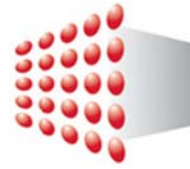


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Clean, Alternative and Renewable Energy: Beyond Buzzwords and Sound-bites

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ABSTRACT

This article is the first of a forthcoming ESI series on clean and renewable energy and is based partly on the work done for a technology roadmap for energy security and environmental sustainability conducted by the author as a Visiting Principal Fellow at ESI. He joined ESI as a Principal Fellow, effective October 2009.

It focuses on a need to go beyond sound-bites and buzzwords in the arena of clean and renewable energy, primarily because advanced technologies in this arena must be connected to legacy systems and infrastructures. A “systems of systems” understanding is paramount because, while emerging technologies may be “sexy” and thus over-hyped by market enthusiasts, eager to make a quick buck, their relevance to the real world in terms of TRL’s (technology readiness levels) and MRL’s (manufacturing readiness levels) must not be overlooked, as has been the case of some technologies (of great technical promise), which have failed to emerge as quickly as Wall Street pundits would have it.

This need for the integration of new and advanced systems with the existing (or legacy) systems and infrastructure extends into all fields, including that of solar energy, wind systems, and micro-grids. The article calls for planning, patience, and persistence to go along with the integration and innovation.

KEY WORDS

CleanTech, Clean and Green, TRLs (Technology Readiness Levels), MRLs (Manufacturing Readiness Levels), “Systems of Systems”, Technology Roadmap, Fuel Cells, Hydrogen, Alternative Energy, Renewable Energy, Advanced Energy, Geothermal, Nuclear, Distributed Generation, Smart Grid, Microgrids, Wind Energy, Solar Energy

1. Today, the terms “CleanTech”, “Clean and Green”, “Alternative/Renewable Energy”, and “SmartGrids” are readily thrown around in the media and have become buzzwords and sound-bites of the day. They proliferate over the I-web, including Twitter (hence sound-bites of the minute or the hour!) and celebrities and politicians globally tout them as the panacea that will save the world from the “domination of foreign oil” and will stop the world from over-heating as international climate change becomes synonymous with “global warming”.
2. It has become politically incorrect not to be seen to be supporting these broad terms which are often short on specifics. And some of the specifics which have become visible are not economically viable as they require massive subsidies. And there are others which have fallen out of favour.
3. Care should be exercised by the global community not to be trapped by such broad terms, which due to the desire to be politically correct, force everyone to take a position rightly or wrongly.
4. There has to be room for a deeper understanding, debate and reflection upon the issues and solutions. Only then can sustainable solutions be found and the compromises that have to be made be understood and widely supported.

Alternative Energy

5. When coupled with the word “Energy”, “Alternative” simply means that these are innovations that will replace the current or legacy systems in use today. Are these alternatives truly cost-effective within the current market mechanisms? And how are the costs defined?

6. Instead of carrying out nitty-gritty life-cycle costing, near-term financiers or short-term managers tend to separate initial capital costs from operating and maintenance issues, opting often to present the lowest initial cost investments. By doing so, they then saddle some other department within the same corporation or government agency with higher operations & maintenance (O&M) costs.

7. Such an approach is common, for example, with promoters who “churn” their developments. So why purchase more capital-expensive, highly efficient chiller systems, when that building would be sold to another entity that will have to carry the O&M costs? Let’s make our near-term return on investment (ROI) first!

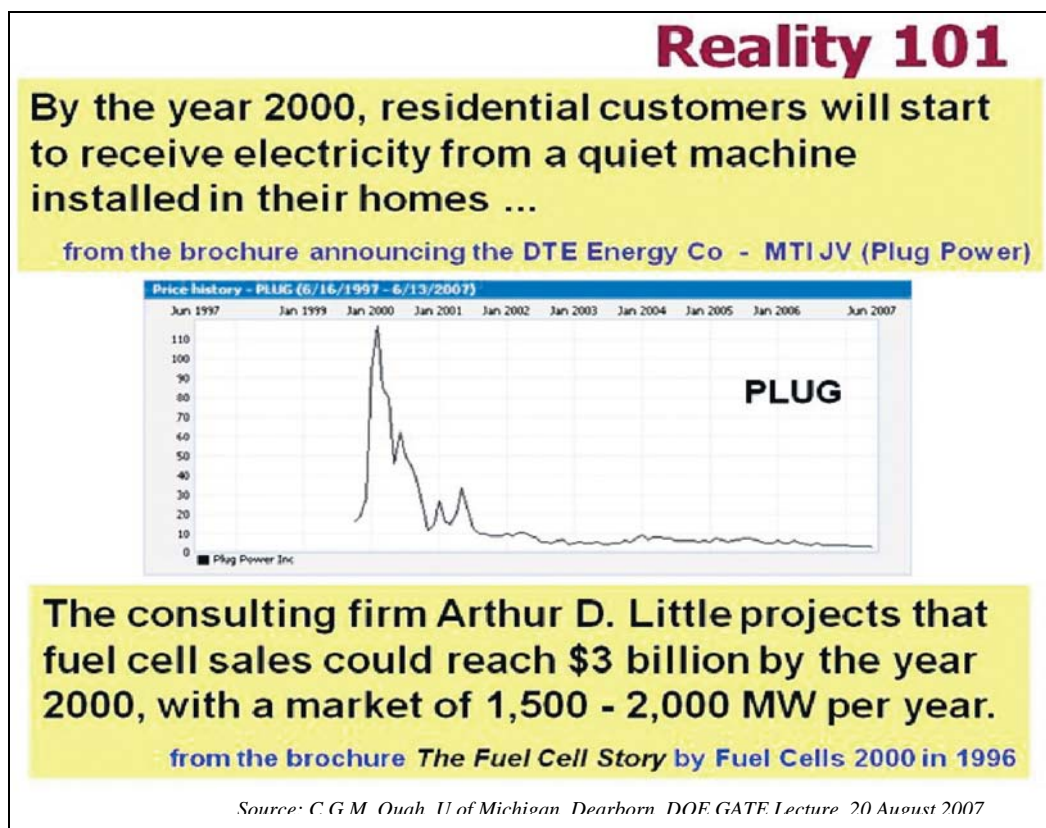
8. There is a difference between being energy efficient and being cost efficient. It is not always the case that an energy efficient solution is also a cost efficient solution.

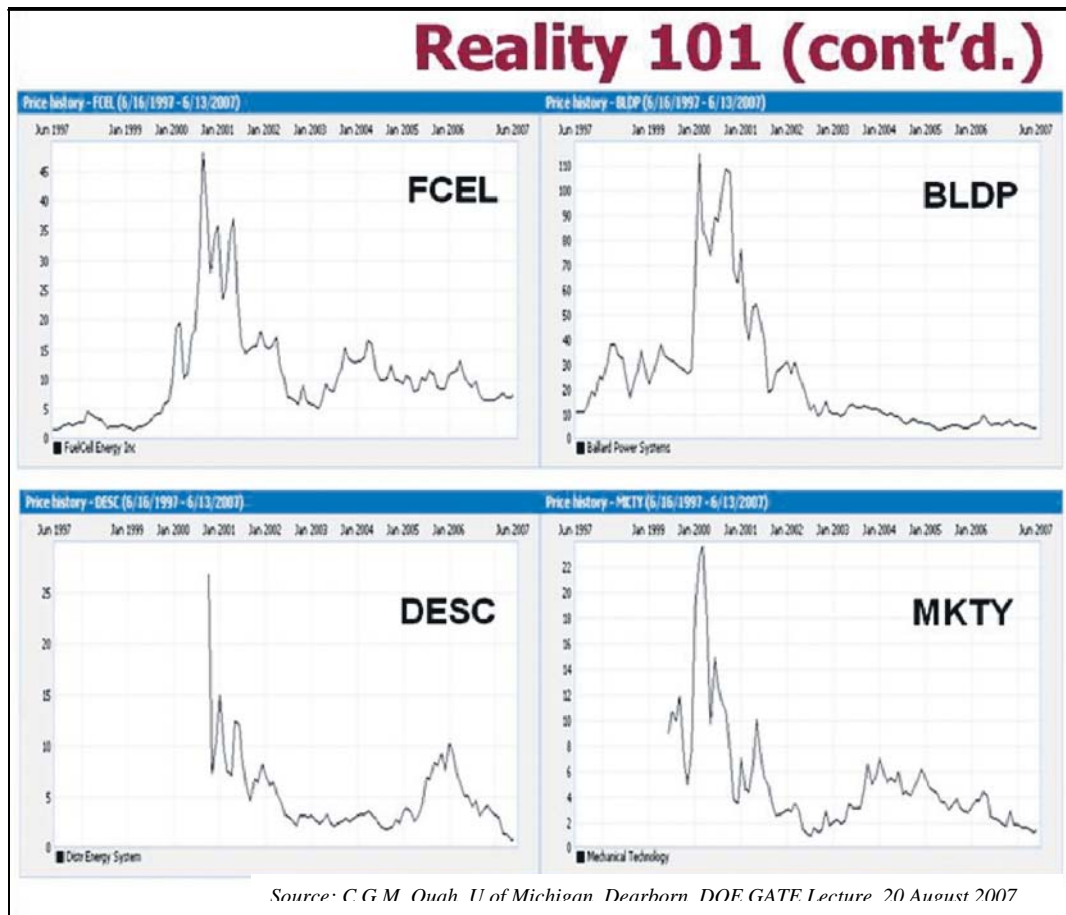
9. Many “Alternative Energy” systems unfortunately are not ready to be commercialised. They are at low Technology Readiness Levels (TRLs) or Manufacturing Readiness Levels (MRLs) and hence, further R&D needs to be conducted and data gathered and analysed.

10. Driven by the current excitement over “Alternative Energy” and in part by the investment opportunities, many Alternative Energy systems have been over-promoted and hyped.

11. Government agencies and some forward-looking corporations which deploy these “not quite ready for prime time” technologies are left to dig into their purses when these alternative systems fail or do not meet often hyped-up expectations.

12. The public investors then get disillusioned and the resulting changes in stock markets reflect this reality. The stock market charts of five of the top fuel cell companies in the US, listed on the NASDAQ illustrate this phenomenon. It is noteworthy that some are now defunct.





13. The fact is that the above alternative technologies DO hold much promise for the future. But the market place will quickly discover if the technology is ready for prime time.

14. The same applies to solar which is supported by subsidies. The financial crunch has rendered these subsidies unaffordable and these are being reduced, for example, in Spain and some countries in Europe. With reduced subsidies, demand for these technologies has also been reduced and this has created an over-supplied market. The good news is that the cost of solar has been driven down by over-supply but markets have some way to go to redress such imbalances in time.

15. There are many lessons to be drawn in terms of redressing from the above “Alternative Energy” examples. Two important ones are:
 - 15.1 Separate the wheat (i.e., the truly innovative technologies backed by sound economics that, if appropriately nurtured, can contribute to the advancement of science, engineering, and society) from the chaff (often promulgated by a financial system focused on short-term gains).
 - 15.2 Go beyond the buzzwords and sound-bites to understand that system integration is critical for new technologies to sustainably enter the marketplace.
16. Before elaborating on these two points, another useful issue to think of is whether the term “Alternative Energy” carries the right connotation. The term “Advanced Energy” may be better. Why? “Alternative Energy” systems are posited as alternatives to the current systems. On the other hand, “Advanced Energy Systems” are posited as systems that are more than just alternatives, in that they must offer more desirable features and benefits that current systems do not have.

“Systems of Systems” Thinking

17. There is a need for an understanding not only of the linear supply chain related to an innovative development but also the peripheral interactions and relationships to the entire marketplace. The influence of current market economics, political winds and trends, and the harsh reality of engineering and thermodynamic constraints are just as important considerations.

18. Fuel cells, for example, are simply engines, albeit they are combustion-less engines. A typical internal combustion engine (ICE) process involves an explosive chemical reaction producing heat and pressure, which is translated into mechanical energy through pistons, shafts, etc.

19. Unlike the ICE, the fuel cell uses hydrogen as the fuel to “drive” a reaction that produces electricity as the form of energy. That electrical current represents the direct and efficient conversion of chemical energy into electrical energy. The equally important feature of the fuel cell is that the product of the reaction is water, which makes the fuel cell a clean form of energy. However, the use of hydrogen as a fuel creates difficult problems at this time. These are:
 - 19.1 How and where do we get the hydrogen fuel and at what cost? Hydrogen is not readily drilled for as is the case for our fossil resources and in fact, today, hydrogen comes primarily from fossil fuels. In the US, over 90% of the hydrogen is produced from natural gas! So, from this perspective is it right for the fuel cell lobbyist to call fuel cells “clean and green”? Can there be cleaner sources of hydrogen that are also economically viable?

 - 19.2 Hydrogen can be readily produced from water and because the product of the electrochemical process in a fuel cell is water, the cycle is benignly continued. But energy is consumed in producing hydrogen from water. If this electricity comes from coal power plants it would be a stretch of the imagination to label fuel cells as being green. In the US for example, the fossil-fuel mix for electricity production is about 40% oil, 23% coal, and 23% natural gas. In Singapore, about 79% of the electricity is generated from natural gas fired systems. This is at least cleaner than coal.

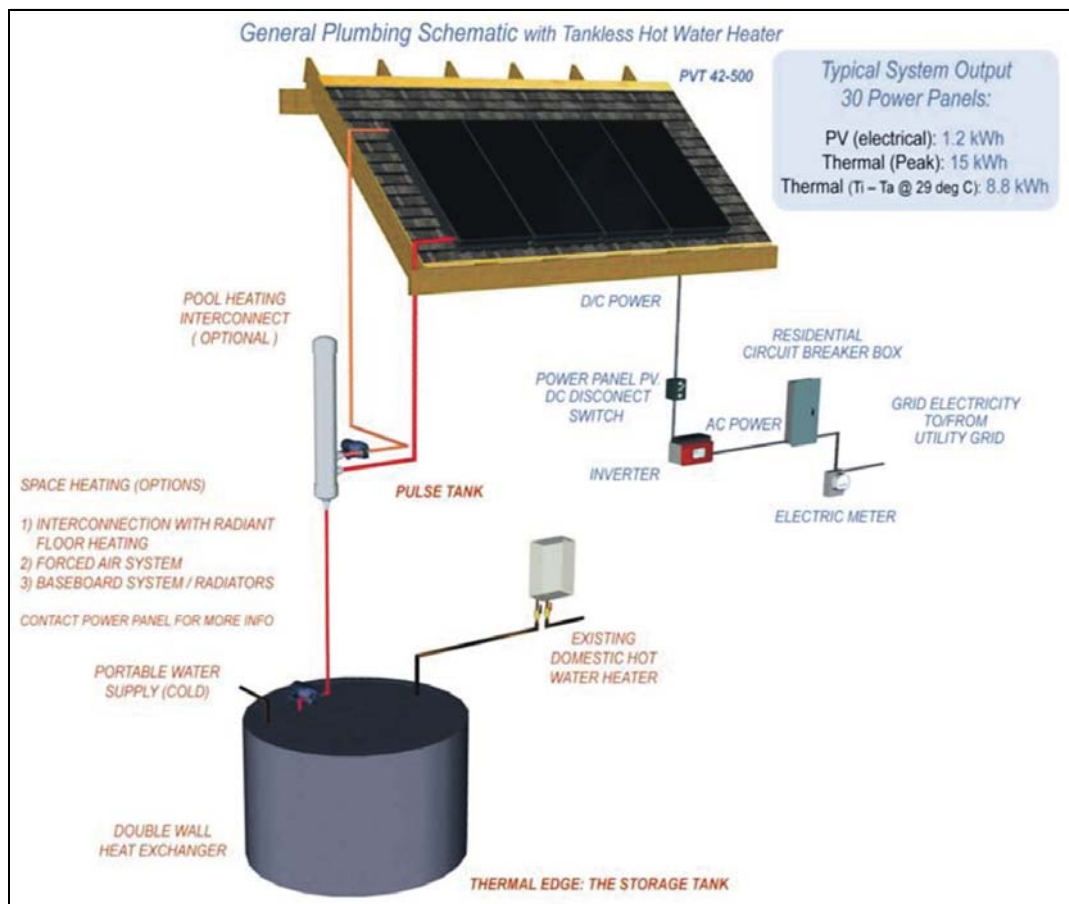
19.3 Of course, electricity could be produced from renewable electricity (solar photovoltaic (PV), wind, wave, hydro, geothermal, and perhaps even Ocean Thermal Energy Conversion (OTEC), etc. For now, ALL the renewable energy programmes globally are “subsidised” in that these technologies, while promising, often are more expensive and cannot compete with the relatively low prices of legacy systems run on fossil fuels. However the cost to use energy from legacy systems can be rendered more expensive by pricing carbon emissions through taxes either in a direct carbon tax or via the cap-and-trade mechanisms. This can help close the cost gap between legacy systems and renewable energy systems.

19.4 The cautionary lessons from the fuel cell industry also apply to other renewable technologies. Advocates of specific technologies often lose objectivity. For example a wind developer will always push wind technologies. But blade designs vary and those which capture Class 3 and higher winds in the temperate zones may not work well with the lower velocity winds in the tropics. Likewise, a solar PV producer of amorphous-silicon PV panels will market such products aggressively even though tropical conditions such as temperature, humidity, salinity, etc. may lead to higher rates of degradation compared to the conditions in Europe and the US. There are a variety of solar PV chemistries, viz:

- The standard crystalline silicon modules, made in two distinct processes today
- The microcrystalline systems
- Amorphous Silicon
- Cadmium Telluride (Cd-Te) direct band-gap semiconductors
- Copper-Indium-Gallium-Diselenide (CIGS) thin films
- Copper-Indium-Diselenide (CIS) systems
- Other organic/polymer and dyes, etc.

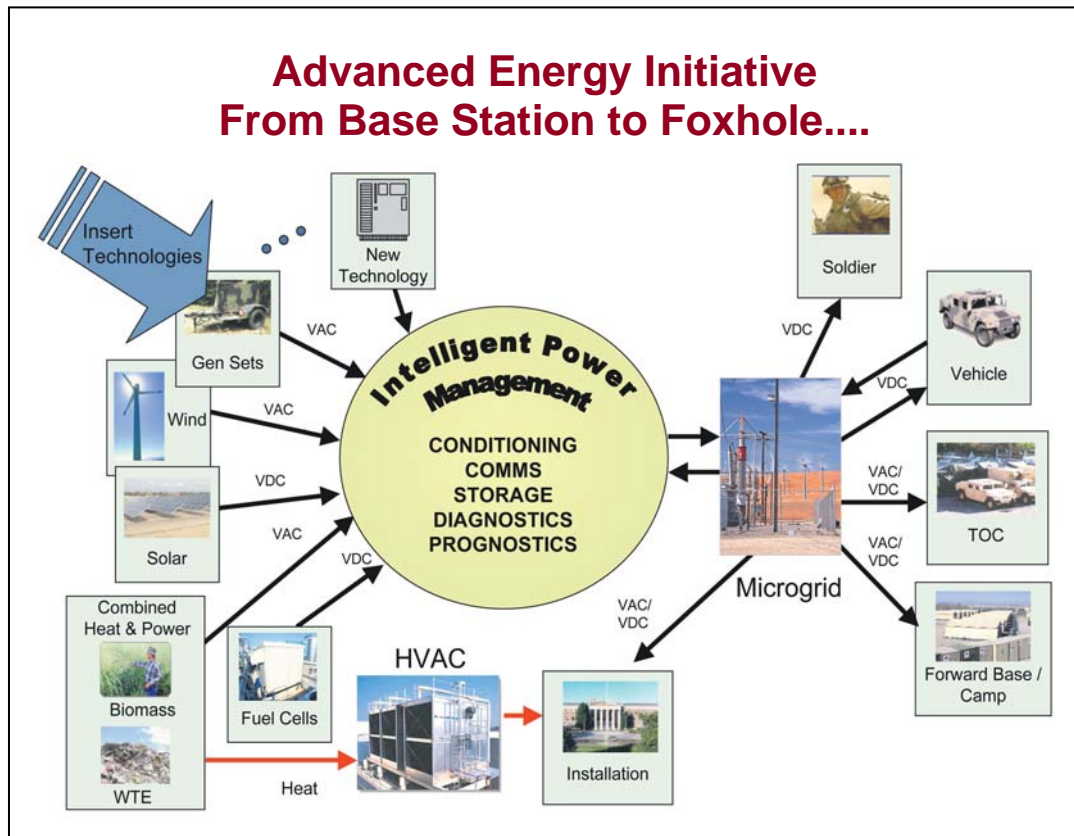
19.5 All are at different stages of development and each is exhibiting different degradation rates under tropical conditions. Singapore, thus, with its excellent government support of test-bedding and R&D programmes, presents a major opportunity for further applied and field-based studies and evaluations.

19.6 A “systems of systems” perspective is necessary to address the question: given Singapore’s solar insolation with often hazy skies and Singapore’s small size, would solar heating make more economic sense? Or perhaps, should a hybrid solar PV plus heating panel be developed as shown below?

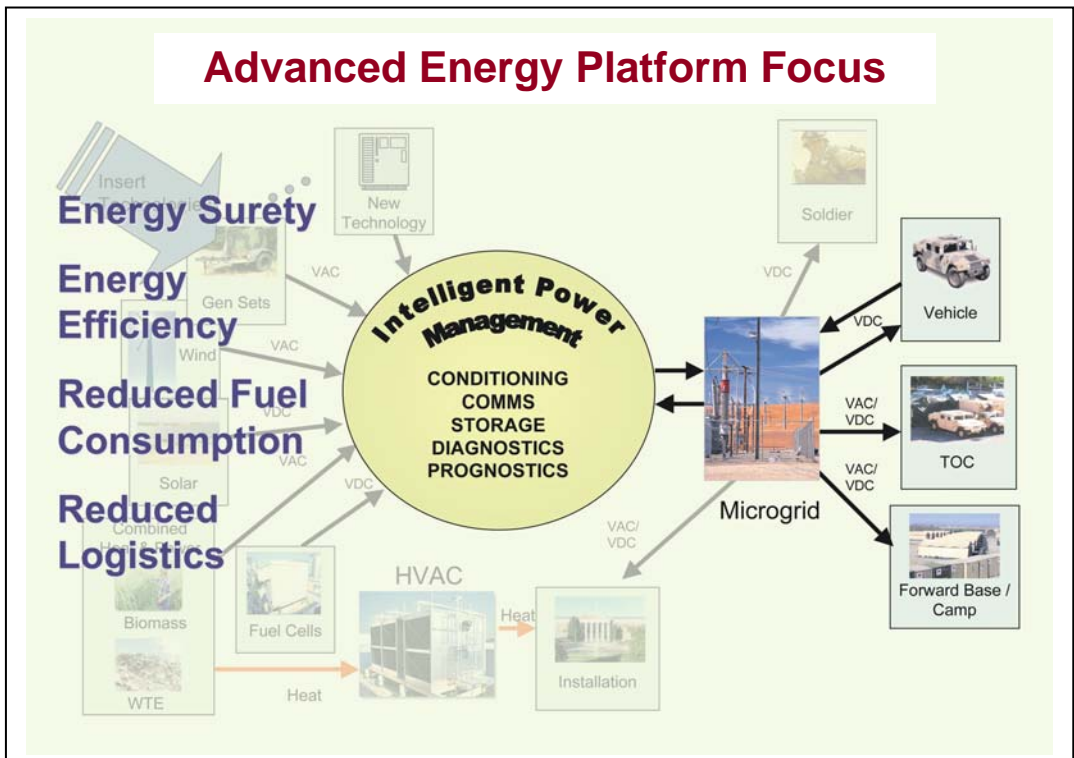


Schematic showing the operations of a “Power Panel”. Source: <http://www.powerpanel.com/index.html><Sept 09>.

- 19.7 Beyond single technology options, each of which must be integrated to function in harmony with the existing infrastructure including the current power grid network, the future of advanced energy solutions demands a consideration of energy diversity as each solution is by itself unable to address all the problems placed on the power supply system. So, how do the wind, solar, wave, tidal, and other systems (some producing direct current, some producing synchronous alternative current, others asynchronous alternative current) operate synchronously with the existing grid or in microgrids of their own (some grid-connected, other grid-isolated)?
- 19.8 The above question also brings up issues relating to smart grids, whereby sources and loads are better balanced, monitored, metered, and controlled. The figures on page 11 illustrate graphically such interconnections, more in the context of a military forward operating base and what features and benefits (energy surety/security, energy efficiency, reduced fuel consumption, reduced logistics) such systems bring. Such systems can easily be adapted for civilian use for remote locations, rural electrification, etc.
20. Further debate and discussion will follow in a subsequent article because this series of articles must probe the depths and not simply repeat buzzwords and sound-bites. So, stay tuned ...




Source: C.G.M. Quah, "Energy Security and Energy Diversity: A Role for Army Leadership?", Energy Lecture at the US Military Academy, West Point, New York, 6 February 2007.



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21. To conclude, beyond the buzzwords and sound-bites on clean energy, alternative/renewable energy, we recognise that technological complexity demands a “systems of systems” perspective and this article has merely touched the surface interconnections. However, Singapore has made the necessary investments in this arena, especially with the Economic Development Board’s current focus on CleanTech entrepreneurship and its holistic urban solutions thrust. Moreover, Singapore’s “blue” legacy in its earlier focus on pollution prevention and water sustainability developments, a journey well-described in the 2009 ISEAS publication, “Clean, Green, and Blue” by Tan Yong Soon, clearly highlights key points to emulate: 5 E’s, 3 P’s, and 2 I’s. (see below) Singapore’s past accomplishments have been based on these key ingredients for success in the water and pollution prevention spheres. These same ingredients must now be put into the mix for alternative, nay, advanced energy technologies for environmental sustainability and economic development.

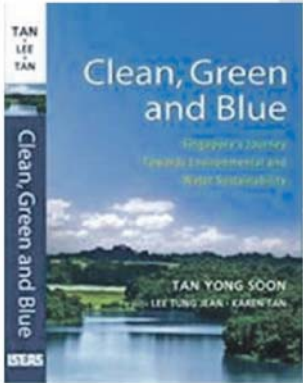


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A Great Example

Key Ingredients for Success

- Overall Vision and Mission Clearly Articulated
- 5 E’s: **Engineering**, Economics, Education, Enforcement, and **Engagement**
- 3 P’s: Planning (Long-term), Persistence, and Practicality
- 2 I’s: Innovation and Integration
- Water and Environment → Now, Energy + Water + Environment



“Systems of Systems” Approach

Source: C.G.M. Quah, slide from “Some Innovations From a Work in Progress: A Technology Roadmap for Energy Security and Environmental Sustainability”, National Sustainability Conference, NUS Kent Ridge Guild House, 20 - 22 February 2009.

About the Author

Dr. **Michael QUAH** has a PhD (1980), MPhil and MSc, all in chemical engineering from Yale University and a BA (magna cum laude) in chemistry and physics, from Harvard.



He worked for the DuPont Company from 1979 to 1999, including stints with DuPont Japan and Singapore (1990-1993).

At DuPont, Dr Quah held positions in R&D, product and business development, and management. His technical work revolved around membrane technologies for reverse osmosis, gas separations, and electrochemical processes, the last area stimulating his interest in alternative energy innovations. When Dr. Quah worked for DuPont in North Carolina (1993-1999), he also served as Adjunct Professor in Chemical Engineering, at North Carolina State University. After early retirement from DuPont, he held management positions in several small commercial companies and in non-profit organizations, including a stint with the US Army.

Dr. Quah has lectured extensively in the following areas: Nafion* and perfluorinated ionomers for use in electrochemical systems (electrolysis, redox flow cells, and fuel cells), membrane separations, micro-grids, and energy / environmental sustainability.

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