EFFICIENCY ASSESSMENT REPORT

GRID STABILITY WITH RENEWABLE ENERGY? - YES, WIND CAN!

Windflow's power-train and its **synchronous generator** enable wind turbines to provide physical inertia and system strength for grid stability.

Solution ID: 378
Company: Windflow Technology Limited
Country: New Zealand
Export Date: 19.12.2019

ASSESSMENT RESULTS

APPROVED

FEASIBILITY

- Credibility of concept	YES
- Scalability	YES

ENVIRONMENT

- Environmental benefits	YES

PROFITABILITY

- Client's economic incentive	YES
- Seller's profitability	YES

GENERAL COMMENTS FROM THE SOLAR IMPULSE FOUNDATION

The solution ID378 is declared by the Solar Impulse Foundation as labelled Solar Impulse Efficient Solution after going through the following selection steps :

- It is falling into the eligibility scope in terms of (1) Minimum Maturity and (2) Type of solution. Moreover, the solution is owned and developed by an entity Member of the World Alliance that is operating in accordance with the Solar Impulse Foundation's ethical position.
- The Solution Submission Form was assessed by 4 independent Experts with at least 5 years of Experience in one of the sectors of application of the Solution and valid and coherent answers with justifications were collected enabling the deliberation of a majority opinion on each of the 5 criteria.
- Based on Experts deliverables, the Solutions Team concluded that the solution's assessments had been satisfactory and that the five criteria obtained a majority of "YES".
- After a final verification performed by both the Experts and Solutions team representatives, the validity of the assessment performed and the requirements for the five criteria were confirmed, resulting in the solution being awarded the Solar Impulse Efficient Solution Label.

FEASIBILITY

This section captures the ability of the solution to be credible (based on a resilient technology or concept) and captures if the solution is already or has the potential to be scaled up and deployed concretely in the real world (vs. in lab). The Experts were required to answer two questions on (1) credibility of design and (2) scalability of the solution.

EXPERTS REVIEWS

CREDIBILITY OF DESIGN

Can the technology behind the solution be constructed and operated as designed?

> YES
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> **Expert justification -** Yes, the Windflow technology's synchronous power-train system is a credible solution because it has been already designed, built and successfully tested. The technology needed to design and build the system is very well known and widely applied in the transportation industry (gear box, shaft,..).

> YES
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> **Expert justification -** In the times of the transformation to renewable energy sources all types of storage systems were facing extensive research, also the Flywheels. The task of wind turbines is to convert the kinetic energy of irregular winds into first kinetic energy of rotating blades and then into electricity via a generator. The generator needs to be synchronous with the grid, where the irregular wind energy is fed in via a regular electric way. Therefore it is just logical to use as a kind of buffer device also a rotating system to reduce losses and to increase the efficiency of the system. Such rotating storage systems are flywheels.

SCALABILITY

Is the manufacturing (if a product) or distribution (if a service) of the solution at scale technically feasible?

> YES
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> **Expert justification -** Yes, the scalability and the industrial manufacturing of the solution is very easy to obtain because the technologies necessary to make a "gear box" are very well known and developed since decades. That means, mature enough for an industrial scale. As mentioned in the feasibility question, the technologies necessary to make and assemble "geraboxes" are widely applied in the industry: transportation, shop machines, aerospace...

> YES
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> **Expert justification -** Flywheels are used in satellites and also electric cars to store kinetic energy. The team worked on the cost reduction in a successful way. A huge amount of wind turbines will be needed in future and 1. the converted energy needs to be stored and 2. it is more efficient to feed in the stored kinetic energy in a synchronous way. Facing this arguments the manufacturing and usage of such a solution at scale is not only technically feasible but has also a huge potential for the future.

ENVIRONMENT

This section captures the ability of the solution to have a direct positive impact on the environment over its entire lifecycle compared to a reference without any significant negative impact transferred. The Experts were required to answer one question on the environmental benefit of the solution.

EXPERTS REVIEWS

ENVIRONMENTAL BENEFITS

Can the solution deliver an incremental environmental benefit versus a reference case, considering the lifecycle (production, use and disposal stages) of its value chain?

> YES
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> **Expert justification -** The solution is a mechanical VS system called the torque-limiting gearbox/low variable-speed (TLG/LVS) system which leaves the generator speed constant (set by the grid) and has a differential (a planetary stage with one input from the wind turbine and two outputs) in the gearbox. One output from the differential drives the generator (constant speed), the other drives a hydraulic pump (variable speed). A hydraulic circuit controls the torque, while the turbine speed is controlled by pitching the blades. Together the hydraulic circuit and the blade-pitch control the power on the generator shaft, enabling it to be synchronous. Thus the important benefits versus the existing solutions are: grid stability, reduces gearbox downtime, low cost hydraulic system, lighter and more compact design, eliminates parts of the costly electronic systems, low cost hydraulic systems. The consequence are a better management of the produced electrical energy and benefit for the environment.

> YES
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> **Expert justification -** The environmental benefit that can be described of this system the easiest way is related to a higher efficiency of synchronous generators compared to not synchronous wind turbine generators. "The 48 MW Te Rere Hau wind farm in Palmerston North, New Zealand, has demonstrated the synchronous power train's ability to contribute to system strength, albeit in a hydro-dominated grid in which inertia is abundant." The cited sentence of the application states that the system is validated. The higher efficiency and system strength of the conversion of renewable wind energy is clearly an incremental environmental benefit.

PROFITABILITY

This section captures the capacity of a solution to deliver an economic incentive for the client and to generate profits for the seller in a 5-year timeframe, regardless of its marketing strategy, its positioning towards competitors, the novelty of the idea and the resources and experience of the team. The Experts were required to answer 2 questions on (1) Client's economic incentives and (2) Seller's profitability of the solution.

EXPERTS REVIEWS

CLIENT'S ECONOMIC INCENTIVE

Can the solution: 1) have the same or lower purchasing price than a reference case? OR 2) create return on investment over the lifetime of the solution despite a higher purchasing price? OR 3) create an economic incentive (value for money) for the client which is not directly related to savings? OR 4) become cheaper than the reference after a change in regulation that is reasonably foreseeable in the next five years in the targeted region(s) and sector(s) of implementation?

> YES
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> **Selected option -** 1 - **Yes**, The Solution creates **direct savings** for the client (e.g. cheaper purchase price).
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> **Expert justification -** I selected this statement because the power-train costs are lower, O&M costs are lower (no power electronics), no need for auxiliary services equipment for grid connection, (SVC, storage, etc.) or reduced need in high penetration. Thus lower overall societal cost of renewable future due to: lower turbine cost, lower wind farm auxiliary costs, larger wind farm potential/less curtailment

> YES
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> **Selected option -** 2 - **Yes**, The Solution creates **indirect savings** for the client (e.g. return on investment).
>
> **Expert justification -** First an investment is needed, a "million dollar investment rather than a $10 million investment required to demonstrate the power-train at this scale." The application is about a 2 MW pilot turbine project. After and while the prototyping and demonstration phase the marketing will take place. Then, after the first systems were sold and are in operation, when the wind blows enough, the savings will start. The indirect savings can be already reached with today's regulations.

SELLER'S PROFITABILITY

Could the solution itself be profitable for the seller within 5 years, with a sale's price at which clients would buy it? Please evaluate this regardless of the marketing strategy, the people behind it, the competitors and the novelty of the product.

> YES
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> **Expert justification -** As the synchronous generators assist in keeping the power system in synchronism by generating and absorbing large quantities of synchronising "reactive" power. Synchronising power is able to flow readily between generators in parallel operation on-line, helping the rotors stay locked in synchronised operation, and absorbing rotor oscillations by the inherent damping available from rotor eddy currents or from built-in amortisseur windings. Moreover the inertia within synchronous generators continually absorbs and releases kinetic energy to smooth and stabilise the system frequency in the very shortest time frame for both, small, routine, and occasionally large, step changes in system load. This smoothing effect is instantaneous, direct and inherent, independent of any generator controls. This cannot be provided by a Perturbation Estimation-based Control (PEC) generator. Consequently, if the innovator in the next two years will be able to convince the wind industry that the synchronous generation has to become a standard for the wind turbine therefore the breakeven will be easily reached in less than five years.

YES

Expert justification - "$20,000 per turbine, and most large manufacturers are building at least 100 turbines per year" The business model is licensing and can be easily profitable within 5 years. After scaling the applied business models the savings will grow until market saturation occurs, which could take hundreds of years. It is just the question, how much investments one wants to put in, if one assesses the application by evaluating the marketing strategy, by neglecting the people behind it, the competitors and the novelty of the product. With the regulation change of increasing e.g. the subventions for renewable energy facilities, the target of market saturation could be reached around 2100, due to enough generally said renewable facilities, that is needed by human kind. At the same time global unemployment could be dammed.

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