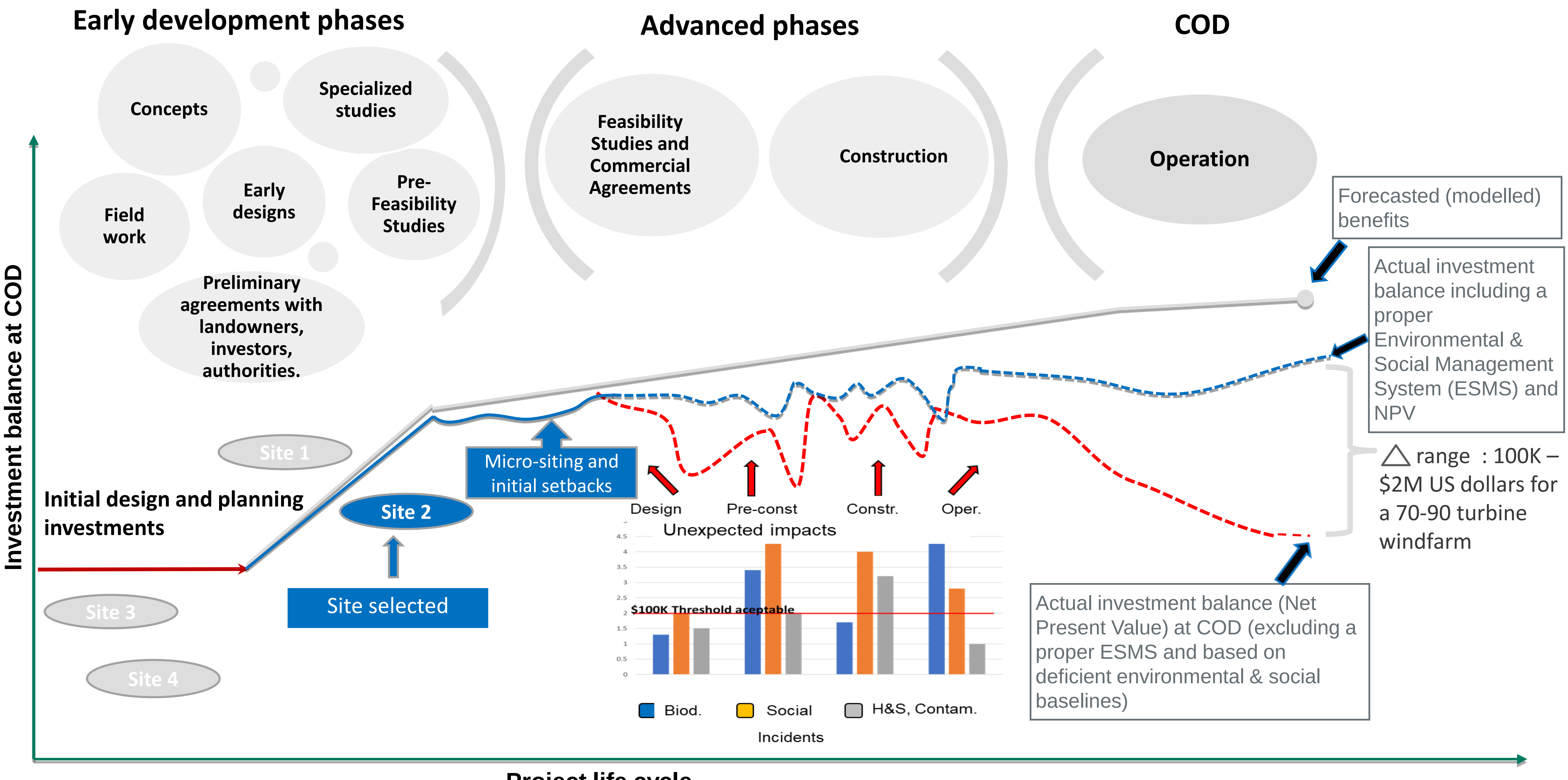
Green hydrogen project components and environmental and social challenges



Examples:

- Environmental impacts to both land and marine environments
- Need for larger surface areas and often multiple agreements with landowners
- Potential for importing labor force into more remote Patagonian areas
- Disposal of production wastes
- Available E&S baseline data might be insufficient (most existing windfarms and E&S studies conducted in Patagonia focused on areas near existing roads and right-of-way of existing transmission lines)
- Costs of project-development requires international financing and consequently applicability of international E&S standards to each of the project components (project bankability).

Real case-example of cost benefits in new windfarm project development



ERM style graph modified to show AMDA's project results

NPV: Investment worth through lifetime discounted today's value

Increasing NPV and biodiversity protection by reducing E&S risks and addressing matters on a regional context. Example: Bird species of concern

Sensitivity analyses for project siting

Siting of large-scale green hydrogen projects

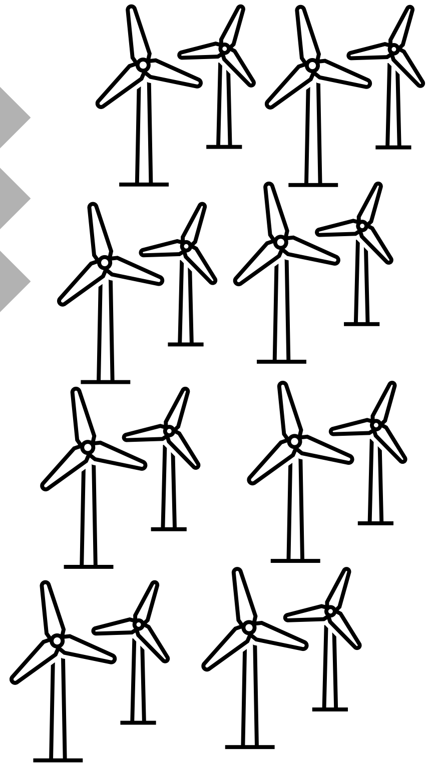
Project definition and siting require an understanding of existing E&S conditions in a region where knowledge is limited

Sensitivity analysis tools

Implementation of sensitivity analysis in early stages can offer a first important screening to focus project development on less E&S sensible areas

Example of key E&S drivers

Migratory bird species or local species of concern can offer a first screening criteria for project siting



Sensitivity criteria

a) Identification and minimum distance of the project to protected areas of any management category supported by the current legislation of each jurisdiction.

b) Identification and minimum distance of the project to important conservation areas.

c) Identification of native forest areas protected by Law No. 26,331 for the Environmental Protection of Native Forests.

d) Consideration and integration with any Strategic Environmental Assessment (SEA) that was developed in the region of the study area.

e) Identification of other wind projects in operation or under development for the area of the project in question (in this Phase of our study a cumulative impact study will not be carried out, but this information will be used for a future study of this nature).

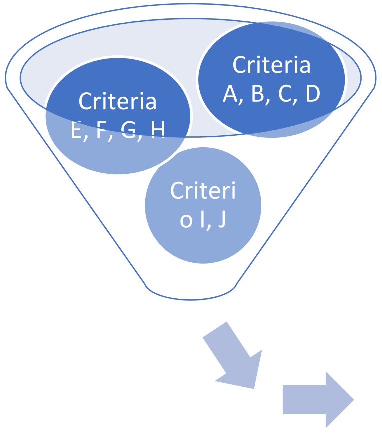
f) Biodiversity of flying fauna present in the study area.

g) Migration routes within the study area.

h) Endemism present in the study area,

i) Threatened species under IUCN and/or National categories.

j) Bird nesting or breeding areas.



Remaining criteria for further analysis and siting definition

Source: Atienza et al. 2011. Guidelines for assessing the impacts of wind farms on birds and bats V4. SEO BirdLife.

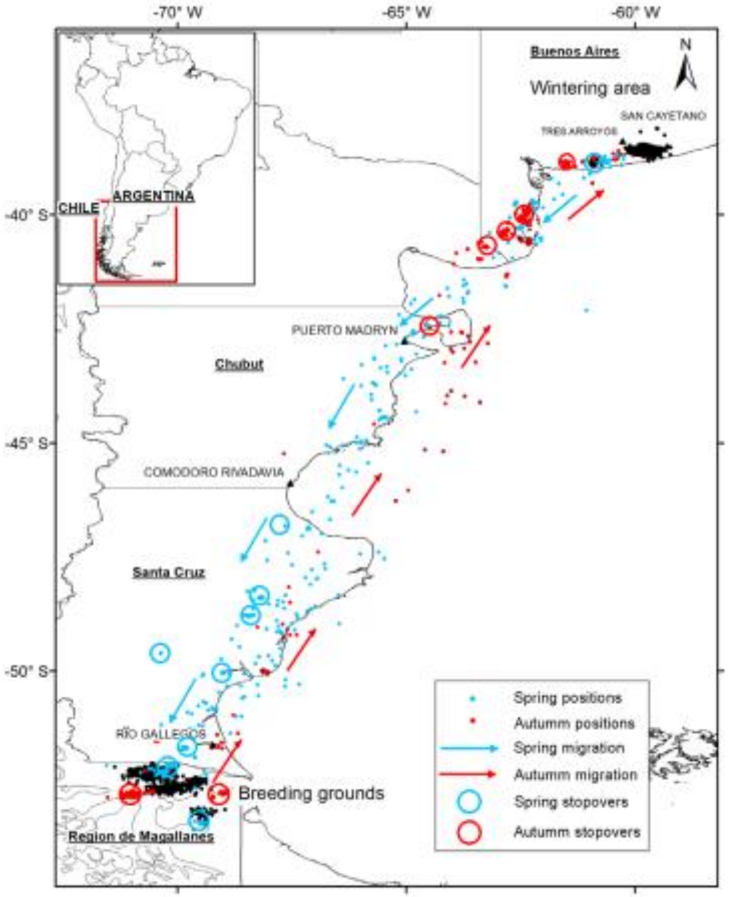
Field and desk-top sensitivity investigations: Results

Example of key species of concern for sensitivity analysis: *Chloephaga rubidiceps* (Cauquen Colorado). [Under 900 remaining in the wild]

Photo: Gonzalo Daniele
AMDA Consultants LLC

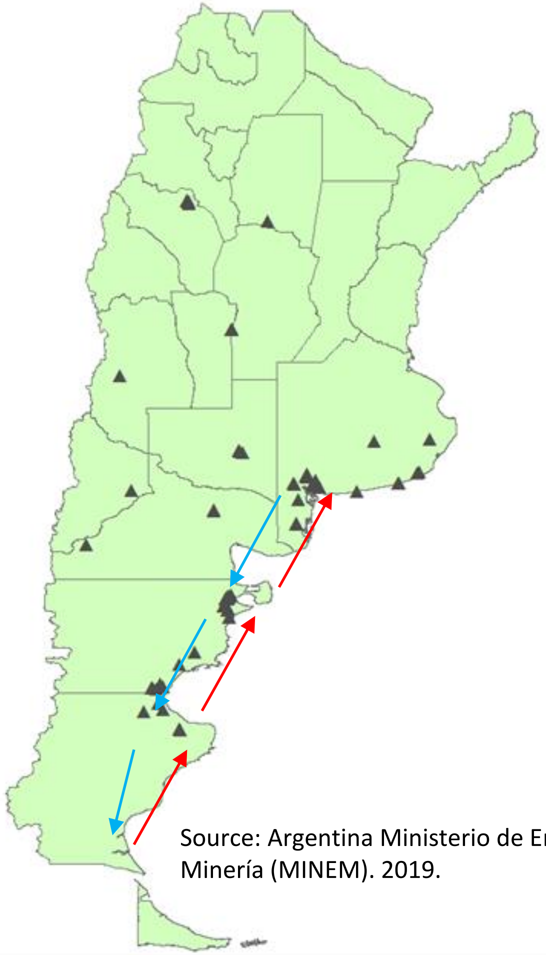
Photo: https://ebird.org/species/ruhgoo1/

Cauquenes Migratory path



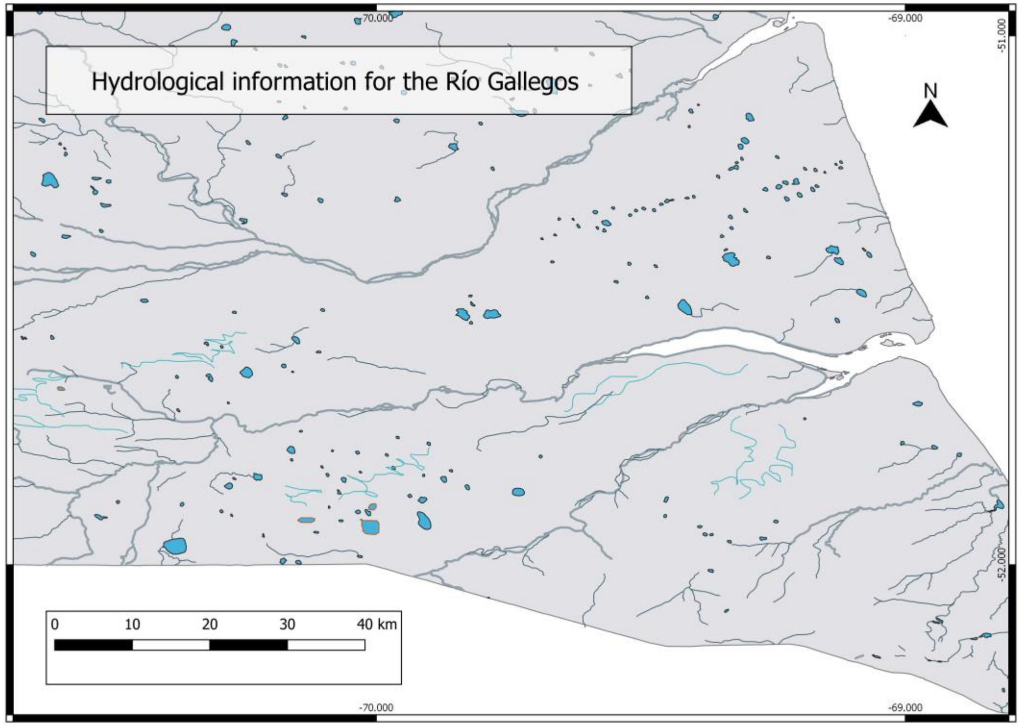
Source: (Pedrana et al., 2011)

Overlap with windfarm projects



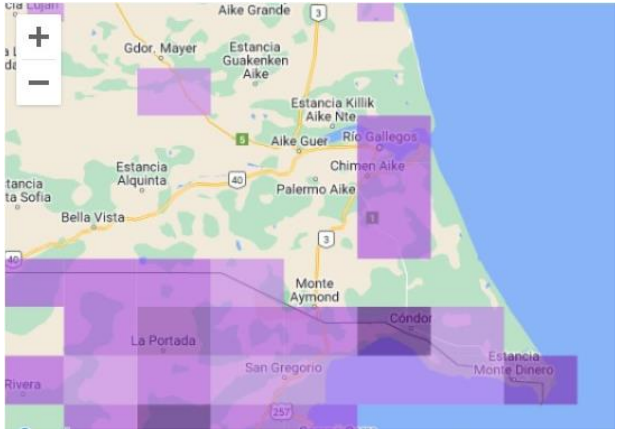
Source: Argentina Ministerio de Energía y Minería (MINEM). 2019.

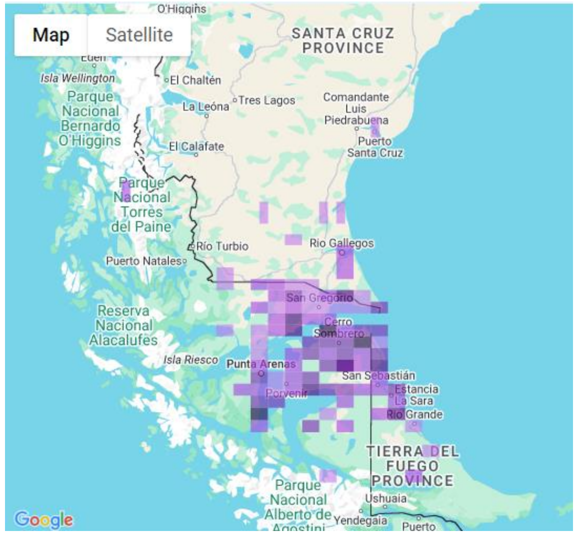
Field and desk-top sensitivity investigations: Results



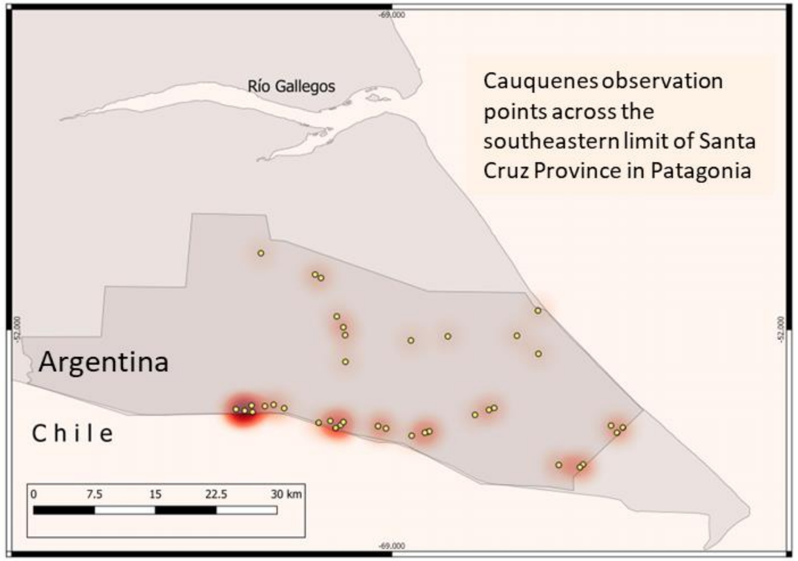
Source: Gonzalo Daniele over data from
https://www.ign.gob.ar/NuestrasActividades/InformacionGeoespacial/CapasSIG

Hydrological conditions in study areas are of particular importance as nesting and migratory sites for Cauquenes. There are no abundant hydrological studies conducted in the Province of Santa Cruz. The National Argentinian Geographic Institute (IGN in Spanish[2]) offers an important overview of the permanent and intermittent streams in the area.



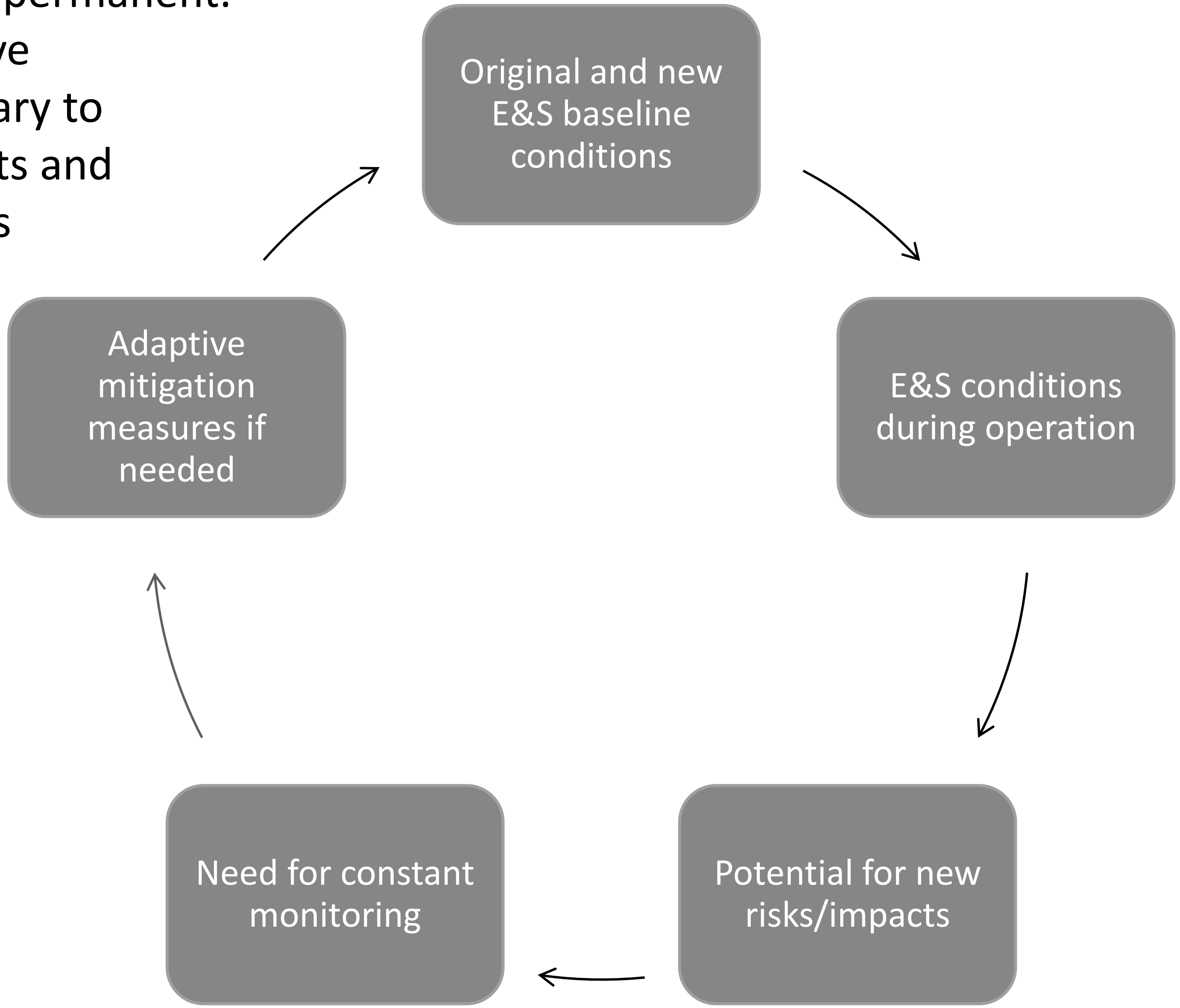


Distribution of Cauquen nesting sites in southern Patagonia Source: https://ebird.org/argentina

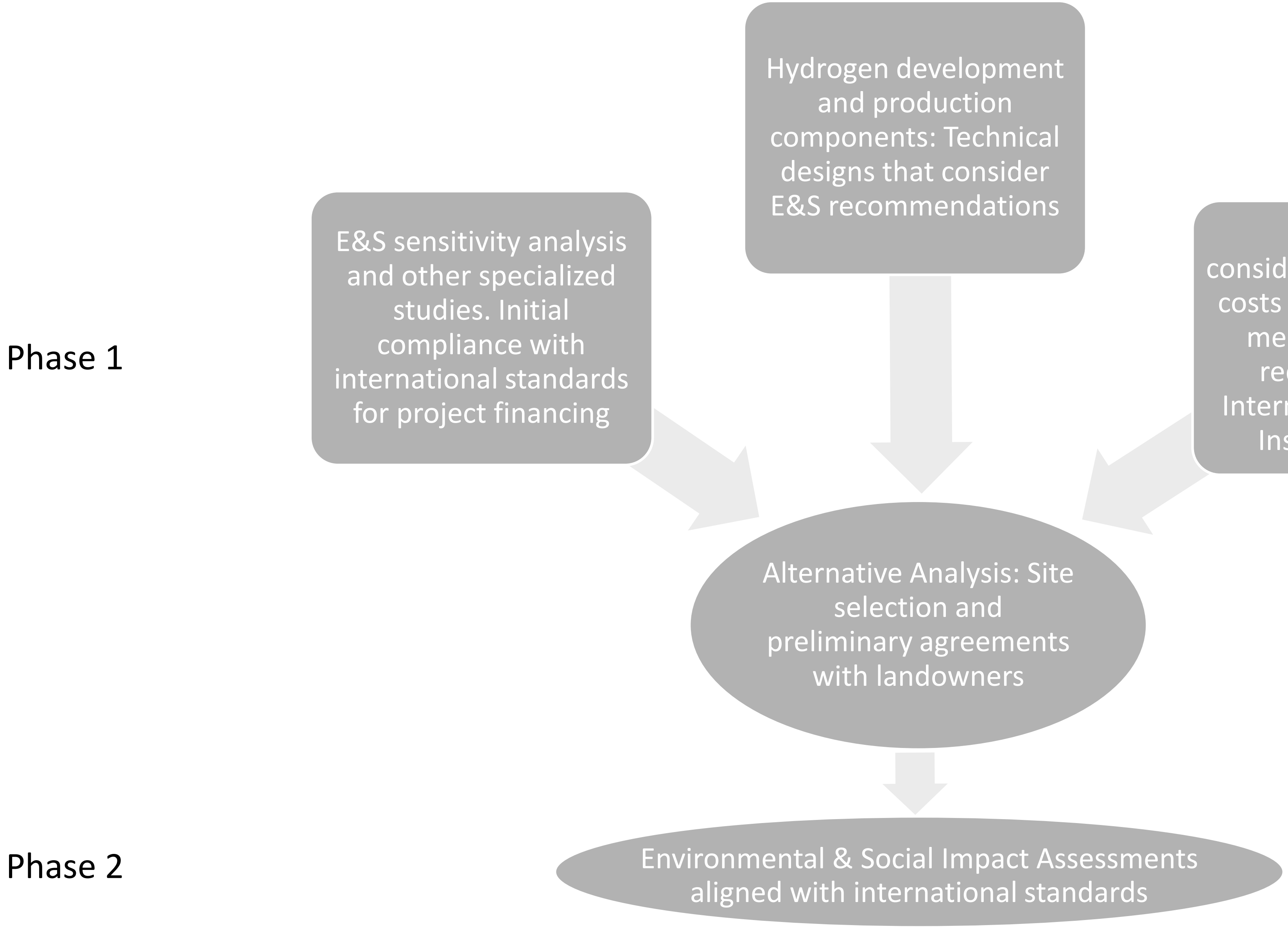


Heat map for density of Cauquenes

E&S conditions are not permanent. Monitoring and adaptive management is necessary to reduce risks and impacts and associated project costs



Integration of E&S, Commercial, and Technical Considerations during the initial project development phase



Thanks!

Green Hydrogen: Key Socio-environmental Issues

9 December 2024

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International Association for Impact Assessment

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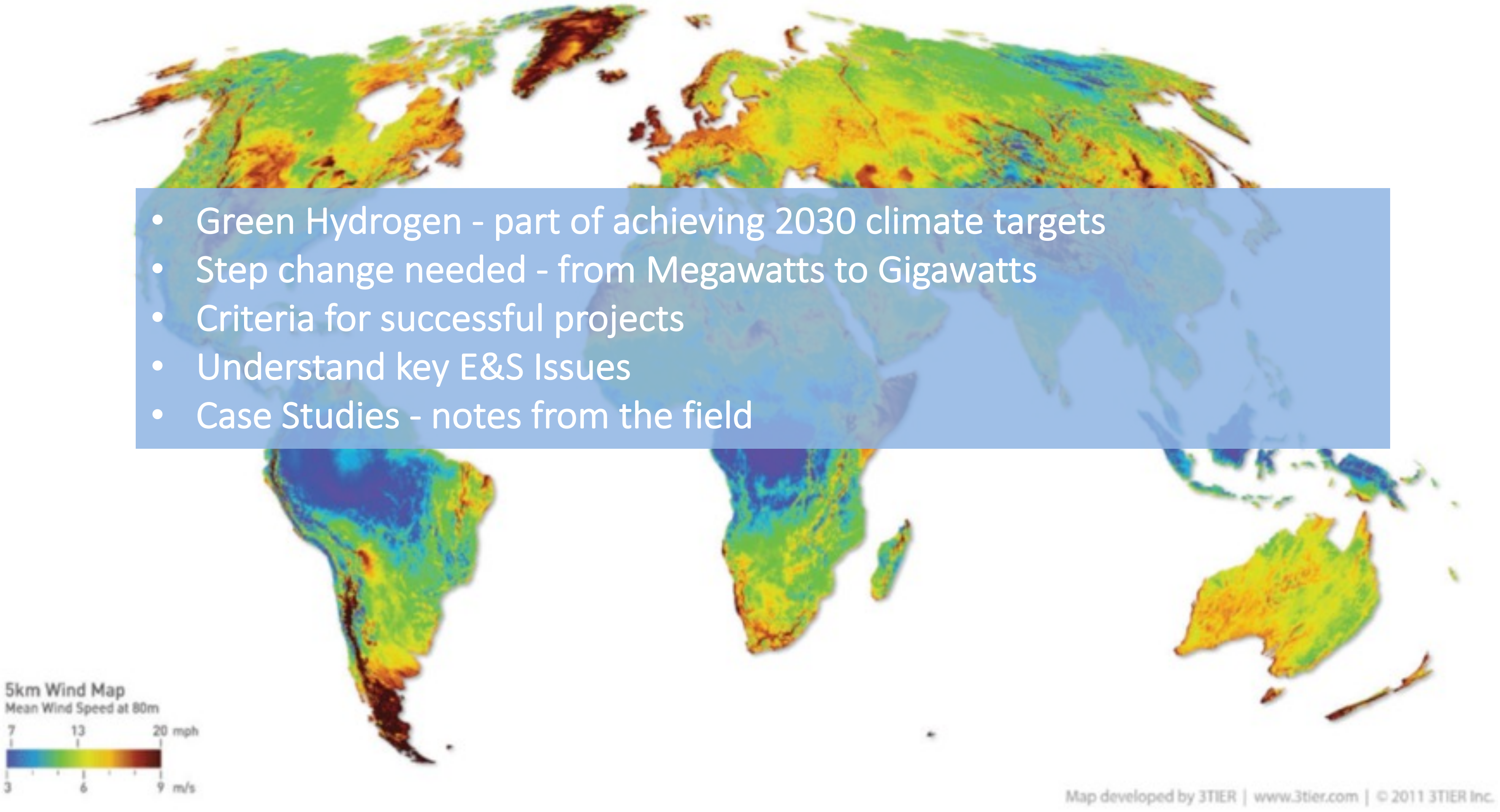
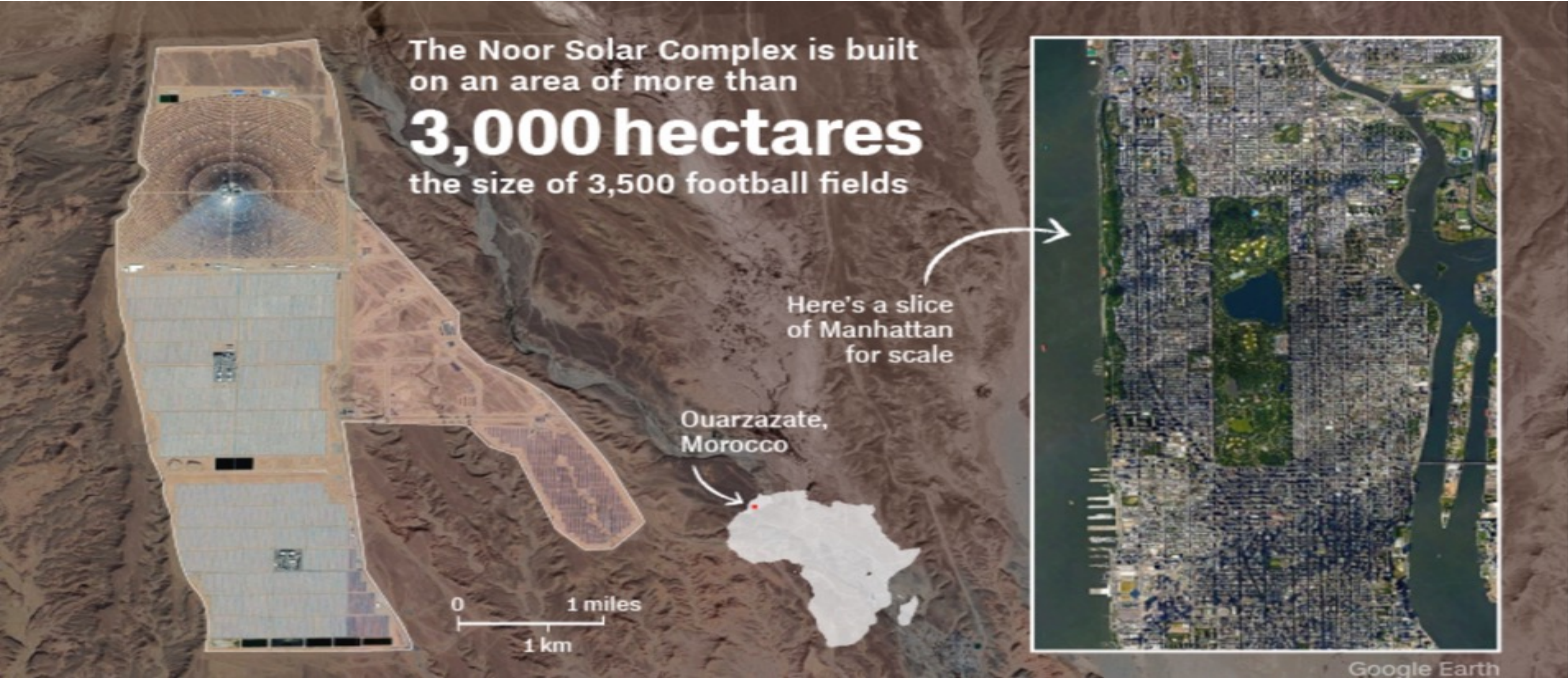
Green Hydrogen and the Energy Transition

- Green Hydrogen - part of achieving 2030 climate targets
- Step change needed - from Megawatts to Gigawatts
- Criteria for successful projects
- Understand key E&S Issues
- Case Studies - notes from the field



Scale a 10MW Green Ammonia Plant (Australia)



Capacity

580 megawatts

Enough to power a city the size of Prague

Height

243 metres

Complex includes the tallest tower in Africa

Temperature

500 degrees (C)

Mirrors reflect rays to top of tower, generating enough heat to melt salt

Energy Storage

Melted salt

The melted salt stores heat, which can be used for energy when needed for power

Case Study (2023)

- 2.3 – 7GW onshore wind-based GH project
- Pre-feasibility E&S Scoping Study
- Integrated techno-economic and E&S risk assessment
- Constraints assessment

Impacts: Environment, Waste and Safety

- Depending on siting potential impact avifauna and other biota
- H_2 production is water intensive – desalination required. Disposal of brine and toxic chemicals
- Despite excellent wind conditions intermittency an issue necessitating a storage solution
- H_2 / NH_3 production & storage are hazardous processes - need for safety buffers and set backs – siting issue
- Size of wind turbines, access roads and foundations
- Lack of port facilities




Project Footprint

Windfarm

- 2.3 GW: 348 turbines (350 km²)
- 6.7 GW: 1,015 turbines (1400 km²)
- Access roads: 500 – 1500km
- Turbines – 200m high

Transmission Lines

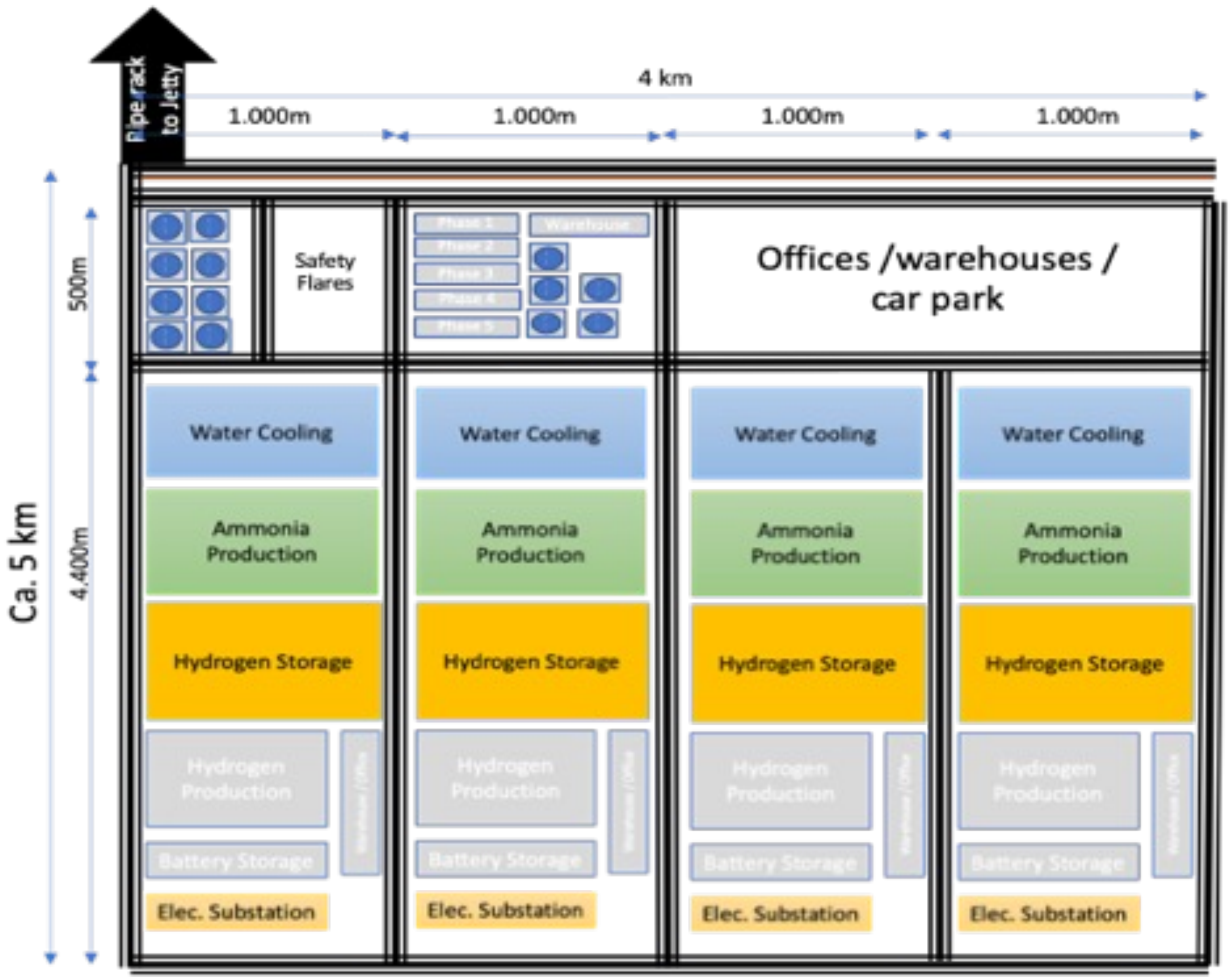
- 4-12 lines, 50m pylons

H2 / NH3 Plant

- 15 km²
- Safety Buffer / Setback

Worker Camp

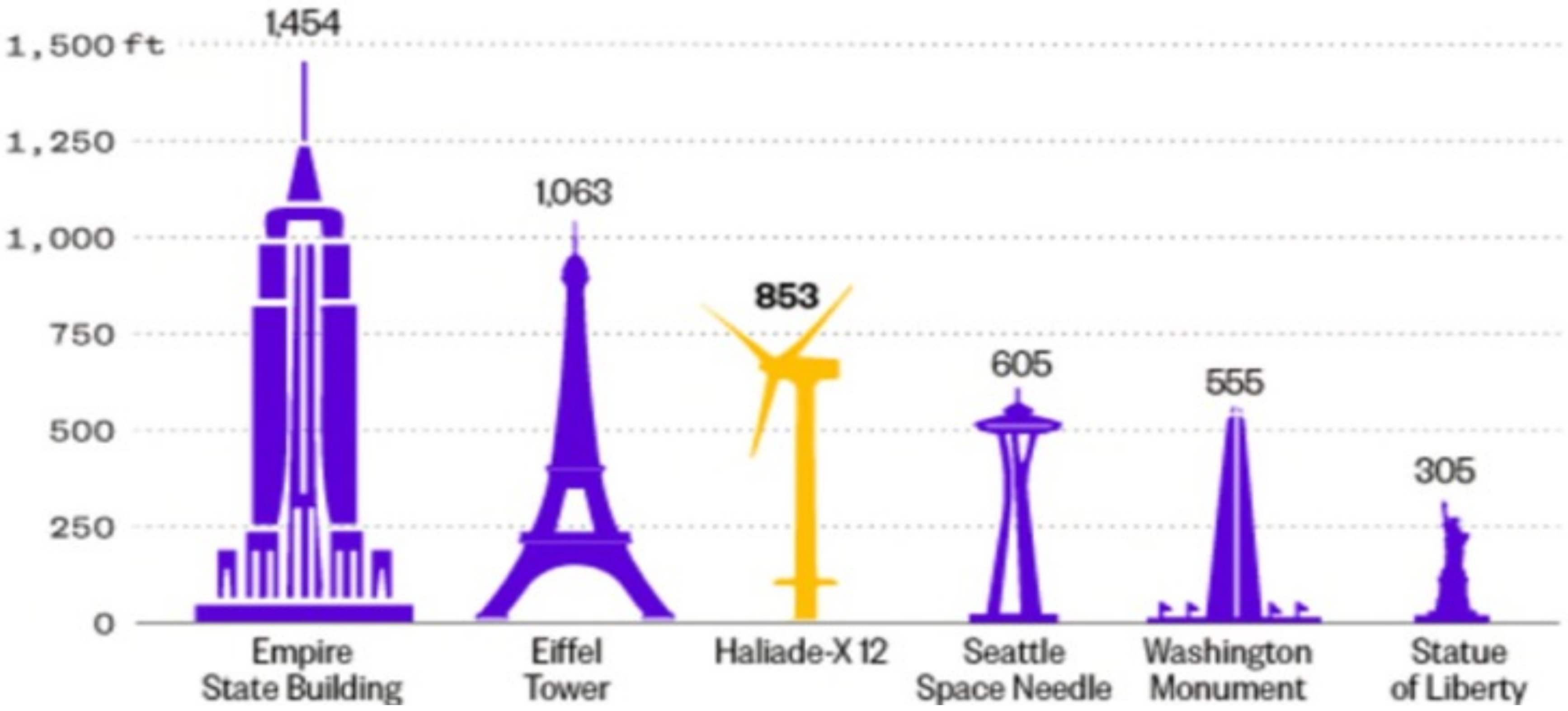
- Up to 6,000 persons (construction)
- 700 persons (operations)
- > 2x local population



Stakeholders and Consultation

- Influx of 6000 workers for construction – potential social impacts
- Lack of stakeholder awareness of project scale
- Project was to go public at pre-feasibility stage to discuss project

Landscape and Visual Impacts



Disturbance of Peatlands

- Peat disturbance in order of 30 km2
- Degraded peatland can emit more CO_2 than it stores
- Big ticket item
  - confirm if Project is carbon neutral
  - some studies indicate that peatland windfarms not carbon neutral
- Minimise footprint, avoid deep peat, follow best practices
- More research needed

Case Study Conclusions

Green does not mean public acceptance is assured

How green is Green Hydrogen?

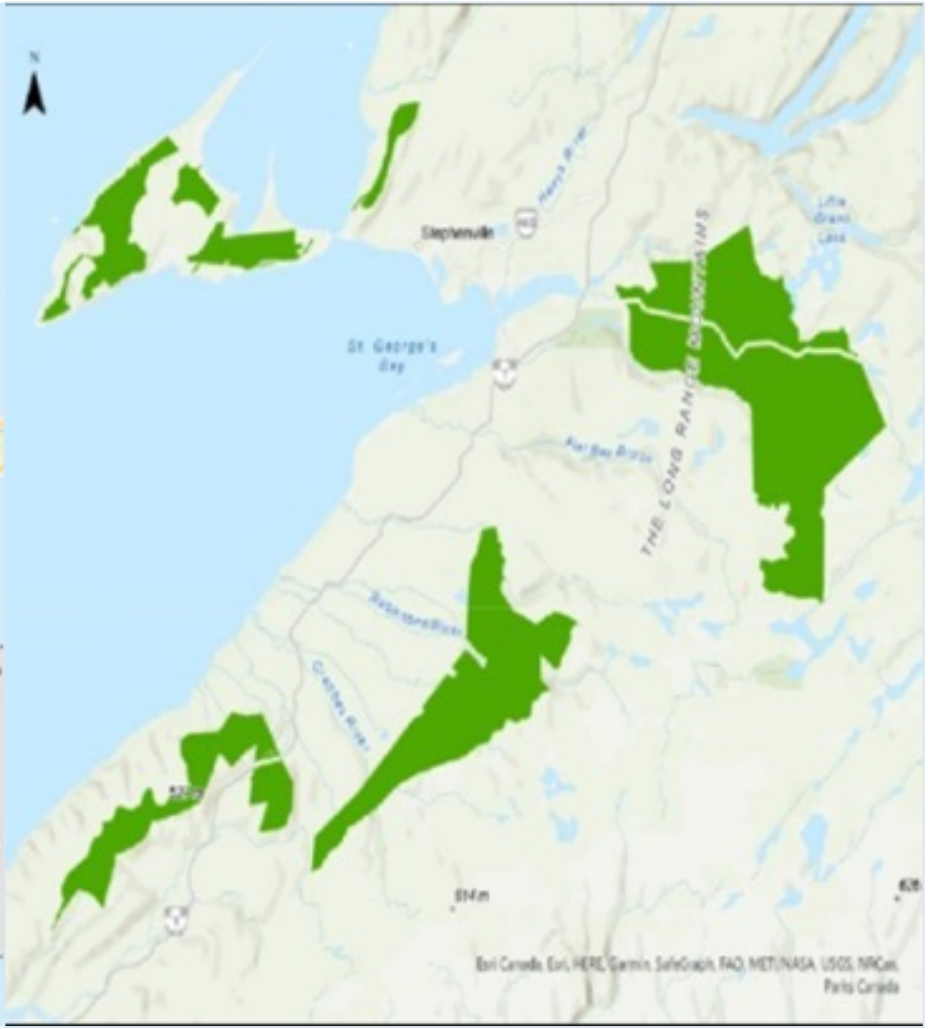
Early-stage scoping / issue identification

- collaboration of techno-economic / E&S experts vital
- transparency and meaningful engagement essential
- constraints assessment to optimise / reduce footprint

Potential red flags / major impacts identified warranting further study in the ESIA

Economics reason for NOT proceeding - BUT project positioned for moving forward

Project Nujio'qonik (Newfoundland)



Impacts are Location-Specific

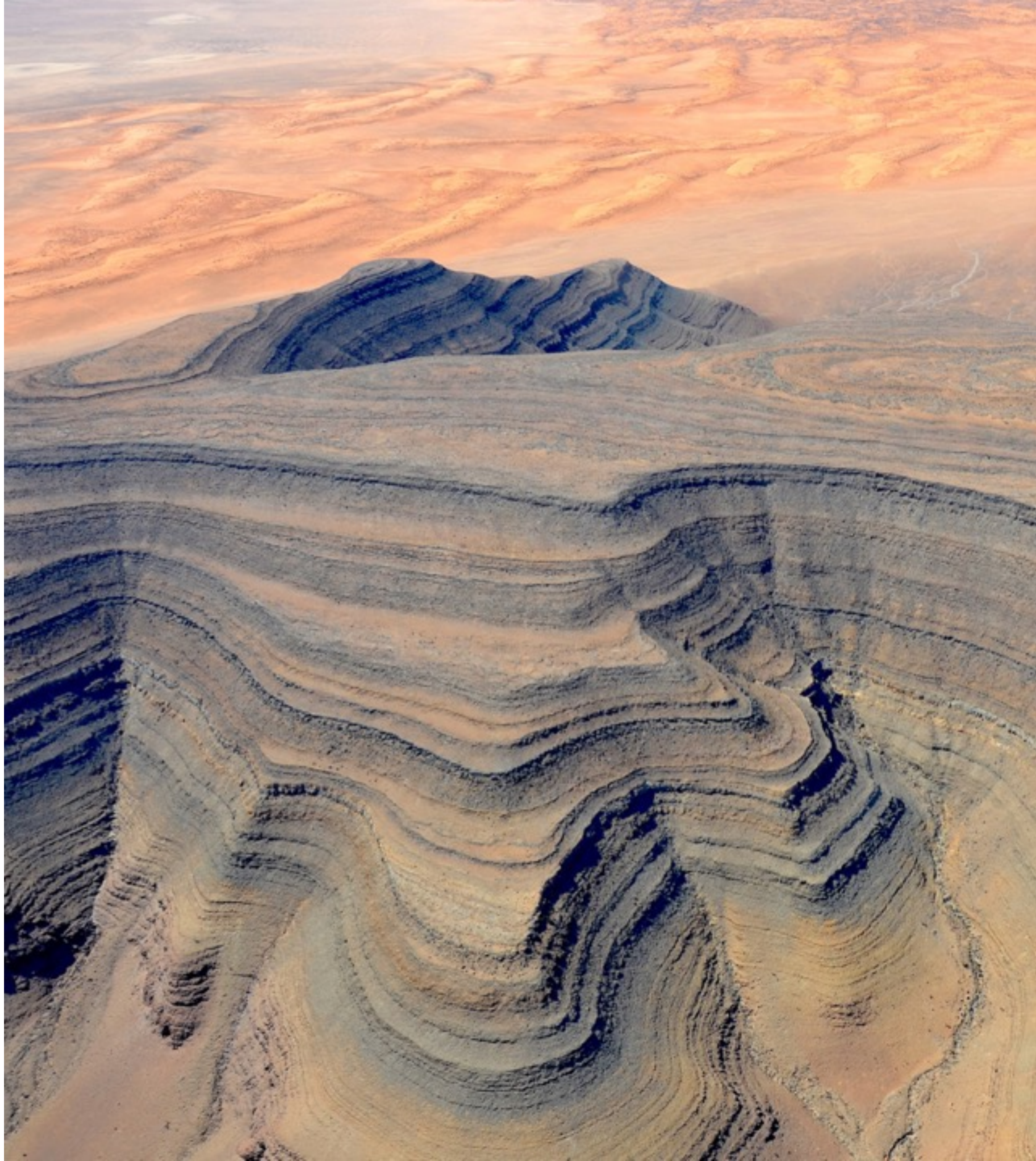
- **Biodiversity:** Hyphen Project (Namibia) overlaps National Park - concerns over biodiversity impacts

- **Cultural Heritage:** Some locations in MENA region feature significant cultural heritage values

- **Presence of Vulnerable Groups**: Increased sensitivity (e.g. noise and shadow flicker)

- **Waste Management:** Poor waste management infrastructure – what happens with used solar PV?

- **Land Use:** Sterilisation of land - potential for land use conflicts



Stakeholders

Even in remote areas there are stakeholders

Nomadic and Indigenous Peoples

Meaningful engagement vital

Importance of good social baseline

Conclusions

- Impacts are location and context-specific
- Scaling-up from MW to GW challenging
- Social acceptance
  - meaningful engagement – low awareness
  - delivery of benefits – value proposition vital
  - manage expectations
- Site selection & constraints assessment
- Pressures to fast track permitting – risky
- Land use – potential for social conflict
- Green H2 has a role to play but not all projects will go ahead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