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Part of
Aker Solutions

Green energy business cases

let the algorithm game it out

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Introduction

Defining and maturing green energy business cases is a challenging endeavor. This white paper outlines our recommended digital approach for the energy industry to effectively tackle the early-phase definition of green energy and decarbonization projects.

Developing any energy business case is inherently complex. Green energy cases must strike the right balance among the three critical aspects of the energy trilemma: energy security, affordability, and sustainability.

In collaboration with our software partner, WhiteSpace Solutions, we have devised a methodology that combines Aker Solutions' in-house expertise and data with bespoke algorithms. This approach is integrated into an intuitive and collaborative digital platform, streamlining early-phase energy system modeling.

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1. "Green energy business cases don't grow on trees"

Fossil fuels have dominated and shaped world events throughout the 20th century, with robust business cases for oil and gas projects playing a crucial role in their continued development. Modern economies have evolved based on deep dependencies on fossil energy, naturally leading to a rapid increase in CO2 emissions. While the oil and gas industry is likely to persist for many decades to come, the energy transition has already begun. Unlike the lucrative returns of past oil discoveries, clean energy projects often lack the substantial financial gains observed in the oil and gas sector. At a high level, this presents two distinct challenges:

Problem 1: Green energy and decarbonization projects require heavy investments with limited return on investment.

Problem 2: Green energy projects face volatility across the integrated energy value chain.

2. The green energy business case is a complex beast

There are plenty of successful examples of green energy projects, just look at the hydropower industry in Norway. However, the era of low-hanging fruits is coming to an end, and more complex undertakings are required to ensure we achieve the decarbonization of our energy system.

Despite continuing technological advancements and regulatory support, the business case for many clean energy projects remains elusive. We view this as a techno-economic problem, the interplay between technology and economics is the key (and regulation, but 'techno-regulatory-economic' doesn't exactly roll off the tongue).

Moreover, most green energy projects today are not islands in the energy system, they need to be integrated into existing systems, which dials up the complexity even further.

Diving further into it, we can see several interrelated factors that have to be solved for:

- Energy security
- Sustainability
- Energy affordability
- Existing energy infrastructure
- Shifting regulatory landscape
- Renewable variability & storage
- Significant upfront costs
- Evolving technological landscape

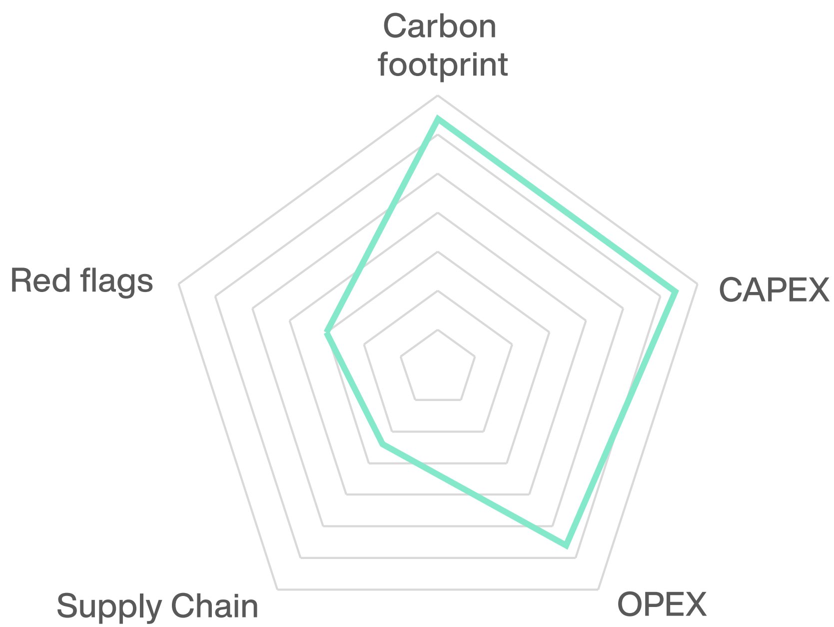
3. The trick to a high-level trade-off analysis, but the devil is in the data

Clearly, a trade-off analysis is necessary. The challenge lies in managing the interplay between factors that create a vast decision tree when defining scenarios and adjusting parameters. The integrated energy system does not lend itself to simplification down to just 2-3 parameters. The option space is typically constrained by what is humanly possible to explore within available timeframes and budgets. Often, simplification is the chosen approach, which can unfortunately lead to unpleasant surprises further down the road.

As with many things these days, the solution is found in the digital realm. This type of problem is an excellent case for advanced search algorithms, rich databases, and simple user interfaces, allowing professionals to explore scenarios and quickly navigate their way through the many trade-offs.

However, digital solutions are only as effective as the data provided. It is difficult to compare apples to apples when assessing early-phase energy projects. Establishing high-quality data sets requires continuous curation by experts who understand the energy project value chain and where the data points fit in. The algorithms are there to do the heavy lifting once the building blocks are in place.

Trade-off analysis



4. A digital recipe for green energy business cases

Business case assessment, quick options screening, early phase cost estimations, configuration optimization, uncertainties analysis – these are just five of many tasks within energy system assessments where advanced digital modelling can make a significant difference for developers and asset owners. Traditionally, these processes have been time-consuming and resource-intensive, relying heavily on manual calculations and spreadsheets. A new approach is to leverage the power of digital to allow for iteration across all these factors in a rapid manner. This provides an intuitive user interface with a powerful algorithm behind the scenes, enabling the user to search through the decision space and investigate the trade-offs needed to reach the most optimal business case.

Digital ingredients list:

- 1 part business case assessment
- 1 part technology options screening
- 2 parts holistic cost estimation
- 3 parts energy system optimization
- 5 parts reference data

Method:

1. Define a simple logic to enable rapid simulation of various project scenarios, allowing for a comprehensive understanding of potential economic viability. With faster turnaround times, developers can make informed investment decisions with greater confidence.

2. Instead of manually evaluating numerous possibilities, use algorithms to quickly and effectively screen an extensive range of clean energy technologies and their combinations. This allows for the identification of the most promising options for further analysis, saving valuable time and resources.

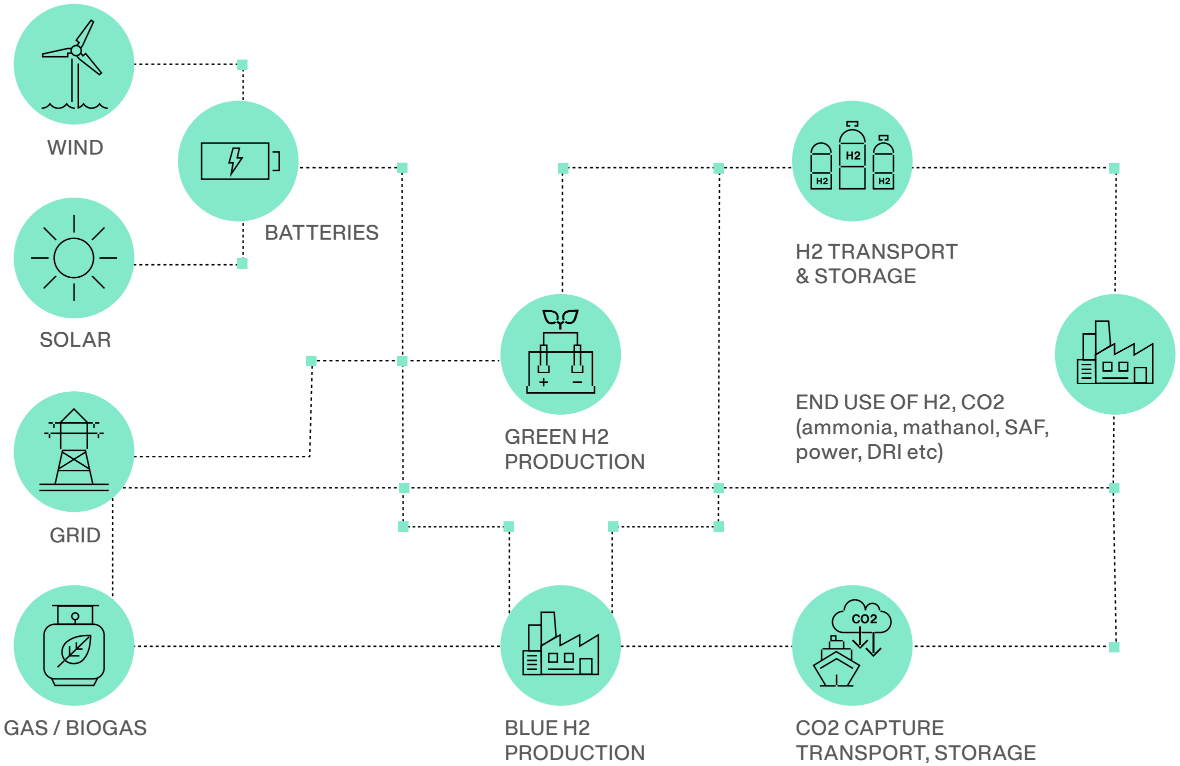
3. Utilize a platform for comprehensive (but high level) cost estimations that considers the totality of the system's financial footprint. By factoring in data from mature projects as well as dynamic market trends, you will be able to evaluate project costs, develop a range of outcomes, identify where the greatest risks for cost growth and accuracy, and reveal the trade-offs.

4. Build-in an optimization functionality from the total system perspective, analysing the entire energy project, considering all interacting components.

   The design should centre around finding the configurations that achieve the optimal outcome based on the customer's specific goals and help them gain a competitive edge.

5. Finally, the most important step, connect the above with a rich set of data to enable better simulation and data-driven analysis of sensitivities linked to all kinds of uncertainties – in the market, in capital expenses, operational expenses and other important parameters in the energy project. This data-driven approach to sensitivity analysis facilitates continuous improvement and the identification of best practices in the industry.

5. How we help our customers find the best business case for their project



We have developed a method and model to rapidly assess integrated energy systems, which includes:

- Quick techno-economic screening of multiple set-ups of different project configurations
- Diverse energy sources and wide range of technologies
- Intermittency handling, supply/demand gap minimization (hourly temporal correlation, energy storage in batteries, pipeline with storage capacity)
- System configuration optimization (capacities, consumptions, costs, CO_2 footprint, levelized cost of <you name it>, local content, timeline etc)
- Analysing system trade-offs and sub-system components
- Optimal operation of plant for minimization of cost or other parameters

6. Let the algorithm game it out to unveil the best options

To create a digital approach to solve this problem we have partnered with WhiteSpace Solutions, a software company that specializes in designing decision support algorithms with intuitive user interfaces. Our know-how is built into the algorithm that helps us search through the vast decision space.

1. The screening problem is formulated as a large-scale combinatorial problem

- Algorithm constructs a tree-like structure representing all possible system states.
- Each state, or tree branch, represents a possible combination of technology choices, and each choice comes with a cost (cost, carbon footprint, land footprint, local content etc).

2. The algorithm then 'games it out' by exploring options and exploiting promising branches of the tree based on the score it achieves in each run.

- Each potential solution is scored based on a pre-defined set of value drivers.
- The trick is to tune the algorithm so that it can approximate the most optimal solution by evaluating millions of concepts , saving computational time.

3. Engineering, cost, economic and value driver calculations are integrated in the tree search.

- The algorithm finds the optimal solutions (the Pareto front) of the multi-objective.
- This makes it ideal for optimizing energy systems where multiple factors like variable renewable sources, demand level and multiple technology options need to be considered.

7. So how does this help the green energy business case?

Compare technology types

- Screen different electrolyser technology types for green H2 production
- Evaluate different substructure types for offshore wind project
- Compare combinations of several turbine technologies and CO2 capture technologies
- CO2 transport & storage options comparison

Find the best route to market

- Screen different H2-derivative product alternatives
- CO2 handling options: permanent storage vs. utilization (producing fuels, chemicals)
- Post combustion carbon capture and storage for combined-cycle gas turbines (CCGT) vs blue H2 based CCGTs

Screen multiple project configurations

- Screen different configurations for green H2 production projects and find the optimal one with the cheapest levelized cost
- Decarbonization routes screening for the existing asset
- Decentralized vs. centralized H2 production with offshore wind

Perform multi-objective optimization

- Evaluate possible process configurations and find the ones with minimum costs and minimum carbon emissions

Compare different project parameters

- Compare project timelines for different options
- Compare impacts of different local content requirements on the project

8. Conclusion - how do green energy business cases grow on trees?

In conclusion, as we navigate the intricate landscape of green energy business cases, we find the early phase option space unnecessarily constrained. In this white paper we have exemplified the power of algorithms and data analytics in realizing energy transition projects, improving our ability to tackle the energy trilemma of security, affordability, and sustainability.

What electrolyzer type should you assume in your business case? What H2-derivative product has the most promising offtake opportunities? What is the best configuration of your production facilities? How do you balance multiple value drivers against each other? Our approach and models map this out in a simple way.

It's not easy, but green energy business cases can in fact grow on trees. With the right digital tools, we can explore the viable options with decision trees. A decision tree is only as good as the available know-how and data though, and such exploration has to be guided by experienced subject matter experts. As we game out the possibilities, we lead the way to a future where profitable green energy is not just a possibility, but a well-rooted reality.

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