Renewable Energy Station

Renewable energy for the electricity grid, hydrogen and electric vehicles.

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1 Executive Summary

The purpose of this document is to present a case for the establishment of renewable energy stations for transport. That is, stations where a renewable energy supply is used to

1. Power electric vehicles
2. Refuel hydrogen powered vehicles
3. Store excess energy as hydrogen, for sale into the electricity grid to meet peak demand.

Renewable energy technologies, similar to ICT technologies over the past decade, are rapidly increasing in effectiveness while rapidly decreasing in cost.

Oil is highly likely to become subject to increasing price hikes, regulation, taxes, and global embargoes in terms of emissions, over the next ten years. So, as well as the moral imperative to reduce the level of greenhouse gases in the atmosphere, it is clear that there are financial incentives and pressures being brought to bear on fossil fuels.

The problem is to find practical alternatives, and transition strategies, so that petroleum combustion engines can be gradually replaced or upgraded to run on newer fuel types, such as hydrogen and electricity.

Best practice renewable energy technologies can now deliver baseload power (predictable, constant power in excess of 10 Megawatts). A particular problem for the electricity transmission authorities, independent of generator source, is the ability to meet the demands of peak power supply, as power is a commodity that is difficult to store, and both households and industry are rapidly increasing their consumption of electricity.

Large-scale solutions for storing energy are very expensive, have a long lead time, and are not the optimal solution to the basis of the energy problem, that is to supply peak and off-peak power demands in a cost-effective way.

Smaller scale facilities can be more flexible, and more easily backed up to provide local power in case of electricity blackouts and brownouts. This also avoids the problem of a single point of failure effecting large geographic areas in case of extreme weather or even disasters.

With the evolution of transport energy systems to electric motors, vehicles require new types of fuelling stations to supply both electricity and hydrogen.

A cost effective, energy efficient and low greenhouse gas emissions solution is to co-locate electric and hydrogen vehicle energy stations with renewable energy generators, using hydrogen to store excess energy for supply at peak times into the local electricity grid.

While initially, the supply of electricity into the grid can provide cash flow, it is anticipated that revenue from transport technologies is to increase over time as the electric/hydrogen vehicle technologies are further developed.

2 Introduction and Background

2.1 Project Rationale for Preferred Option

The purpose of this proposal is to establish renewable energy sourced vehicle transport.

The energy stations for transport of the future provide a few major objectives (and associated revenue streams)

1. The supply and storage of renewable energy, and the sale of peak power into the electricity grid

2. The delivery of energy based fuels for transport – the sale and supply of electricity and hydrogen for vehicles.

3. The technologies associated with conversion and adaptation of existing vehicles to use hydrogen.

4. The provision of energy metrics, analytics and market data via a secure web portal to stakeholders.

These goals can be met by:

1. Provision of cost effective hydrogen and electricity for vehicles by direct sourcing of energy:

a) Buying or leasing renewable energy production facilities, according to local feasibility, availability and cost.

b) Site energy stations close to the energy production facilities, enabling hydrogen production [5] and direct electricity supply.

c) Using an electricity market mechanism, provide scheduled supply of electricity into the grid by conversion of stored hydrogen into power via hydrogen fuel cells and power converters.

2. Provision of technology conversion centers for existing vehicles to use hydrogen based technologies, such as hydrogen fuel cells and combustion engines.

New renewable energy technologies provide a range of options, suitable for particular locations. Tidal power, wind turbines, solar-thermal and solar generators can all provide industrial strength energy at commercial levels.

The development of conversion of petrol combustion engines to use electric/hydrogen energy and hydrogen/petrol/diesel combinations, can be accelerated by the development of energy stations.

This proposal combines the following:

- The conversion of vehicles to hydrogen fuel cells or combustion engines.
- Supply of renewable energy
- Storage of renewable energy supply as hydrogen

- The provision for vehicle transport fuel in the forms of hydrogen and electricity

- Web portal for tracking electricity, hydrogen and greenhouse gas emissions offsets

After initial investment, cost recovery for these activities can come from supply of excess energy into the electricity grid as peak power supply to transmission authorities. As electricity prices rise, over the next five years, this is liable to be a lucrative income stream.

2.2 Hydrogen

Hydrogen as a fuel for transport is now a mature technology. Two main uses of hydrogen in vehicle engines are:

1. Adaptation of existing combustion engines either to run on hydrogen, or to provide improved power efficiency from hydrogen mixed with fuel types such as gasolene and diesel.
2. Use of hydrogen fuel cells to provide power for electric vehicles - these fuel cells take in hydrogen and oxygen, and give off pure drinking water, and electricity that powers the electric motors.

Hydrogen is also an efficient energy storage mechanism, and a two-way process can take electricity, store it as hydrogen, then when required, provide fuel cells with energy that can be converted back into electricity, suitable for supply into the electricity grid. [1]

Electric powered vehicles, using either batteries or hydrogen cells as a power source, are becoming increasingly available. These vehicles require either electricity or hydrogen to operate. Co-locating vehicle depots with renewable energy production to supply on-site electricity and hydrogen can provide cost-effective energy, particularly in the current situation of rising electricity prices.

2.3 Current Situation

The production of electric and hydrogen vehicles, and conversion of current vehicles to hydrogen is slowly increasing, in accord with increasing awareness and regulation surrounding greenhouse gas emissions associated with fossil fuels. Acceleration of

production of new energy fuels for vehicles is set to continue, with or without regulation of emissions, and associated greenhouse gas emissions pricing offsets.

Vehicle manufacturers such e.g. Honda , Mercedes, BMW, Toyota are producing electric powered vehicles with hydrogen fuel cells for supply into the marketplace, predicted to make a serious entry in 2015. They are also producing engines to run on a mixture of hydrogen and petroleum based fuels, mixing fuel types to provide

improved fuel economy. This type of technology while useful in the short-medium term, has a sunset period, because the efficiencies are not sufficient to maintain market share as new vehicle production advances hydrogen fuel cell and combustion engine technology.

Clearly new vehicle fuels require new energy resourcing stations, however in the early periods of operation, this is unlikely to be profitable until the take up of the new vehicles becomes widespread.

2.4 Description of the Problem

The cost of production of fossil fuels is rising as supply is declining. New energy sources are in a strong growth phase, and cost of production has been steadily decreasing, and is forecast to continue to decrease, with the high level of expenditure on research & development providing recent technology advances.

For enabling vehicle fleets with clean energy, the problem remains to provide convenient supplies of hydrogen and electricity, particularly in view of rising electricity prices because of replacement of aging infrastructure to meet increasing demand.

New energy supplies for vehicles can facilitate the transformation of land transport. Electric and combustion engine performance is improving with advances in hydrogen fuel and fuel cells.

Many companies are engaged in the development of vehicle engines, and as the technology advances, costs are coming down.

The question is how to ensure the viability for the supply of hydrogen during the transition period from 2011 through to 2020.

2.5 Opportunity

There is an opportunity to provide a lead for the business transition from fossil-fuel intensive transport to renewable energy, in view of the technology advances and decreasing costs in this sector.

The key is that hydrogen is both a new energy source for transport, and also a means of storing energy for production of electrical power into the electricity transmission grid.

Energy stations can provide hydrogen and electricity, not only for vehicle energy sources, but also for peak power supply to the energy market. This is likely to become increasingly valuable with the current upward trend in electricity prices.

With incentives to reduce greenhouse gas emissions, renewable energy can attract greenhouse gas emissions credits/discounts for energy buyers, such as electricity transmission authorities, wholesalers and retailers.

The cost of production of renewable energy is decreasing, and some types are now level with or lower in $ per Kilowatt hour to existing fossil-fuel energy production, such as coal.

Cost of production of renewable energy is decreasing with high levels of investment, while fossil-fuel costs are rising, as supplies dwindle and become increasingly difficult to access.

2.6 Business Objectives

There are a number of business goals and objectives a renewable energy station for vehicle transport can satisfy:

1. Technology advances in both renewable energy and hydrogen powered vehicles.
2. Reduced cost of renewable transport energy in the foreseeable future
3. Protection from changing global business conditions by diversification
4. Obtain credits and discounts that reward the use of renewable energy

2.7 Scope

The scope of development of Energy Stations for Transport is the establishment of the following facilities:-

1. Renewable energy technology for a particular site
2. Hydrogen production and storage technologies

3. Hydrogen fuel cells, and power conversion technology for the production of electricity
4. Arrangement with electricity transmission authorities to supply power into the electricity grid
5. ICT technology for scheduling and supply of electricity and market metrics for electricity production

2.8 Business Benefits

In addition to the social benefits of reducing greenhouse gas emissions, there are clear business benefits for the production of renewable energy, to provide both energy for vehicle transport as well as electricity for the power grid.

These benefits include:
1. Products (renewable energy and hydrogen for vehicles) that are at the start of a growth cycle
2. Position of leadership for transition of land transport to energy sustainability.
3. Opportunity to add value to low greenhouse gas emissions vehicle engine development.

An important driver (other than climate change) is the local availability of suitable renewable energy to enable hydrogen production.

2.8.1 Local Supply

It is an advantage, in terms of energy security, to enable distributed local renewable power sources, rather than having to rely on long-term fossil-fuel supply, with declining cost-effectiveness.

Cost benefit studies of the hydrogen economy are factoring in costs of transportation of hydrogen. To avoid these financial and environmental costs, it makes sense to produce hydrogen on site, by locating the energy stations where renewable energy supplies can be made readily available.

A new model of electricity generation, different from the monolithic power stations of the past, is flexible small scale local area supply, with the capability to distribute excess power generation across transmission regions.

This can be accomplished using ICT control systems, critical to increase energy security as rising electricity infrastructure and maintenance costs, and extreme weather events can create potential instability in the electricity grid.

Interesting developments in hydrogen storage facilities provide encouragement that a low-cost solution can be found to suit particular sites, enabled by location specific types of renewable energy supply, e.g. new-generation tidal, geothermal, as well as solar and wind farms.

2.8.2 Energy Decentralization

The decentralization of power supply has parallels to distributed data processing, particularly because the energy industry is moving towards Smart Grid real-time metrics enabled by Information and Communication Technology (ICT).

From a security perspective, it is arguably better to have a lot of small generators linked into a redundant grid, able to self-heal, rather than one big system that takes out everything if it goes down – the obvious parallel is an 'internet for power'.

2.8.3 Energy Data

Energy grid control systems, to manage balancing the supply and demand sides, are critical for maintenance and development of energy security in the electricity grid. Control systems can be applied to renewable energy generation to link small renewable energy generators into a centralized real-time energy market, unhampered by the constraints of older technologies.

Another important aspect is the ability to develop metrics and analytics for renewable energy production, hydrogen storage, and scheduled electricity supplied into the market, enabling greenhouse gas emissions offset monitoring and pricing.

These metrics can ensure alignment of internal measures and systems dashboards to realize and align the business benefits with financial targets.

Performance monitoring and management ensures that transport and energy behaviours can be seen, evaluated, and encouraged.

2.8.4 Economic benefits

Renewable energy stations for vehicles can enable the following:

1. Real-time renewable energy electricity metrics and greenhouse gas emissions offset calculation services
2. Scheduling renewable energy in advance for peak market supply
3. Decentralized supply of renewable energy to increase local economic stimulus
4. Development of new vehicle energy technologies to create a positive feedback loop for the supply of renewable energy and hydrogen.

2.9 Assumptions

The major business assumptions are as follows:

1. The renewable energy production has a 10 Megawatt capacity

a) 8 Megawatts to supply the electricity grid, either directly or stored as hydrogen for scheduled peak supply,

b) 1 Megawatt for production of hydrogen for transport fuel, and

c) 1 Megawatt for electricity for electric vehicle charging.

2. Capital cost target for renewable energy generator is set at $1.5 million per Megawatt in line with European best practice estimates [3]

3. Operational, maintenance and transmission costs are estimated at $12 per Megawatt Hour. [2]

4. Energy generation production is 9 hours per day.

5. Average price for normal and peak demand estimated at 30 cents per Kilowatt Hour.

6. Average price for supplying electricity to vehicles estimated at 20 cents per Kilowatt Hour.

7. Inflation is estimated at 3% per annum

8. Cost of capital is estimated at 5% per annum

The major technical assumptions are as follows:

1. Vehicle depots to be sited where cost-effective renewable energy supply is available, or can be made available.

2. New generation renewable energy technologies can be purchased or leased

3. ICT data center technology to be outsourced

4. Smart grid technologies to be used for metering and logging of data for supply of electricity into a regional transmission grid.

2.10 Potential Business and Human Resources Analysis

The innovation and potential long term benefits of this project means that specialist consultancy and technologies have to be employed to realize the development.

Technology transfer can enable skilling of organization human resources for renewable energy station maintenance.

2.11 Potential Technology Impact Analysis

The impact of this initiative is to provide transition for business operations, and technology capability to gradually reduce reliance on fossil-fuels.

The impact of provision of this technology can be minimized by outsourcing of infrastructure/

The development of metrics for grid electricity generation and supply, and associated greenhouse gas emissions offsets offers a technology advance that is likely to prove popular, particularly as the data can be made available via a secure web portal.

2.12 Organizational Impact Analysis

Changing technologies always initiates physical and cultural transition challenges in any organization. These changes can be facilitated with good planning and information delivery campaigns.

Costs for these changes have not been estimated, however technology transfer is taken into account.

2.13 Implementation Plan

At a very high level, the project can be implemented in three phases.

1. Phase 1 constitutes the inception and evaluation stage, delivering a proof-of-concept of the main technologies – 13 weeks
2. Phase 2 constitutes a pilot project comprising one energy station, with appropriate performance monitoring to provide optimal outcomes, and technology transfer – 26 weeks
3. Phase 3 provides the ongoing rollout of energy stations with continual improvement from analysis of acquired knowledge and experience – ongoing.

Program management can provide detailed schedules and resourcing during the project inception phase. This information is provided for use by the management team (project governance group) to determine the viability in terms of human, fiscal and time resources.

3 Key Selection Criteria

The approach taken is to presume that strategies for the transition of fossil-fuel based transport to sustainable energy are being prepared by most governments and transport dependent organizations.

The challenge is to find a cost-effective path to enable the transition of vehicle transport from fossil-fuels to renewable energy.

In view of the current situation, that is over 600 million fossil-fuel combustion engine vehicles on the planet's roads, clearly a transition strategy is required for existing petrol combustion vehicles, as well as production of new hydrogen combustion, hydrogen fuel cell, and other electric powered vehicles, being developed by all major vehicle manufacturers.

Rather than competing interests to capture the vehicle market, to meet emission reduction targets, a co-operative approach to the transformation of global transport to renewable energy is critical.

For this reason, this proposal addresses the key problem – to supply power to renewable energy vehicles, from renewable energy sources, while encouraging the localization of vehicle depots that can provide not only fuel, but also workshops for adaptation of internal combustion engines from petroleum based products to compressed hydrogen gas.

4 Environmental Credentials of Hydrogen

Hydrogen can be produced with 100% renewable energy at the point of production

Towards zero emissions can be achieved by selection of hydrogen production facilities that have a low greenhouse gas emissions manufacturing process.

4.1 Methane Gas

Coal seam gas and natural gas, although collected from different sources in nature, are the same fuel, methane gas. Although the burning of coal seam and natural gas produce less CO2 emissions than burning coal, the methane emissions released in the production of these gases means that the net effect is to produce more warming than coal. [6]

4.2 Biofuels

The production of bio diesel fuels competes for arable land with old growth forests and food production. While they can be a useful alternative with appropriate crops on land that is otherwise unproductive, they have in practice been used to reduce biodiversity on a massive scale in SE Asia and South America.

Biofuels raise serious social concerns for food supply for a growing world population, and dislocation of people from traditional lifestyles and arable subsistence farmlands, further adding geo-political pressure to strained resources for food and shelter, according to the UN-REDD program. [7] The greenhouse gas emissions savings are highly variable, depending on the fuel used to convert crops into biofuels. There is evidence to indicate that the levels of nitrogen gas emissions from biofuels has been underestimated in past studies. [8]

5 Recommendation

What is clearly imperative is that to cut the cycle of increasing emissions from land transport, renewable energy sources of hydrogen and electricity for new-generation engines has to be supplied.

To ensure that the energy used for transport is renewable and secure over the next decade, it makes practical, economic, social and political sense to begin the transformation of existing transport fuels and engines, in consideration of new developments in cost effective renewable energy technologies such as new generation tidal turbines, and solar cells, as well as geothermal and wind power.

5.1 Weighting

The following factors have been equally weighted in arriving at this recommendation for transportation.

1. Ongoing security of energy supply
2. Medium to long term price stability for transport fuels
3. Reduction of greenhouse gas emissions

5.2 Constraints and Limitations

The critical constraints that were considered during the evaluation of the solutions and alternatives include

1. Location of vehicle depots as close as possible to renewable energy sources or potential sources, to eliminate transport costs for hydrogen.
2. The imperative to ensure local area energy security in view of possible adverse weather events and other risks

6 Preferred Alternative – Co-location

Co-location of renewable energy and hydrogen production with a vehicle depot is the preferred option.

The vehicle depot can not only provide alternative fuels, but also provide facilities for the adaptation of fossil-fuel combustion vehicles.

Financial viability is ensured by scheduled supply of excess electricity into the grid to satisfy peak demand, enabling time for the natural growth of new generation vehicles.

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