



Innovation in partnership with

Imperial College
London



Lion Alternative Energy plc

Our Technology Portfolio

Lion Alternative Energy owns a substantial collection of proprietary technologies in the renewable energy sector. Our technologies specifically relate to energy storage, solar thermal power production, and supporting materials technologies. In addition, we have a proprietary NO_x and SO₂ abatement technology. Each technology addresses potentially multi-billion dollar opportunities.

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Solar Power Generation Technologies

The technology: Government policies driven by environmental concerns are leading to a rapid expansion in solar power generation capacity. By 2040 it is expected that solar will represent 15% of all power generation.

Lion own a collection of technologies related to solar thermal generation plants. In combination, these give Lion the ability to build solar thermal power plants in the 5 KW to 100 MW range suitable for regional, local or individual end-user energy needs.

The key elements are:

- **Electrochemical Thermal Converter:** a revolutionary technology for the direct conversion of low temperature heat (temperature ranges: 60 °C-100 °C) into electricity based on a continuous regeneration of an electrolyte using the thermal energy of the heat source with 65%-75% efficiency at an approximate cost of 30% of the cost of a gas turbine;
- **Efficient Solar Collectors:** high thermal efficiency solar collectors of proprietary design using a polymer with a high optical transparency and long-term stability to photo and thermal degradation. The collectors have a thermal efficiency of 75 - 80% due to the low operating temperature (70°C - 100°C) and their proprietary design;
- **Mono-polar Electrolyzer:** a more efficient hydrogen generation technology using alkaline hydrated hydroxides in pure or mixed molten state;
- **Hydrogen Storage:** a new energy storage technology that allows the long term and low cost storage of energy using hydrogen as a storage agent by the catalytic hydrogenation of an aromatic compound used as support substance.

Solar Power Technology Overview

Technologies:

- collection of technologies including:
 - o Electrochemical Thermal Converter
 - o Efficient Solar Collectors
 - o Mono-polar Electrolyzer
 - o Hydrogen Energy Storage

Stage of development:

- Laboratory proof of concept completed

Markets addressed:

- solar thermal power generation - new installations of US\$135bn pa
- other markets: waste industrial and geothermal heat, and energy storage.

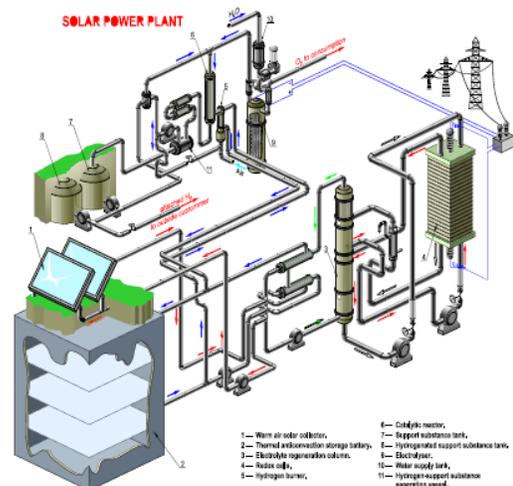
Why is it compelling:

- dispatchable power with a levelised cost of electricity of US\$0.015/Kwh on a capital cost of under US\$1m/MW. Other "blue sky" applications.

Monetisation Strategy:

- Licencing

Example plant layout



With our Hydrogen Storage technology, the hydrogenation and then de-hydrogenation (extraction of hydrogen from the support substance) has a combined energy efficiency of approximately 75%. The cost of the equipment (not including the storage tank for the support substance) is under US\$100/KW production capacity.

Key benefit of the technology: The Lion plants have superior features including lower capital cost (under \$1 MM / MW), higher thermal - electrical efficiency (55%), higher capacity factor (90%), lower levelised cost of electricity (0.015 \$/Kwh), and flexibility in geographical implementation.

In addition, the various technologies have a considerable number of other applications where low quality heat is available for recovery, or thermal/energy storage solutions are required. These include applications in industrial waste heat and in geothermal power. There is estimated to be available heat from geothermal sources of around 100 million exojoules or quads (1 quad = one quadrillion BTUs). Since the current energy use worldwide is only just over 400 exojoules per year, the world energy consumption could be covered by capturing just a fraction of this heat.

The market: Between 2016-2040, solar will account for 43%, or 3.7TW, of all new power generating capacity added. This represents over US\$3 trillion of new investment or an average of US\$135bn invested per year over the next 25 years.

Given the thermal/electrical energy conversion efficiency of 65% - 75% of our core Electrochemical Converter, the input temperature (under 100°C) of our system and the low capital cost we will have a dominant position in the solar thermal market, waste heat recovery market and geo thermal markets.

Lion's Redox Flow Battery Technology

The technology: Environmental concerns are driving the large scale proliferation of renewable (intermittent) and distributed power technologies. A break-through in Energy Storage is required to leverage these promising developments.

Lion has developed a battery in the flow category which has major performance and cost advantages over existing battery technologies and could play an important role.

The technology uses widely available materials and offers an energy density 2 - 3 times higher than the leading flow battery, round-trip efficiency of 75% and a depth of discharge from full to 25% state of charge (compared to a depth of discharge of only 80% for conventional lead acid batteries).

Subsidiary technologies include a permselective ion exchange membrane that has a favourable combination of low electrical resistance - high mechanical resistance, the specific redox couple electrolytes, composite electrode structure and electrode irrigation architecture, hollow polymer tubing and special adhesives used in the stack structure.

Key benefit of the technology: The consensus of industry and government labs is that for flow batteries to be widely adopted, their price must be under US\$100/Kwh. The Lion flow battery specific production cost will be under US\$80/Kwh capacity. This compares to the average specific acquisition cost for conventional batteries of over US\$250/Kwh, for lithium-ion batteries over US\$400/Kwh and for the existing flow batteries of over US\$350/Kwh.

The market: According to IHS, the energy storage market is set to reach an annual installation size of 6 GW in 2017 and grow to 40 GW by 2022. Current flow battery technologies represent a niche application of around 10% within this sector. This would be the equivalent to annual sales of 160,000 units of the typical 25 KWH system commonly offered by current manufacturers. While the market is currently dominated by lithium ion solutions, our technology offers the potential for break-through pricing and a radical shift in market share and market size.

Flow Battery Technology

Overview

Technology:

- A flow battery using new redox couple electrolytes and supporting technologies

Stage of development:

- Laboratory proof of concept completed at

Markets addressed:

- Energy storage for intermittent renewable power sources and on- and off-grid storage estimated to be 40 GW pa of new installations by 2020

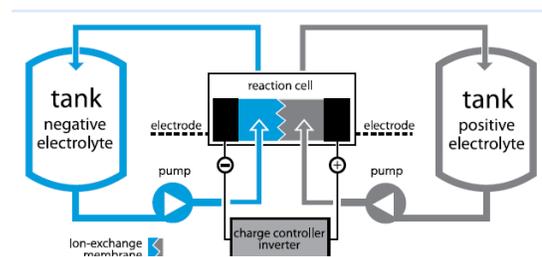
Why is it compelling:

- Break through costing

Monetisation Strategy:

- Develop prototype and licence

How a flow battery works



Lion's Recycled Composite Construction Materials Technology

The technology: Our composite material technology consists of a proprietary process, which turns unsorted plastic scrap into a powder which is then used as a matrix for composite materials that can incorporate practically any type of fill materials. Using our technology we can use waste plastic, used tires, coal ash and other fibre sources.

Due to the high percentage of fill materials (over 70%), the properties of our composite materials can be customized for practically any application by the use of various fill materials and/or multiple layers (structural resistance, wear and tear resistance, fire resistance, specific weight, finishing quality and colour, porosity, waterproofing, heat insulation, etc.).

When structured as a combination of multiple layers with different properties, our composites can work structurally together, so that the products can be customized to respond to complex requirements.

Key benefit of the technology: Our technology allows the low cost production of composite construction materials based entirely on the use of post-consumer and industrial waste and other non-conventional raw materials. Given that the feedstock is largely based on recycled products, These can be manufactured at 50-70% below competing materials.

Target application: The technology can be joint venture with new and existing manufacturers to produce:

GENERAL PLANKS AND PILINGS (CONSTRUCTION, MARINE, ETC.)	CONCRETE FORMING PANELS
RAILROAD TIES	SHIPPING PALLETS AND CONTAINERS
FACADE PANELS	INDUSTRIAL FLOORS
SHOCK ABSORBING FLOORS.	HEAT RADIANT FLOORS
SOUND PROOF FLOORS	THERMAL INSULATING & RADIANT WALLS.
PHASE CHANGE (HEAT ABSORBING) WALLS.	STRUCTURAL ELEMENTS (BEAMS, POSTS, ETC.).
WATERPROOF ROOFS.	DOORS AND WINDOW FRAMES.
FURNITURE.	COMPLETE MANUFACTURED HOMES.

Recycled Composite Materials Technology Overview

Technology:

- Process for producing composite materials from waste materials

Stage of development:

- Laboratory proof of concept completed

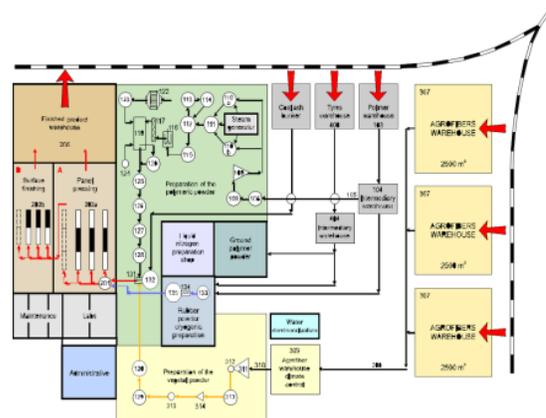
Markets addressed:

- Recycling and building and specialist materials

Monetisation Strategy:

- Licence or joint venture to establish production plant

Example plant layout



Lion's NOx and SO₂ Abatement Technology

The technology: Environmental regulations have made abatement of NO_x and SO₂ emissions a significant issue – particularly for coal fired power plants.

Lion has developed a total abatement solution based on a selective, reversible chemisorption process using thermally controlled complexing solutions that allows the recovery of by-product SO₂ and NO_x in pure state. In addition to recovering the heat content and valuable by-products, our technology provides for total abatement as compared to the existing solutions which aim for a partial abatement as total abatement would be economically prohibitive. The technology is also applicable for recovery of NO_x and SO₂ from low concentration gases (below 0.5%).

Benefit of the technology: An example application study on the Ohio 600 MW Cardinal generating unit demonstrates its exceptional potential. With a capital investment of only US\$8m, the power plant could generate an extra US\$37.7m in annual profits from by-product sales in addition to achieving abatement targets (a payback of 2.5 months). This compares to most technologies which require a capital investment to meet abatement targets and also increase operating costs.

Key markets: By 2025, 21 of the world's 37 megacities will be in Asia and many of these currently have non-existent or ineffective air pollution regulations. At least half of China's 696 cities and counties suffer from acid rain.

In China alone, it is estimated that polluted air is causing 400,000 deaths each year and reducing China's gross national product by 8 - 12% according to the World Bank. Currently, China's installed Flue Gas Desulphurization facilities (FGD) cover about 53,000 MW of its generation capacity, accounting for only 14% of installed thermal power capacity. China plans to invest heavily in reducing its level of emissions according to the State Environmental Protection Agency.

NO_x and SO₂ Abatement Technology Overview

Technology:

- A total abatement solution which also recovers by-products

Stage of development:

- Laboratory proof of concept completed

Markets addressed:

- Coal fired power generation

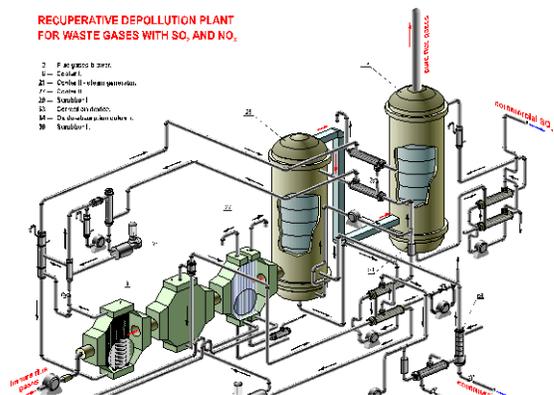
Why is it compelling:

- Turns a cost into a profit centre with by-product sales

Monetisation Strategy:

- Licence/sell

Example plant layout



Our Management team



Kostas Liapis

Chief Executive Officer

Kostas founded Lion 10 years ago. He has more than 30 years' of international business experience.



Hammad Farooqui, FCA

Chief Financial Officer

Hammad previously worked for Deloitte, Motorola and was Vice President at Merrill Lynch. He is a Fellow of the Institute of Chartered Accountants.



Dr Giulio Franzinetti

Chief Operating Officer

Giulio is an engineer with over 20 years' experience in management, technology and social and environmental capital. He was previously a Director of Vigeo Rating Agency which was the largest independent social and environmental impact rating agency in the world and on the Advisory Board of the European Social Investment Forum.



Gabriel Didham, CFA

Executive Director of Funding

Gabriel has over 25 years' experience in finance and wealth management in the UK and Asia with Deutsche Bank, Barclays and Standard Chartered. He is a former number 1 rated investment analyst and a Chartered Financial Analyst.



Prof Nigel Brandon, OBE, FRENG

Advisor on behalf of Imperial College

Prof Brandon is Vice Dean of Research of the Faculty of Engineering of Imperial College and Director, imperial College's Sustainable Gas Institute. He previously spent 15 years as a scientist with BP and Rolls Royce.

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