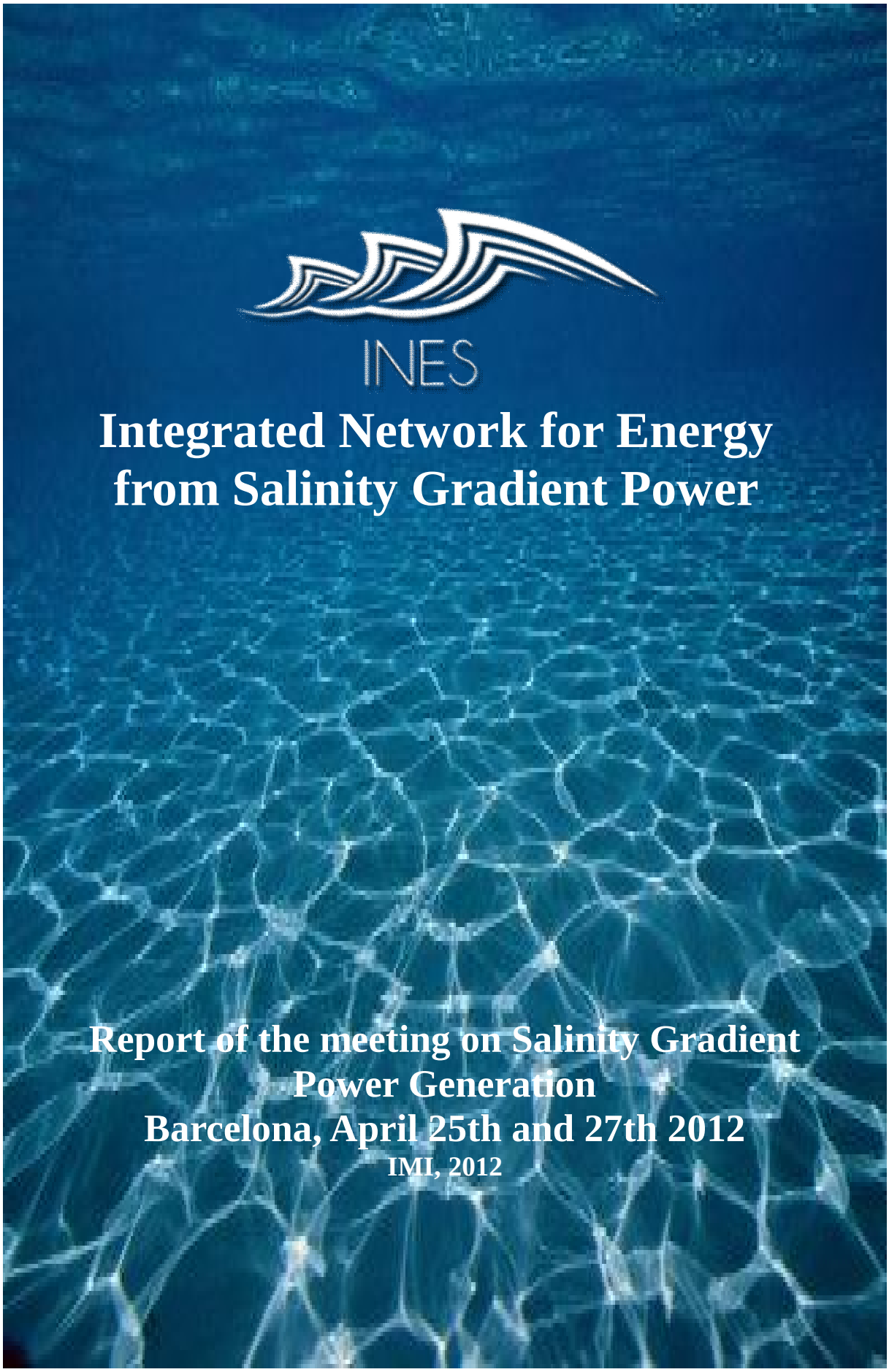
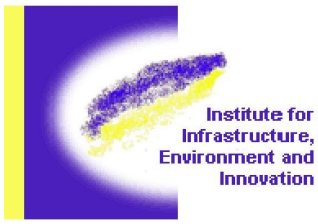


Integrated Network for Energy from Salinity Gradient Power

Report of the meeting on Salinity Gradient Power Generation
Barcelona, April 25th and 27th 2012

IMI, 2012

Seminar organized by the Institute for Infrastructure, Environment and Innovation



Contributors:

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Project Manager, Blue Energy
Province of Fryslan, The Netherlands

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Gwangju Institute of Science and Technology (GIST).

Professor Hassan Arafat
Head of Unit of the Water and Engineering Department
Masdar Institute.

Professor Chung Tai-Shung Neal
Head of the Membrane Group National University
Of Singapore

Mr Frank Neumann
Director Institute for Infrastructure, Environment
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Mr Winson Lay
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Public Utility Board of Singapore (PUB).

Professor Ho Kyon Shon
Centre for Technology in Water and Wastewater treatment
University of Technology, Sydney

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SUMMARY

This INES workshop was the first meeting between European, Asian and Middle East partners and participants, including Singapore, South Korea and the UAE. It was particularly meant to introduce European and Asian partners to each other as well as the kick-off off for a discussion on possible pilot projects in Singapore and in Australia.

The first day presentations were held on Friesland (Netherlands), Singapore (Research advances and general intro) and possibilities for PRO and RED in South Korea and the UAE. The second day had a more specific focus on possible pilot projects in Singapore and in Australia.

An important common interest at this meeting was an exploration of the potential possibilities for using waste streams from waste water treatment and desalination for salinity gradient energy generation.

The discussion was animated and diverse, also due to the representation of various technologies (PRO, RED, Capmix) and disciplines. An important result was a shared vision between the participants regarding joint activities that are very important for the further development of all the different types of salinity gradient energy, including:

1) The development of a general update of salinity gradient energy, including RED, PRO, Capmix and possibly other methodologies for use of communication with relevant external parties. Currently with a wider group of parties as international organisations, local and regional governments, not much is known about the state of the art of salinity gradient energy. In addition, within the salinity gradient sector not much common methodology and definitions exists. It will be the purpose of this update to provide such. Ideally the update should also be connected to the work of relevant international organisations as the International Renewable Energy Agency (IRENA), as well as the European Commission and international financial institutions. This point is also important for future financial facilitatation of salinity gradient energy research and particularly its further upscaling.

2) The development of a tentative global resource analysis, where the various countries could be involved. Some very general analysis has already been done on resource estimations, but not one that starts of from an agreed common starting point. An over-all resource analysis is important as a common ground, for researchers as well as project developers to identify priorities and distribute budgets for R and D properly with view on future phases of upscaling

3) The setting of general standards that are necessary to make comparisons e.g. research on power densities of membranes and or other essential parts of salinity gradient power generation (i.e., spacers, installations). The most relevant, also in conjunction with the Statkraft meeting was the methodology used to measure the power density of membranes. At the meeting, it seemed that presenters were all using different methodologies.

These joint activities will be further elaborated at the shorter meeting in Brussels as part of the Sustainable Energy Week on the 20th of June 2012. In addition the issue of standardisation of membrane measurements will come back at the meeting in Milan on the 5th of September 2012, and, more in detail at the meeting in Singapore the 19th of October 2012.

Many thanks for this meeting go besides to all presenters and participants, to the team of the European Desaliniation Association and Statkraft that allowed INES to present itself and simultanously hold a meeting at the site of their Osmosis Summit.

25 April- Barcelona Princess Hotel

Programme

DAY 1 PILOT PROJECTS IN FOCUS

15:30	Meeting at the Lobby of the Princess Hotel, Av. Diagonal Del Mar 1

OPENING

16:00	Welcome INES, meeting objectives.
16:15	Partner round introduction. *Mr. Jan de Heer, Project manager, Blue Energy* *Province of Frysland, The Netherlands*

R&D AND PILOT PROJECTS

16:30	The new Research and Pilot Programme on Salinity Gradient Power 2012-2014 in South Korea - and possibilities for INES. *Prof. Dr. Joon Ha Kim, Director Sustainable Water Technology Centre, Gwangju Institute of Science and Technology (GIST).*
17:00	Possibilities for Salinity Gradient Power Projects in the UAE / Gulf Region. *Prof. Dr. Hassan Arafat, Head of Unit* *Water and Engineering Department, Masdar Institute;* *with participation of Dr. Joost Helsen, Senior Researcher (Vito)* *and Prof. Neil Chung, Director of the Membrane Research Group (NUS).*
17:30	*Short Break*
17:45	First exploration INES study societal aspects and resource analysis. *Dr. Frank Neumann, Director of the Institute for Infrastructure environment and Innovation (IMI).*
18:00	Conclusions and follow-up.
18:30	Closure.

INFORMAL DINNER

20:15	Dinner at "Casa del Pescador" - in walking distance from the Princess Hotel - Diagonal Del Mar Shopping Centre. Gathering at the *Princess Hotel lobby at 20:00 hr.*

Mr Jan de Heer
Blue Energy, Province of Fryslan

provinsje fryslân
provincie fryslân

Mr Jan de Heer spoke about the possibilities, intentions and plans in Fryslan province, The Netherlands.

Renewable Energy Programme:

- Sustainable energy programme as the main strategy on sustainable development.
- Committed to saving and generating renewable energy.
- Committed to employment trough a sustainable energy approach.
- Ambition to generate the 14% of renewable energy by 2015.

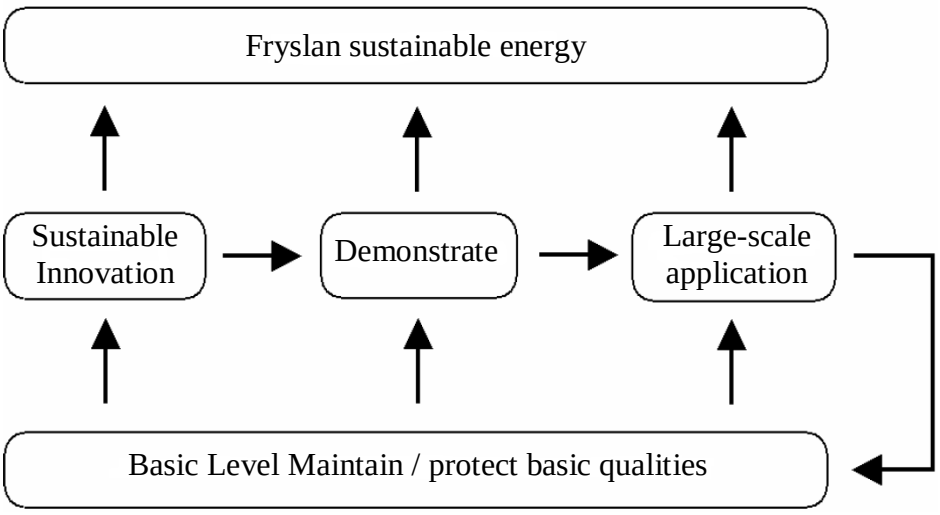
Blue Energy Central:

- Unique possibilities on the Afsluitdijk of generating electric power in Friesland.
- Scaling to experiment: from pilot (in 2012), to full-scale energy power plant in 2020.
- Requires an investment of 7,8 million to setup.
- Collaboration between the companies REDstack, water-setting Wetsus and Fuji.
- The power plant will have a capacity of 200 Megawatts, enough to produce electricity for 500.000 households.

General:

- The Afsluitdijk is a selling point for energy dikes all over the world.
- Friesland is located in the centre of the so-called Energy Valley, a join venue for energy and innovation.
- Friesland is an ideal outdoor laboratory for testing all types of water technology.
- The special islands in the Wadden Sea will become completely self-sufficient for water, energy and water waste treatment.

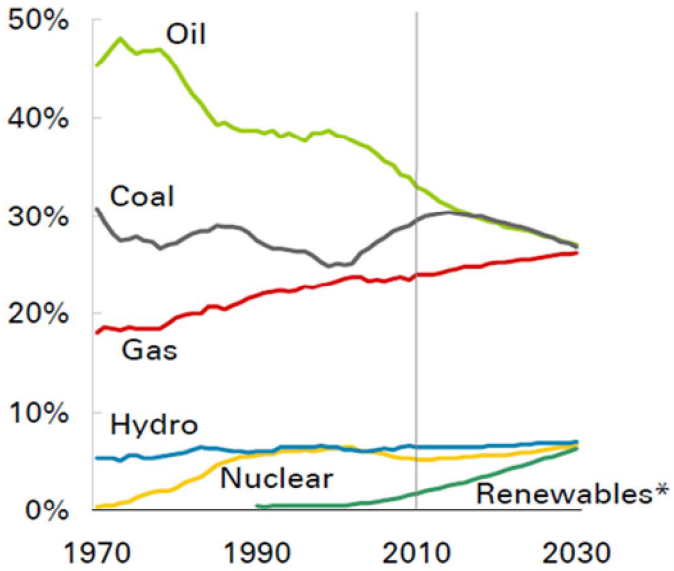
The Friesland government besides blue energy has a high priority for water innovation projects and aims to facilitate international co-operation and local intiatives with these themes.



Through his presentation, professor Joon explained the principle of Retarded Osmosis, Desalination, Preassure Retarded Osmosis and showed his current research on hybrid desalination at it's initial state.

Views on investments and energy consumption:

- As shown at the graphic, the percentage of usage of renewable energies will soon reach some conventional non renewable sources. Limited resources as petroleum, coal or gas shows a sharp decreasing tendency.



- Even if water remains an issue for several countries, by 2025 the situation is expected to improve in two-thirds.

- In average worldwide investment for infrastructure is increasing in water and electricity matters:

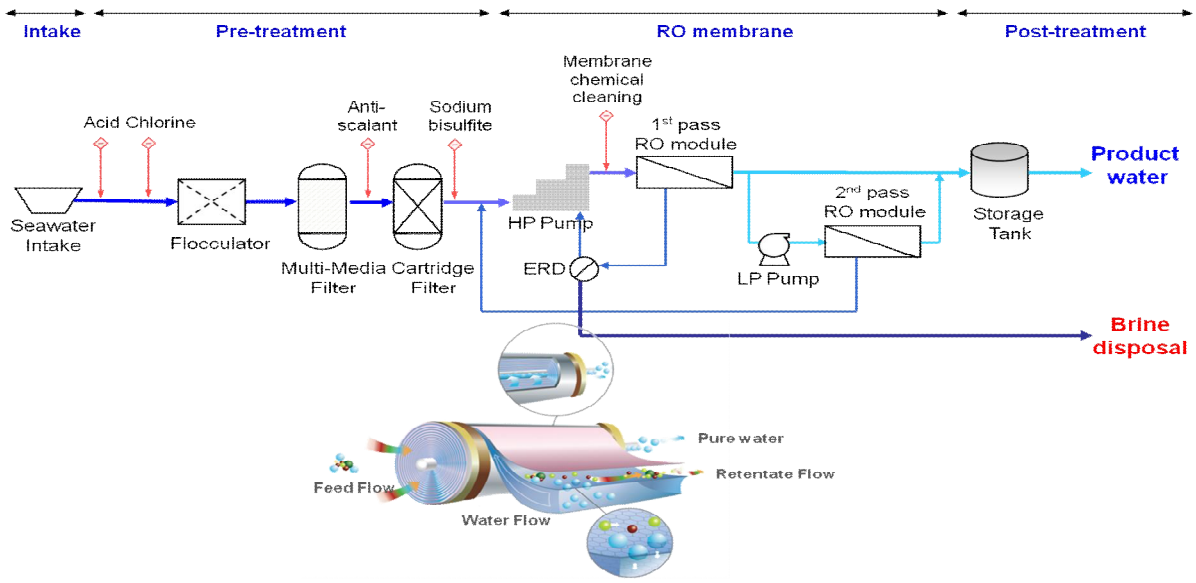
Infrastructure	2001 to 2010 (annual average)	2011 to 2020 (annual average)	2021 to 2030 (annual average)	2011 to 2030 (accumulative)
Roads/Railways	269	299	350	649
Telecommunications	654	646	171	817
Electricity	**270**	**383**	**513**	**896**
Water	576	772	1,037	1,809
Total	1,769	2,100	2,071	4,171

Principle of RO:

Feed water converts to fresh water by passing through a membrane with the application of high pressure.

Thermodynamically, this process generates a irreversible process. The osmotic process is reversed by applying higher preassure than normal osmotic preassure leading the water to pass through the membrane un the reverse direction of osmosis.

Seawater Reverse Osmosis (SWRO):



Advantages:

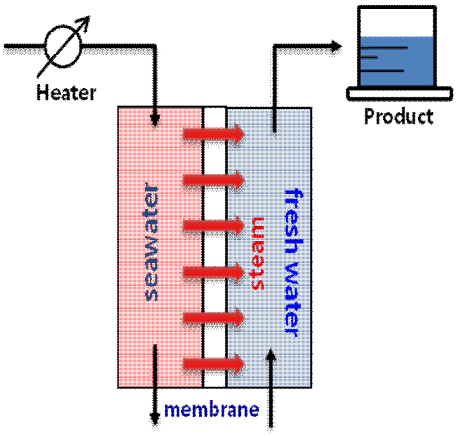
- lower energy consumption (3~$ kWh/m3) compared to distillation (10~16 kWh/m3)
- Well systematic process ampng the desalination process
- Production of high quality freshwater (Na+<80~30 ppm TDS)

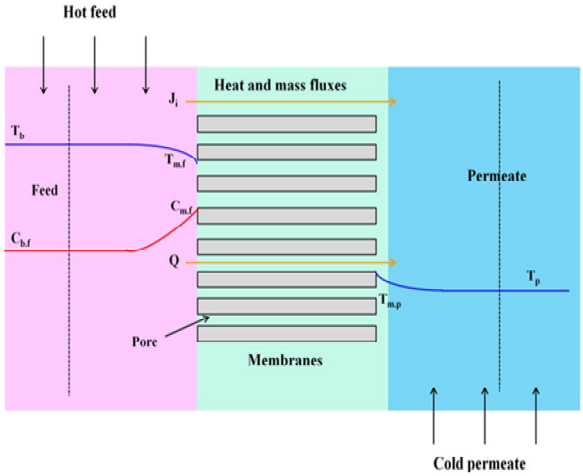
Limitations:

- Membrane Fouling
- Membrane cleaning/ replacement
- Requirement of pretreatment system (MF, UF, DAF, DMF and anti-scalant)
- Increase in cost to produce freshwater

Principle of Membrane Distillation (MD)

- Thermally driven process
- Hydrophobic porous membrane: water vapor molecules from the heated feed solution are transported through the membrane pores
- Driving force: temperature difference (i.e., vapor pressure difference)
- According to the method maintaining vapor pressure difference
  DCMD, AGMD, SGMD, VMD





Advantages:

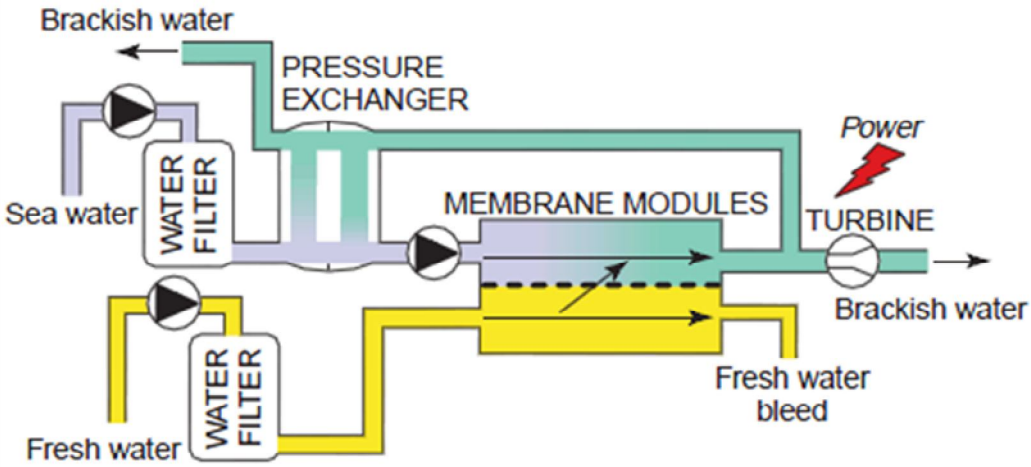
- 100% (theoretical) rejection
- Lower operating temperature than distillation (utilize waste or solar energy)
- Low pressure operation
- Reduced influence of concentration polarization compared to pressure-driven membrane processes
- Minimization of membrane fouling and scaling

Limitations:

- Temperature polarization phenomena
- Pore wetting
- Low permeate flux compared to RO
- Bench scale process due to imperfect analysis of MD

Principle of PRO:

- Driving force: chemical potential difference between feed and draw solution
- Energy coming from: depressurizing the permeate through hydro-turbine



Advantages:

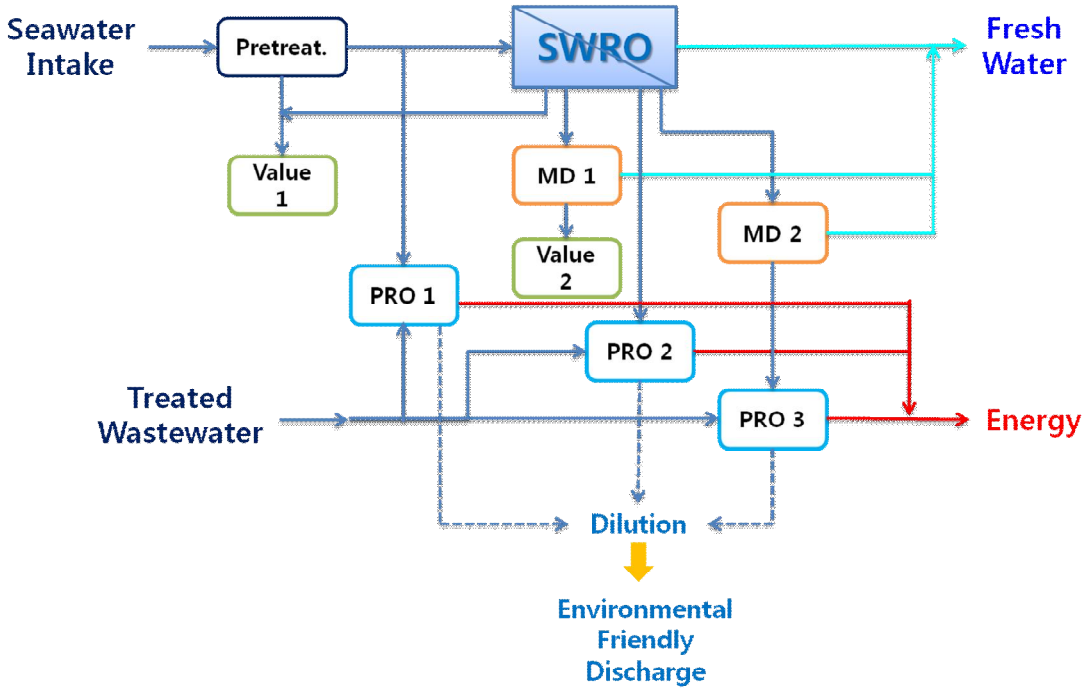
- Feasible power density for commercialization
- Possibility of reaching a power density > 10 W/m2
- Membrane price is close to target

	Power density (W/m²)	
Membranes	Seawater	RO Brine[b]
Lab Cellulose-Acetate-FO[25]	0.7	2.7
Lab TFC-FO[26]	6.1	15.3
Lab TFC-FO[24]	3.8	10.1
Lab TFC-FO (hollow fiber)[23]	5.5	8.7
Commercial FO Cellulose Tri-Acetate[11,24]	2.8	7.8
Lab TFC-FO[22]	4.7	6.5
Commercial RO Cellulose-Acetate[a24]	2.4	5.9
Commercial TFC-RO[a24]	1.2	2.1

Limitations:

- Need of two pre-treatments
- Energy recovery for initial energy input
- Membrane: Concentration of polarization (ICP, ECP), reverse draw salt flux
- Membrane: Negative effect of coupling between ICP and reverse salt flux

SWRO-MD-PRO Pilot plan for Research Purpose:



Technical Target:

- Environmental impact reduction.
- SWRO Retrofitting.
- Valuable Resource.

Conclusions and benefits from MD-PRO hybrid System:

- 30% increase of product water.
- 5.0 W/m2 of membrane.
- Possibility of reducing energy consumption down to 3.0kWh/m3 or less.
- Possible reduction of negative impact on marine environment.

Short discussion and questions:

Professor's Joon's presentation was followed by a short discussion where technical questions on PRO and the state of membranes was held. Considerable and animated debate followed, particularly on the challenge to combine such complex processes to an efficient whole. For being efficient it seems both PRO and RED need to be developed in an enhanced way. Just that is an important objective of the salinity gradient power policy that is being developed in South Korea.

Integrated Network for Energy from Salinity Gradient Power

Professor Hassan Arafat
Masdar Institute

Professor Arafat had outlined the situation in the United Arab Emirates (UAE); he presented the advantages and possibilities to develop salinity gradient power projects in the UAE.

General context and situation

- Increasing UAE increasing water demand:
  - * Population growth (6% annually till 2030)
  - * Per-capita consumption (quality of living)
- Dependence on desalinated water for domestic use (highest globally consumption)
- Many desalination plants in a row at the coast side
- Great concentration of salinity in groundwater
- Abu Dhabi's residential water is mainly desalination-sourced (183 MCM/yr) and water for agriculture is groundwater-sourced (1489 MCM/yr)

Abu Dhabi's vision for 2030

- Focus on developing new sectors in clean-tech, aerospace and semiconductors to drive the socioeconomic growth of the emirate.
- Objective of 30% of all energy needs from alternative and low carbon energy sources
- Commitment to addressing climate change issues
- Transition from commodities-based to knowledge-based economy

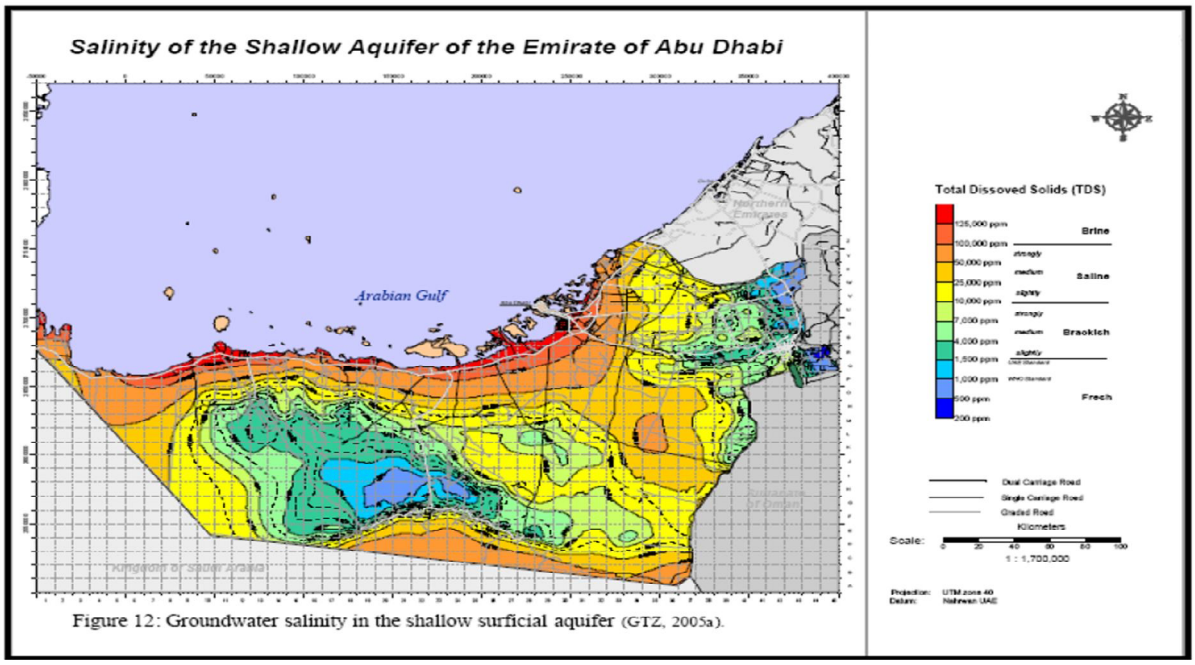
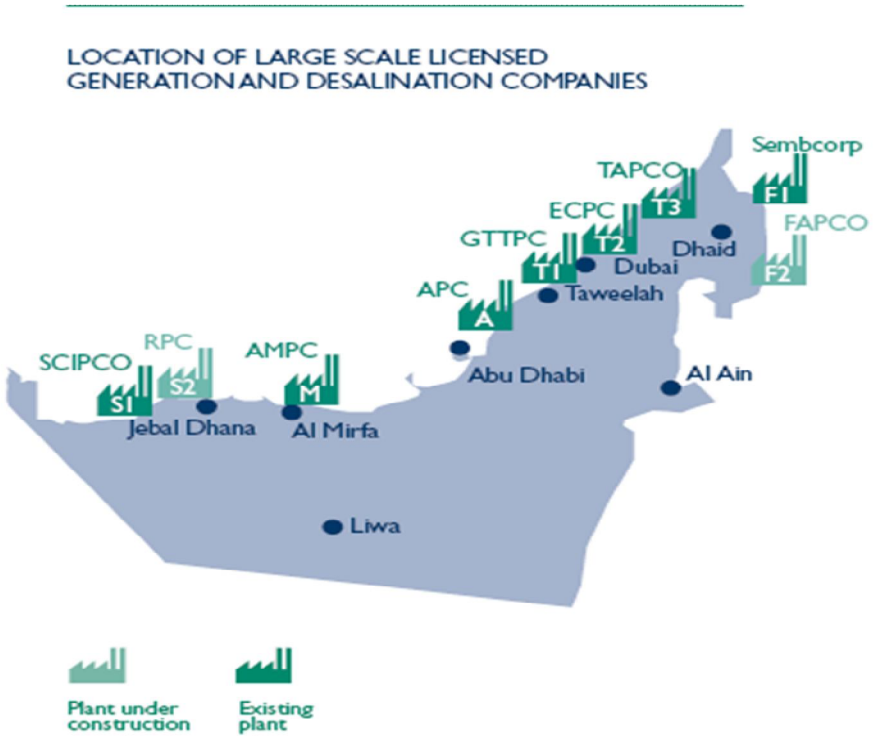


Figure 12: Groundwater salinity in the shallow surficial aquifer (GTZ, 2005a).

The opportunity this creates:

- Brine concentration with salinity gradient power generation
- Aquifer salinity reduction (recharge)



Possible approach:

- Initial "exploratory" study: 2 - 3 years
- Goals:
  -Technical assessment (geological, power generation estimates, etc)
  - Environmental
  - Approximate economic feasibility
- In collaboration with an international expert partner in SGP
- Possible ways of funding activities.

Masdar is not expected to fund such study all by itself. A combination of partners is what would be looked for. However if a successful outcome is attained, perhaps in a next phase an application can be made for an UAE funding programme on Environment.

Integrated Network for Energy from Salinity Gradient Power

About Masdar Institute

- Independent, private, non-profit organization
- Graduate level (MSc & PHD)
- Focused primarily on sustainable technology and clean energy
- 50+ World class faculy graduating from top universities (MIT, Stanford, Berkeley, Cambridge)
- State of the Art Facilities:
  * Campus at Masdar City: Living Laboratory
  * Well Equipped Labs
- Close collaboration with MIT

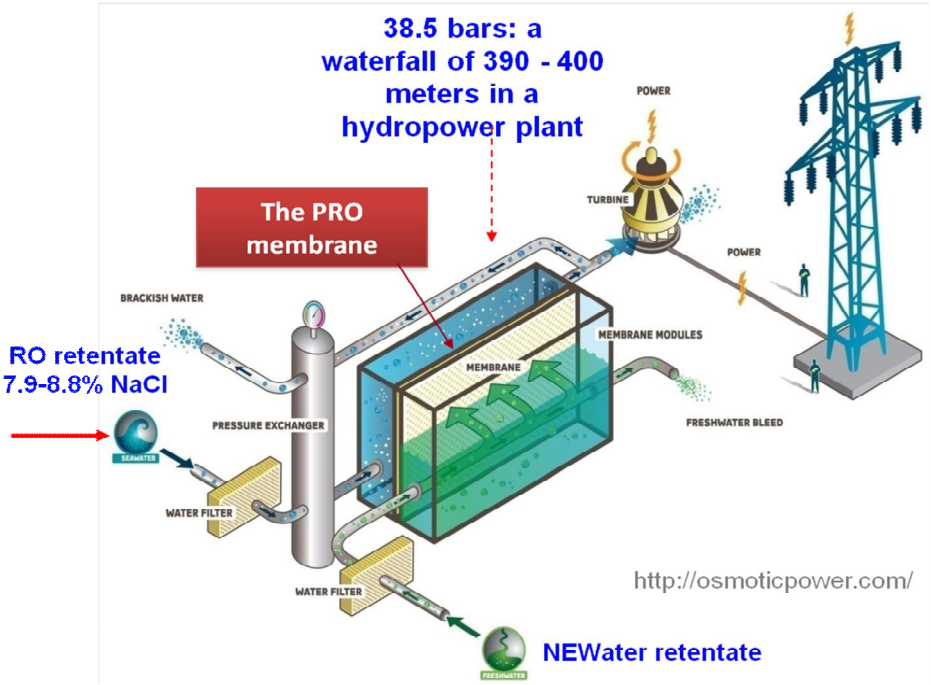
After the presentation of Professor Arafat there were some questions and dialogue on the possibilities:

It seemed that beside saline groundwater one of a more resources with great opportunity for salinity gradient power generation in the UAE could be also the waste coming from the desalination and waste water treatment installations. In a follow-up it will be explored to what extent the exploration of such a project could be undertaken by interested parties within INES. Masdar is asked to become member of the INES netwerk, and professor Arafat mentioned one of the next meetings of the international network could be possibly be held at Masdar so that the INES participants could also see the environmental technologies at Masdar city.

Professor Neal Tai-Shung Chung
National University of Singapore

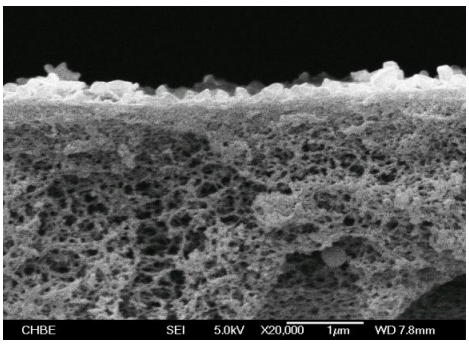
Professor Neal Tai-Shung Chung, presented the research activities of the department of Chemical and Biomolecular Engineering of the NUS. The main focus is on polymeric membranes for osmotic power generation.

Professor Chung showed a model of osmotic power generation + RO retentate = Energy + Water

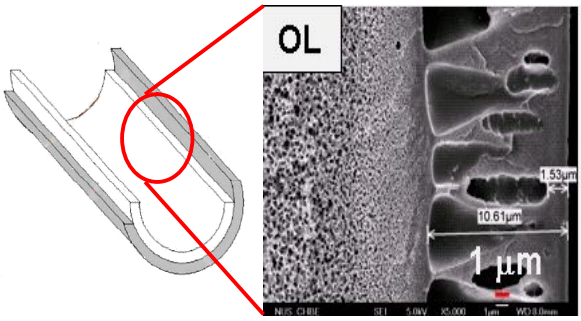


Through his presentation Professor Chung led and built the Hyflux membrqne R&D team in 2004-2008. He is a co-inventor of Hyflux Kristal 600tm ultra-filtration membranes for water treatment:

Thin-film interfacial polymerized FO membrane

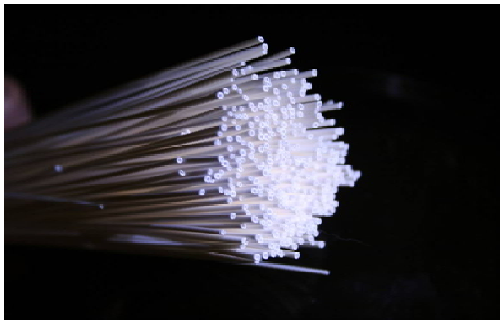


Dual Layer PBI/PES

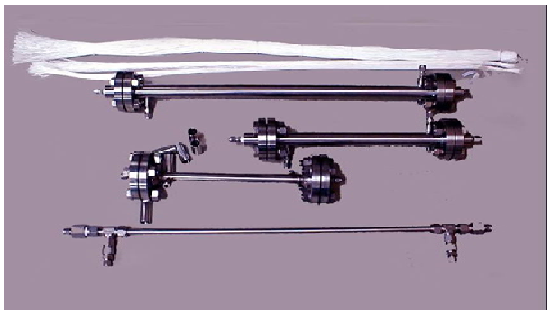


Professor Chung also showed the hollow fiber membrane modules, lab modules for liquid & pharmaceutical separation, modules for gas separation and high pressure modules for natural gas separation. At his group research on PRO is done to improve the power densities of Membranes as well as on the improvement and development of modules. In the Statkraft Summit compelling new research will be presented on the attainment of higher power densities.

Hollow Fibers



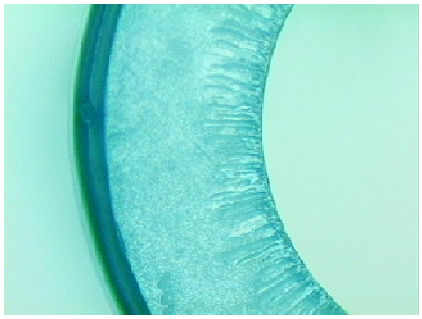
High pressure modules for natural gas separation

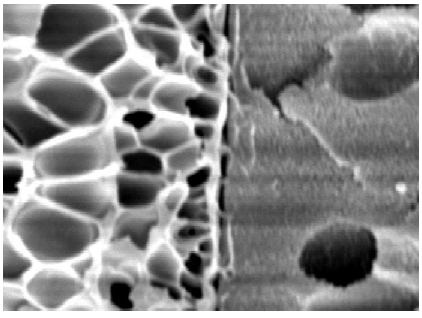


Modules for gas separation

Lab modules for liquid & pharmaceutical separation

And some of their advances on Dual-Layer Spinneret and spinning: Concentricity & uniformity of both layers.





Dr Frank Neumann
Institute for Infrastructure, Environment and Innovation

Frank Neumann presented possibilities for common activities of the INES network, including societal, ecological and resource aspects of salinity gradient energy (PRO, RED, Capmix). For stand-alone applications of salinity gradient energy the ecological aspects are very important for permitting in countries with strict protection of estuaries (as e.g. in most EU countries, Canada). In such cases, mitigation of effects, and proper monitoring and adaptive management are highly important, also for pilot situations. There is a strict environmental protection amongst others in the EU countries, Canada and USA of estuaries as large surfaces of estuaries disappeared in the past fifty years there due to coastal zone development, land reclamation.
For salinity gradient energy applications, connected to a process where waste water or desalination brine is used, the environmental and ecological implications seem beneficial.

INES partners visiting the first PRO pilot of Statkraft in Norway -Tofte- in 2011

Particularly for pilot projects and upscaling in areas with high environmental protection ecological aspects are important, as a proper treatment and mitigation are essential for obtaining a permit. In addition also in the study of Stenzel (2012)* it is demonstrated that it is an important factor in determining the possible potential in such areas.

In the follow-up discussion, it turned out that for partners outside of zones with strict estuary protection, at this moment making the technology work has highest priority. This issue does currently play a role for the pilot plant in development in The Netherlands.
Other issues that turned out to be highly important for the participants include:

* 2012, P. Stenzel Ph.D. Thesis Osmotic Power

1) A global resource analysis worldwide, using a common methodology.

2) Standardisation of research methodologies on membranes; other common definitions.

The International Renewable Energy Agency (IRENA) has already shown also an interest a general update in the state of the art of Salinity Gradient Energy and contacts will be made to see how INES could be helpful in providing that information.

As a follow up to this discussion, a proposal will be made by INES for a study on a resource analysis and for a part on environmental and ecological aspects. In addition, it will be explored what kind general standards, methodologies can be developed in bilateral discussion and co-operation with the partners.

Resource	Power (TW)	Energy Potential (m)
Ocean currents	0.05	0.05
Ocean waves	2.7	1.5
Tides	0.03	10
Thermal gradient	2.0	210
Salinity gradient	**2.6**	**240**

(From Ocean Energy Roadmap 201!– this does not take into account the difference between technical and ecological potential)

27 April - Barcelona International Convention Centre
Rambla de Prim, 1

Programme

DAY 2: COLLABORATIVE PROJECTS CONTINUATION

OPENING

14: 30	Update and INES programme continued - objective of this session *Co-chair Prof. Dr. Chuyang Tang, Singapore Membrane Technology Centre (SMTC) National Technical Unversity of Singapore.*
14:45	Exploration of enhacing energy efficiency for desalination by leveraging salinity gradient power technologies. *Dr. Winson Lay - Technology and Water Quality Office,* *Office of Water Technology of the Public Utility Board of Singapore (PUB).* *of Singapore -*

R&D AND PILOT PROJECTS

15:20	Brief reaction from INES PRO and RED partners. Discussion on possibilities for RED and PRO research and pilot projects in Singapore.
16:00	*Short Break*
16:10	Possible applications of decentralised PRO and RED pilot projects using saline groundwater and the Murray-Darling River in Australia. *Prof. Dr. Ho Kyon Shon - University of Technology at Sydney,* *School of Civil and Environmental Engineering* *Centre for Technology in Water and Wastewater treatment.*
16:30	Discussion on PRO- aspects. Dicussion on RED- aspects.
17:00	Synopsis and summary. *Follow-up actions. Preview to INES Meetings in Singapore; Brussels; and initiative for technology and resource assessment.*

CLOSURE AND DRINKS

17:30	*Terrace near Hotel Front Maritime* *(in walking distance from the Barcelona Convention Centre).*

Dr. Winson Lay
Public Utility Board of Singapore (PUB)

Water for All : Conserve, Value, Enjoy

Dr. Winson Lay presented the challenges on desalination, PUB policy and strategy and the leverage on salinity gradient power production in Singapore.

Challenges ahead

- Rising Energy Prices
- Rise of Megacities
- Population Growth
- No pristine water sources
- Climate change
- Stringent Regulations and Public Expectations

PUB's strategy is based on long term sustainability of water supply:

- Adequate Water Supply:
  * Rainfall: 2,4 m
  * Land area of 700 km2
  * Large domestic and industrial demand

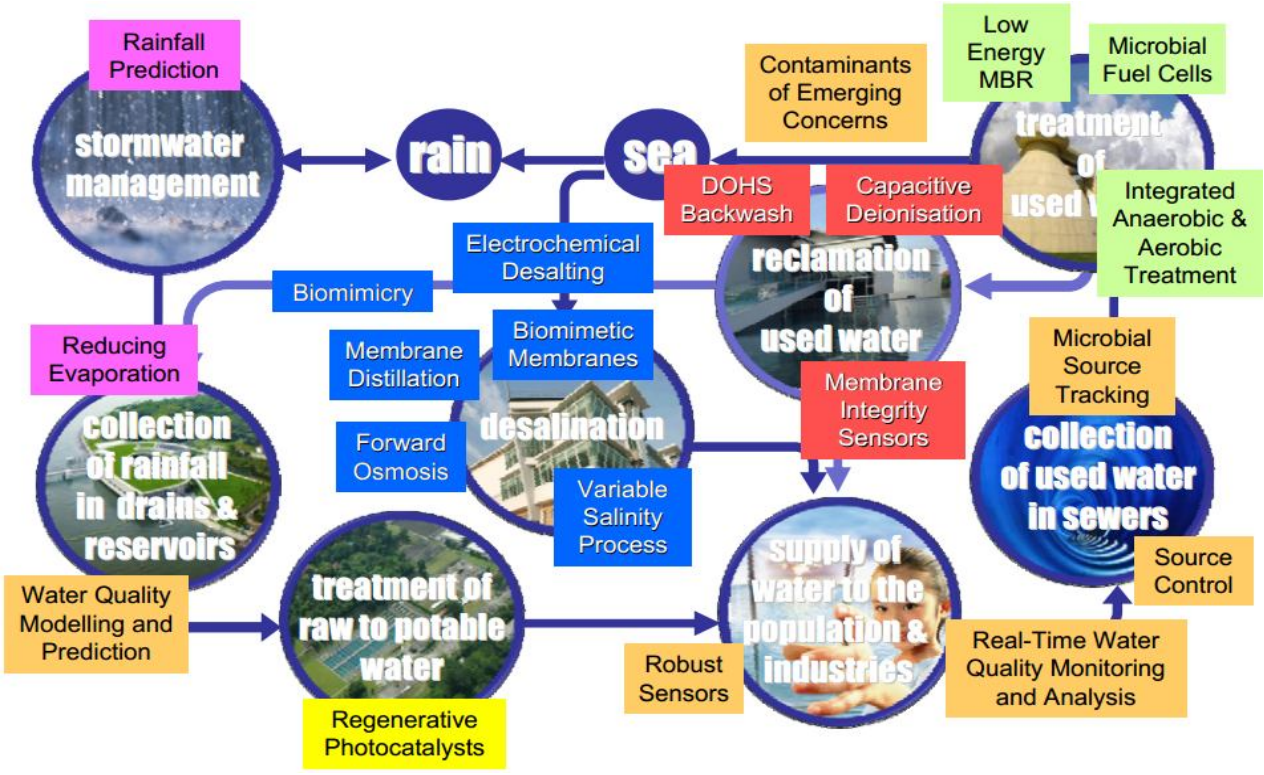
- Good Water Quality: water resources coming from unconventional sources

Strategic Thrusts:

- Increase water resources
- Protect water quality and security
- Reduce production costs

PUB's Investment in R&D Innovation

- Number of projects to date (since 2002): 319
- Total project value: U$176 mil



Environment & Water Industry Programme Office

- Since 2006 the National Research Foundation has set aside funding amount to $470 Million to develop water technologies sector for Singapore

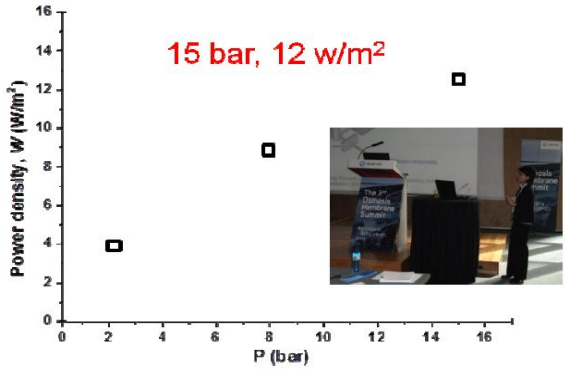
Snapshot of R&D projects on osmosis processes

Snapshot of R&D projects on osmosis processes

Project Reference	*Project Title*	*Grant Amount [S$]*	*Duration*	*PI*
0801-IRIS-05	Integration of Novel Forward Osmosis Membranes and Optimized Bioprocess for Water Reclamation	1,417,100	Oct 2008 – Sep 2011	Prof Anthony Fane (NTU)
0801-IRIS-14	Development of Forward Osmosis Membrane Bioreactor (FO-MBR) for Water Reclamation	1,427,900	Nov 2008 – July 2011	Assoc Prof Ng How Yong (NUS)
0801-IRIS-17	Material engineering and fabrication of high-performance nanofiltration-based FO membranes for water reuses	1,154,400	Oct 2008 – May 2011	Prof Chung Tai-Shung, Neal (NUS)
0901-IRIS-02-01	Novel Pressure Retarded Osmosis (PRO) Technology for Cost-Effective and Environmentally Sustainable Desalination Brine Disposal and Osmotic Power Harvesting	1,825,400	Apr 2010 – Oct 2013	Assoc Prof Tang Chuyang (NTU)

PRO (osmotic power) tests

PRO results of tests sponsored by PUB:



Draw solution: 1M NaCl solution;
feed solution: DI water

Contributing and pushing innovation in water technology and energy has a very high priority with PUB, therefore there is also a large interest in exploring the feasibility of a PRO and/or RED pilot in relation to the desalination configuration in Singapore. In the next INES meeting and site visit in Singapore on October 19 2012 at the Singapore Water Hub that will be one of the central themes.

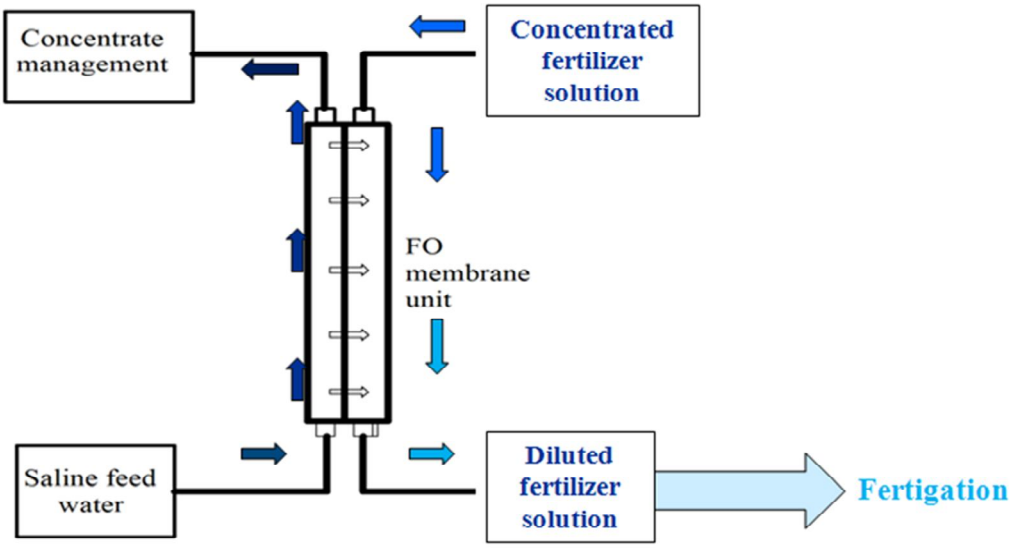
Integrated Network for Energy from Salinity Gradient Power

Professor Ho Kyong Shon and Professor Sherub Phuntsho
University of Technology, Sydney.

This presentation was focused in the possible applications of decentralized PRO and RED pilot projects using saline groundwater and the Murray-Darling River in Australia.

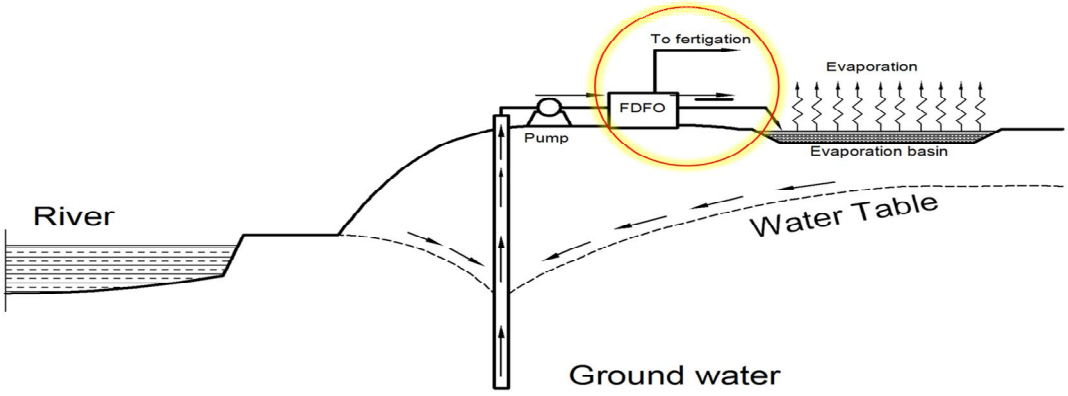
They have introduce a new concept mixing fertilizers and forward osmosis:

- Desalination for non-potable purpose such as irrigation
- In FDFO, a highly concentrated fertilizer draw solution is used
- The diluted fertilizer solution can be used directly for fertigation
- FDFO does not require separation process & therefore no energy



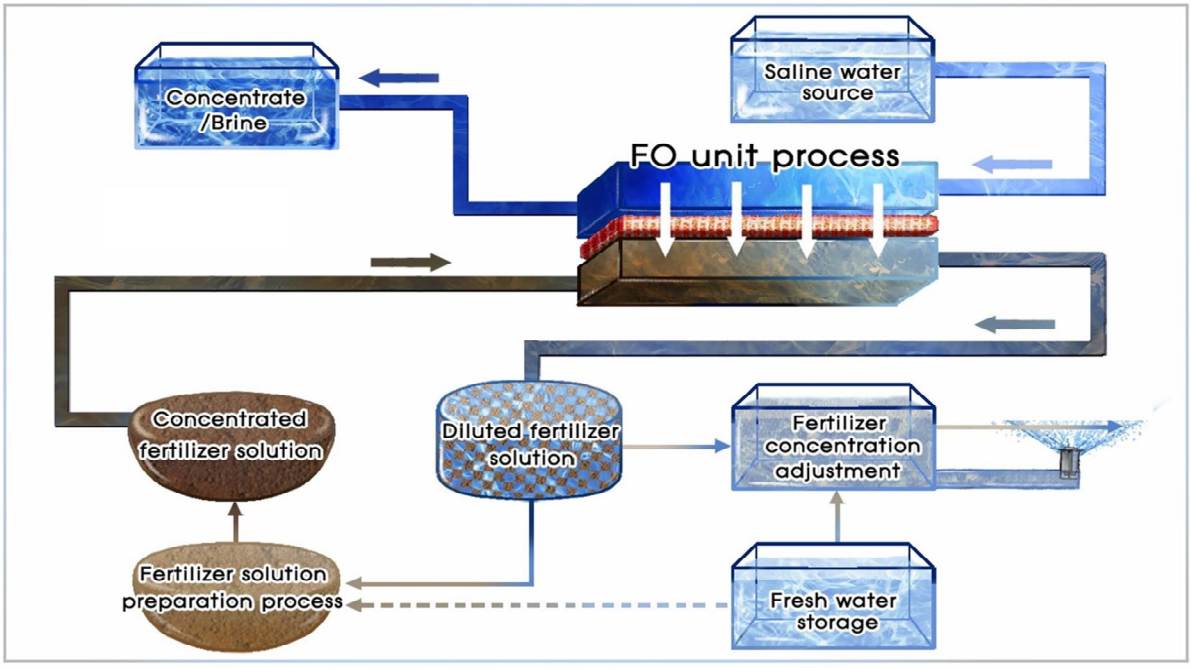
Alternate Salt Interception Scheme

- Use brackish groundwater as alternate source of water for irrigation
- Integrate FDFO with existing SIS
- Lead to sustainable use of groundwater for irrigation
- Reduce pressure on the river water for irrigation & increase environmental flows



Why Fertilisers as draw solutes for FDFO desalination?

- 5.3 million tonnes of fertiliser used
- From our previous study, 1 tonne of fertiliser produces 10 tonnes of fresh water from seawater (100 tonnes from bracikish water)
- 50.3 million tonnes of fresh water from seawater



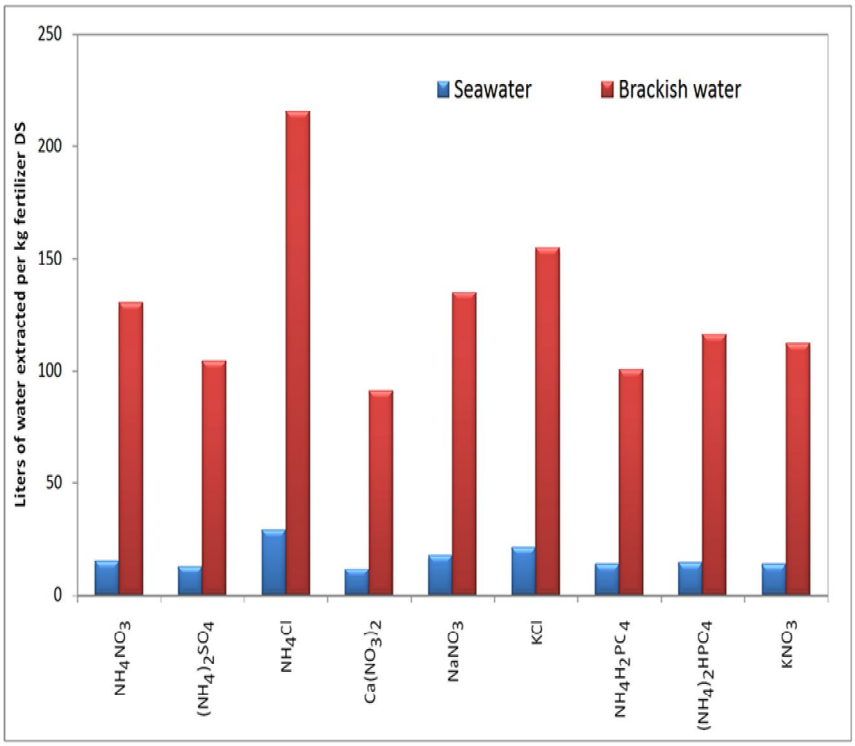
Performance of single or basic fertilizers as draw solution in terms of water flux

- Ratio (%)= (actual water flux/theoretical water flux) x 100
- NaN03 has the highest performance ratio (22.4%) followed by KCI and NH4CI
- Urea showed the lowest performance ratio at 8.5%
- Generally, calcium, sulphate and phosphate fertilizer draw solutions showed lower flux
- Lower PR is mainly attributed to concentration polarization effects

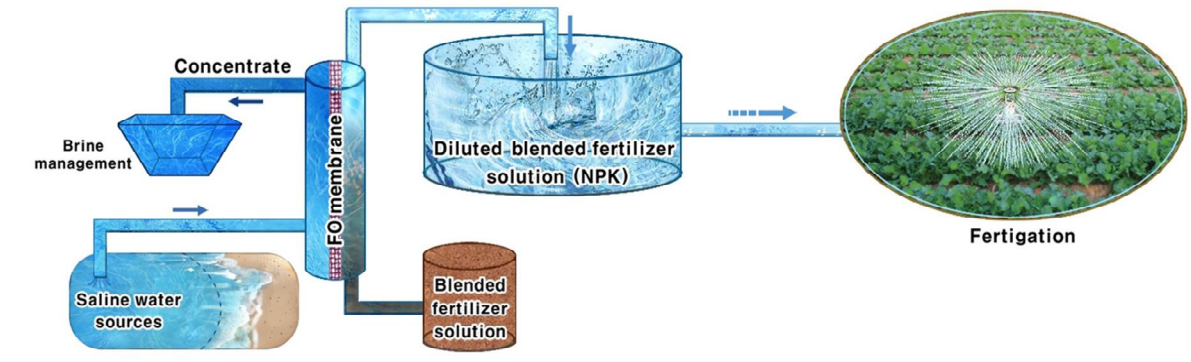
Major findings of FDFO desalination

How much water can a kilogram of fertilizer extract?

- Depends on the molecular weight (MW) of the fertilizer compound & feed water salinity
- Fertilizer with smaller MW can extract more water
- 90-215L of water from brackish water (TDS 5000 ppm)
- Less with seawater

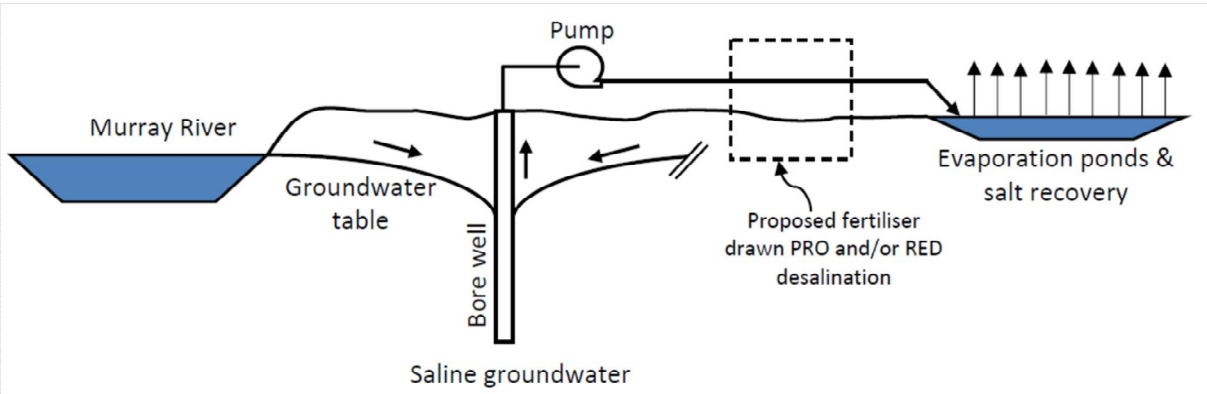


FDFO process:



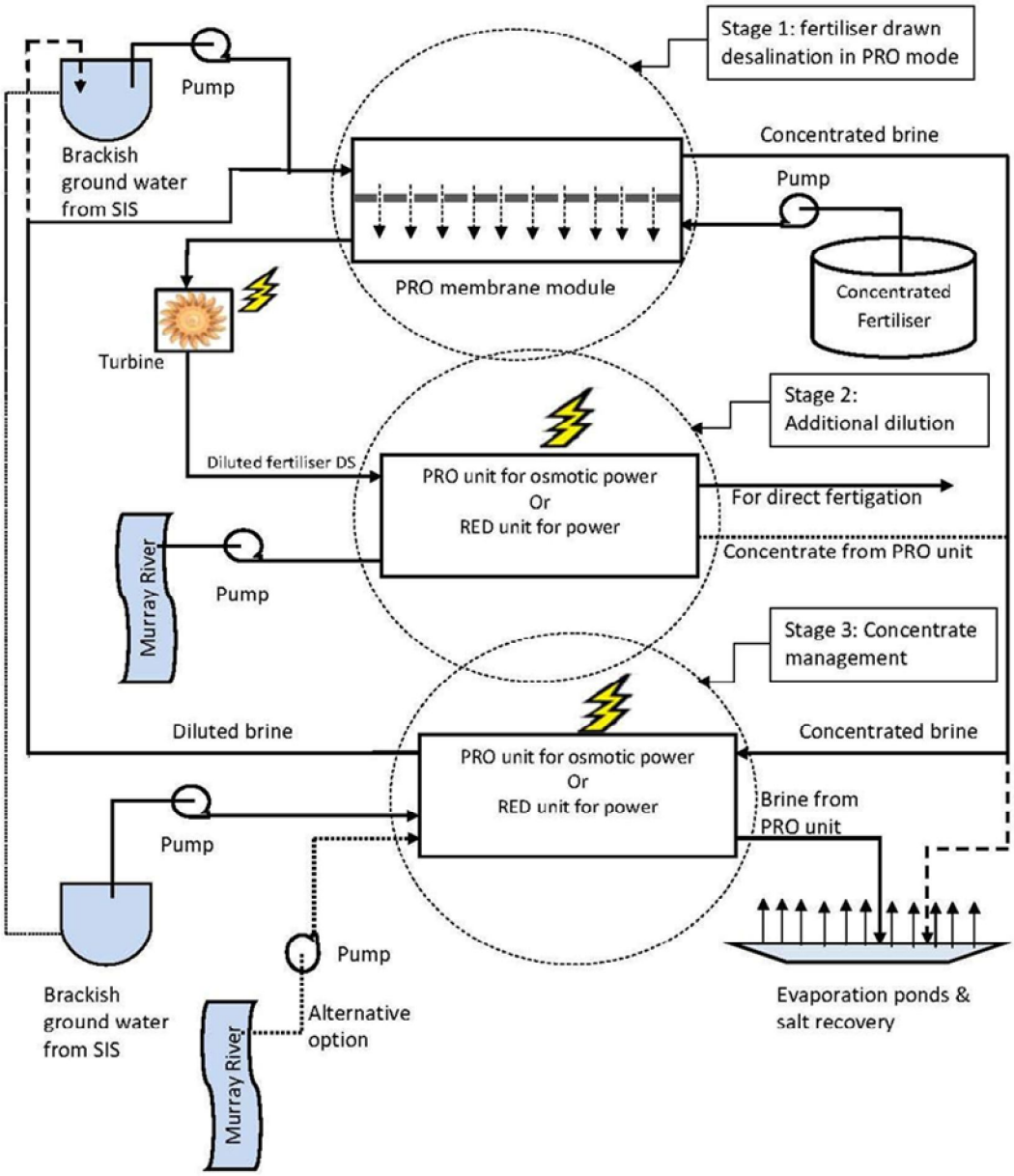
Pilot-scale FDFO hybrid system for direct fertigation

Renewable energy using PRO and RED for FDFO



Renewable energy using PRO and RED for FDFO

- Power generated by PRO: 1543 kW
- Power generated by RED: 233 kW
- Pump power required: 114 kW
- Net power: 1429 kW



Conclusions:

- Nine different commonly used fertilizers were finally screened from comprehensive fertilizers and, their performance were assessed in terms of pure water flux and reverse draw solution flux.
- Although KCl, NaNO3 and KNO3 indicated the best performance in terms of specific water flux MAP, DAP, Ca(NO3)2 and (NH4)2SO4 performed much better in terms of reverse solute flux.
- MAP and DAP can be used as a suitable draw solution for FDFO desalination
- Performances of fertilizers evaluated in terms of:
  * High feed water recovery rates
  * Water flux: comparable water flux and PR
  * Specific reverse solute flux
  * Nutrient concentrations in final FDFO product water
  * Blending of two or more fertilizers
- Two limitations (reverse salt flux and final concentration) were identified and can be mitigated with various manners.
- Power generated by PRO and RED is 1543 and 233 kWa

The presented approach was considered to be very novel, and seen with great interest for further investigation by all participants. None of the other participants had thought to look at the feasibility with water containing fertilizers and utilizing them in a salinity gradient energy solutions so the approach would be considered greatly useful for further investigation and discussion in one of the next meetings. Bilaterally this option will be further explored by Prof. Shon in conjunction with PRO and RED partners .

INES Workshop conclusions

The topics and the discussions where diverse and varied from the presentation of an innovative method combining salinity gradient power generation with fertilizers to the new developments in hollow fibers.

Some overall-observations:

- The propose of the meeting was to show the variety of possibilities and opportunities in the sector, to provide an overview of the latest developments and ongoing projects all around the world.

- Even if salinity gradient power production remains a young technology, a fast development has been shown. There is an increasing interest among universities and private companies to further develop and tackle the limitations and constrains to commercialize and develop power plants. Some of the projects presented at the meeting are ready to be implemented in pilot projects.

The follow-up actions derived from the discussion in the workshop include:

1) Develop a plan for a study for a general update on salinity gradient energy and common definitions for the larger public. The purpose is of sharing information with European authorities, international organizations (IRENA) and with other possible funding institutions.

2) Explore the development of a more systematic overview of salinity gradient resources usable for developers and governmental organizations.

3) Prepare for a discussion on a common understanding of methodologies to measure membrane performance –i.e. measurement of power densities- to be discussed at Milan and Singapore workshops.

4) Further steps for the exploration of pilot projects in Singapore, Korea and Australia, depending on the follow-up discussion in Singapore and possible bi-lateral discussions.

   The meetings following these actions are planned in Brussels at Sustainable Energy Week on 20 June, in Milan from 4 to 6 September, where also a closer look will be taken at the Capmix methodology and, finally at the meeting in Singapore on 19 October 2012 that will be held in conjunction with the ECI meeting from 16 to 19 October (see also http://www.smtc.ntu.edu/sg/pages/news/aspx).

Pictures from the conference

Province of Fryslan representative

Coffee break discussion I

Coffee break discussion II

Discussion on PRO technical aspects

Singapore partners

After conference drinks'

THE INSTITUTE FOR INFRASTRUCTURE, ENVIRONMENT AND INNOVATION is an independent Brussels-based non-profit organization. Its mission is to initiate and implement projects at European and local level that demonstrate that the development of infrastructure can be reconciled with nature protection and environmental goals.

Apart from initiating, financing, and developing European co-operation focusing on sustainability, occasionally the Institute also gives individual, practical, organisational and legal advice with respect to the implications of European Nature Protection Policy for projects and plans.
IMI gives advice on infrastructure projects, management plans and nature restoration measures, in relation to Natura 2000, not only in coastal zones and estuaries, but also on land based projects, and provides legal risk analysis and checks conformity with European nature protection legalization for development projects, nature restoration measures and integral management plans.

Project funding of the Institute comes mainly from national, local, and regional governments and government project organisations. The start-up of new projects is mostly done independently by the Institute on its own behalf. So far, the working programme has particularly focused on infrastructure within coastal zones, coping with environmental protection and also renewable energy production, implementing and promoting innovative techniques.
IMI is also involved in Marine, Wind and Solar energy and more recently energy generation through salinity gradient and network creation on tidal energy for knowledge sharing. These are the fields in which IMI is active.

The Institute employs a small multi-disciplinary and international staff. Working languages include English, French, Dutch, Spanish, German and Latvian.

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