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Osmogen - Continuous Flow Osmotic Power Generation

Introduction

To design portable, medium scale and commercial scale osmotic generators using our distinct designs. Although a large scale design is already under way we believe the patent design of Inergy three dimensional membrane surface modules will be far more efficient. These osmotic differential capsules (Inergy Cells) will be the primary focus of the research to augment the 'generator pressure' produced through the concentration potential between sea water and rain water.

The source of rain water being manifold, including rivers and direct rain harvesting. The design could include the integration of other zero carbon renewable energy technologies including solar thermal, solar PV and wind turbines. These will also power lighting, fluid feed pumping and 'waste' removable back to the sea.

History and Description

Osmosis is the movement of water from an area of low concentration of dissolved ions through a membrane to an area of higher concentration. The nature of the membrane is important in that if it is selectively permeable (semi - permeable) it will allow water molecules to pass through but not the ions. As the water is drawn through the membrane in one direction only, in an endeavour to equilibrate the concentrations, a pressure is naturally generated which can be utilised to generate electricity.

In an osmotic power system fresh water (from estuary, river or rain) and sea water are fed into separate chambers which are separated by a patent commercial osmotic membrane. The salt in the sea water draws the fresh water through the membrane which generates pressure on the chamber containing the sea water. This pressure corresponds to a water column of 120 metres and can be used to drive a turbine

Osmotic power stations can be sited anywhere where freshwater flows out to the sea which makes the Severn estuary an ideal area for the first UK pilot site. Osmotic power potential is determined by differentials in ion concentration which is effectively consistent. Unlike other renewable power systems such as wind turbines, solar thermal, solar PV and hydropower, power output from osmotic power systems is not so determined by fluctuations in environmental parameters such as rainfall, cloud cover and ambient temperature. The global potential of osmotic power generation is estimated to be in excess of 1700TWh/yr (1). China consumes about this amount of energy per year. But some would argue that global potential is significantly more than this depending on the efficiency of the design/s of the osmotic systems and the

scope for their locations. This is where Inergy UK Ltd is keen to research. Norway for instance is considered to be able to produce about 12 TWh (12×10^{12} Wh) per year.

Osmotic power generating systems can become a major contributor to the generation of fully carbon free power - ultimate green renewable energy systems. They can also be built as part of integrated renewable energy systems. These plants would combine a range of renewable energy technologies to augment the output and energy independence of the system during part 'down' times and servicing.

Osmotic power systems release no discharges to the atmosphere or water and have negligible effect upon flora and fauna. This applies to both sources of fresh water such as estuaries, rivers and reservoirs and also the abundant sources of sea water. Sea water is there in relatively limitless supply as is fresh water in many parts of the world. The water may be terrestrially visible but it may also be subterranean in arid parts of the world, where aquifers present a natural transmission system which could be used to feed osmotic power plants. It's estimated that a power plant the size of Wembly could supply 15,000 homes. Such power plants can be built as unobtrusive underground energy systems.

Another attractive feature of osmotic power systems is their simplicity and low noise pollution. This can be of particular interest to the military who could be interested in a portable 'silent' power module.

In the 1970's Sidney Leob designed a membrane technology for the desalination of seawater. In so doing he realised the potential of generating power from osmotic potential. At this point it's important to remember the link between the global need for fresh water and the need for power. The security of a nation depends upon the adequate provision of these two great inescapable needs. The jeopardy of this provision is highlighted by political events and conflicts of recent days, which raises the profile of energy independence and a secure fresh water supply. This is a major driving influence on every nation – adequate water and sufficient power. Military security hangs on these provisions. Without adequate independent sources of power a nation becomes vulnerable to every skirmish influencing the major 'suppliers' who themselves are beginning to consider more seriously alternative energy systems of the renewable kind. Nuclear power requires radioactive minerals which are in depleting supply. Until fusion power can be harnessed truly renewable carbon free systems will be a more intensive focus of research. This is especially by those that can see the significance of the need, which is no longer altruistic but is essential for global provision and political stability.

During the 1980's Torleif Holt and Thor Thorsen at SINTEF finally got funding in 1995 after fifteen years research for a feasibility project referred to in a number of research publications. In 1997 Statkraft contacted Holt and Thorsen and a collaboration project commenced.

In 2001 osmotic power generation research was given European Union (EU) funding. In this same year the first environmental study was carried out.

In 2003 Statkraft was awarded a patent for its osmotic power membranes design and opened a test site at Sunndalsgira in 2008. This was the worlds first prototype osmotic power station, in Tofte south west of Oslo, Norway.

Setting the Scene

Statkraft aims to develop an osmotic power membrane with sufficient osmotic efficiency to power a commercial plant. The target date is 2015.

Aims and Objectives

I would like to invest and contribute towards the knowledge and technology of renewable energy systems, becoming a specialist in osmotic power generation. I would also like to see general progress in this renewable technology as alternative carbon free power source.

The study and research aims to develop osmotic power systems of one or more of the following types – generically known as Osmogen Systems. The power output from each system in kWatts / MWatts will naturally be a coefficient of design and materials used, which is a prime mandate of the proposed research. Although similar designs (2-6) are being researched there is considerable commercial potential for UK based development, built on robust and well resourced modelling and material selection. The design nature and materials used will be new and attractive both commercially and environmentally. Aesthetic nature will be consciously considered in design as opposed to simply efficacy of the system

- Small portable systems – portable primarily designed for military use also to be defined as ‘silent’ power systems due to the relative quietness of the technology. These portable modules can range in size, their nature requiring simply Inergy salt capsules and fresh water where access to sea water would not be a requirement
- Medium size – Domestic power systems
- Large scale systems – Industrial power systems located on coastal sites around the UK
- Commercial power plants – Generating power for the national grid. Sites in coastal locations where there is sufficient ‘feed’ of fresh water. This includes estuaries, rivers, reservoirs and where there is high rainfall for water harvesting.

The predominant issue and focus for research beyond system design is the structure, geometry and material nature of the ‘partition’ separating the sea water from the fresh water. This partition being a patented optimised selectively permeable Inergy membrane. For optimisation of osmotic power potential the proposal would be to develop matrices of Inergy cells which would increase the osmotic potential through increased surface exposure. This would be in contrast to the traditional model of single surface exposure to the fluids. Effectively membrane development will be unique and patented with the inherent design nature of the Inergy cells.

There will be a need for software modelling and system verification for power production and model construction at chosen test scales before being trialled in the field.

Options in design include considerations such as tidal fill which conserves considerable power compared to pumping, gravity fill of fresh water and elastic systems where the elastic nature of the environment/chamber augments osmotic transfer and therefore power production. Tidal fill in itself saves energy, cost of power production and is simple to achieve on coastal sites. Excavation is also simple to achieve and requires less maintenance of additional pump machinery. Further options include reciprocal power drives with valve controls as fluid volume increases on one side of the partition as the contrasting fluid volume decreases. The system design and component design options will be considered in relation to the materials available or to be developed and subject to the resources available in the department.

Other applications of osmotic power systems

- Submarine and ship systems
- Ocean laboratory power
- Integrated Osmotic Power and Desalination Plants
- Shoreline and inland anti personnel mine clearance

Points to note

It is of interest that the process of desalination or crystallisation produces the very substance that can produce power – salt. This can be transported to inland regions where there is only fresh water available, such as mountainous land-locked terrain. When added systematically to fresh water it constitutes the contrasting partner fluid medium to water for osmotic power generation.

References

1. Statkraft site on the link below for basic technology

http://www.statkraft.com/pub/innovation/tecnology/osmotic_power/how_osmotic_power_works.asp

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Abstract - An often-overlooked source of marine renewable energy is the energy available from salinity gradients. The potential resource for the osmotic pairing of fresh water and seawater is estimated at 2.6 Tw. Several ...

Milestones

6 months - End of review on computation, numerical and software systems analysis

12 months – Small scale models designed and constructed with patent membranes simulated with available materials using proposed Inergy cell design permutations

18 months – Trialling on coastal field sites with small scale models

24 months – Validation (Confirmation) of performance of systems using selected models

30 months – Correlation of performance data with available and published data with similar or different system models

36 months – Documentation of research findings and thesis write up for Osmogen Systems power production

Outcomes and Benefits

This research will investigate many system and material options for optimal osmotic potential for the generation of carbon free power. Rigorous modelling and testing prior to use in a field setting will ensure that the efficacy of the developed technology will be high. This will significantly improve not just the efficiency of the process but also the effective useable power - depending on the module chosen to develop. The proposed design is intended to exceed any current model or system currently in place in terms of aesthetic appearance, power to dynamic fluid volume ratio kW/m^3 and effective power output in kW/MW .

Three year project Costing

*** NB - although the proposed PhD research is for 3 years we believe ‘first phase’ Osmogen products could be available commercially within a much shorter period. This would significantly depend on manufacturers and investors**

Research grant – salary
Hardware
Construction of test & pilot models
Manufacture
Marketing
Conference attendance
Test facilities
Academic and technical supervision
Other overheads

Output

The dissemination of this project will be by means of publications in International Journals and by presentation at IEEE conferences wherever possible. The formal outcome of this research and development will be available to UK companies subject to the University procedures and by agreement with Inergy UK Ltd subject to disclosure agreements in place prior to commencing the research.

Principle Investigator/s

- Director
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- University Supervisors
- Others TBC

Investors/ manufacturers

- TBC