ESI 090930/O/005/GE

ESI

ENERGY STUDIES INSTITUTE

# BULLETIN ARTICLE

HUM Wei Mei

## A New World in a Clean Tech Era?

ESI Bulletin on Energy Trends and Development, Vol 2 / Iss 2 • Sep 2009

NUS National University of Singapore

# *ABSTRACT*

*The Clean Technology (Clean Tech) sector is central to establishing the future global economic and political pecking order. It is the industry and the instrument the world will have to employ if meaningful progress toward reducing mankind's harmful impact on the earth's ecosystem is to be made. Clean Tech's significance derives from three key sources: 1) its central role in mitigating the costs of impending climate change measures, 2) its ability to reward enterprising countries with new avenues for profit, growth and development and 3) its ability to provide strategic options for energy security by creating alternate routes to energy independence. Countries that come out ahead in the Clean Tech sector will be more economically competitive, more secure, and healthier. The compelling logic of Clean Tech puts it the core of the twenty-first century grand strategy of nations preparing to adapt to a carbon-constrained world.*

*The effects of nations positioning themselves for a new energy future are already giving rise to a new type of resource competition and changes in the geo-politics of energy. Since Clean Tech relies on access to scarce raw materials, in particular high-technology metals such as Rare Earth Elements and Lithium. Countries possessing these commodities may be thrust into new positions of geo-political power. At the same time Clean Tech's underlying emphasis on energy efficiency and energy security through the reduction of reliance on imported fuels has given rise to neo-mercantilist sentiments amongst countries that are better endowed with the scarce raw materials that will make a new energy future possible.*

*Climate change has thus given some nations an unprecedented chance to redraw the rules of global commerce as well as to forward new economic and geopolitical strategies. Smaller countries with less clout or without indigenous sources of Clean Tech's raw materials, such as Singapore, will do well to assess how best they can fit into such a context.*

## *KEY WORDS*

*Resource Politics, Energy Security, Energy Independence, Raw Materials, Clean Technology, Electric Vehicles, Wind Power, Rare Earths, Lithium, Mercantilism, Neo-Mercantilism, Export Quotas, WTO*

1. In spite of being in its infancy, the Clean Technology (Clean Tech) sector is central to establishing the future global economic and political pecking order. It is the industry and the instrument that the world will have to employ if meaningful progress towards reducing mankind's harmful impacts on the earth's ecosystem is to be made. Clean Tech's significance derives from three key sources: 1) its central role in mitigating the costs of impending climate change measures, 2) its ability to reward enterprising countries with new avenues for profit, growth and development, and 3) its ability to provide strategic options for energy security by creating alternate routes to energy independence. Countries that come out ahead in the Clean Tech sector will be more economically competitive, more secure, and healthier. The compelling logic of Clean Tech makes it the core of the twenty-first century grand strategy of nations preparing to adapt to a carbon-constrained world.

2. The effects of nations positioning themselves for a new energy future are already giving rise to a new type of resource competition and changes in the geo-politics of energy. Since Clean Tech relies on access to scarce raw materials, in particular high-technology metals, the nations possessing these commodities will be thrust into new positions of geo-political power. At the same time Clean Tech's underlying emphasis on energy efficiency and energy security through reducing the reliance on imported fuels has given rise to neo-mercantilist sentiments amongst countries that are better endowed with the scarce raw materials that will make a new energy future possible.

3. Climate change has thus given some nations an unprecedented chance to redraw the rules of global commerce as well as to forward new economic and geopolitical strategies. Smaller countries with less clout or without indigenous sources of Clean Tech's raw materials will do well to assess how best they can fit into such a context.

**Why Clean Tech, Why Now?**

4. Without clean technology to enable increases in energy efficiency or to provide alternatives to fossil fuels, carbon abatement would mean sacrificing growth, development and a concurrent drop in living standards. No country is prepared to sacrifice the comforts that its citizens have come to expect and so the rules in a carbon-constrained world necessitate the deployment of clean energy technologies. Thus it has become clear that a strong position in the field of Clean Tech yields distinct competitive and strategic advantages for any country that possesses and harnesses it.

5. Clean Tech's strategic importance derives from the fact that it enables countries to mitigate the costs of impending climate change adjustments by increasing the efficiency of machines and reducing the reliance on fossil fuels, thereby making a country more carbon-and cost-efficient. Clean Tech also provides a recourse that reconciles the seemingly contradictory goals of curbing greenhouse gas emissions and preserving economic growth. This is because Clean Tech itself is a lucrative new industry, with significant export potential that can enable countries to climb the technological ladder and create new types of lucrative "green collar" jobs. For example, the wind sector alone now employs more than 400,000 workers around the world and the value of new power generation equipment installed in 2008 alone was worth nearly $US50 billion.[1]

6. Clean Tech's strategic value emanates from the reality that increasing energy independence will promote a nation's energy security. Although fossil fuels are expected to remain the world's primary source of energy for many years to come, Clean Tech's products such as wind turbines, solar power technologies and advanced energy storage systems will allow countries to autonomously achieve greater energy independence by increasing the proportion of energy produced

within their own national boundaries.

7. The heavy and rapid investments in Clean Tech bear testament to the commitments countries see themselves making towards employing clean energy a part of their futures. US President Barack Obama's stimulus package has enabled the US Department of Energy (DOE) to award an estimated US$4.3 billion (S$6.1 billion) to projects that will upgrade segments of the American electric grid to allow for the management of intermittent generation from renewable sources such as wind or solar. The European Union has also earmarked £3.98 billion (S$9.38 billion) for investments in energy infrastructure while the Chinese government is reportedly setting aside 120 billion yuan (S$24.8 billion) for a "New Energy Programme" aimed at turning China into a world leader in renewable energy production and low-carbon solutions.

**Resource Politics in a Clean Tech World**

8. As nations take the initial steps towards a world driven by clean technologies, non-fuel raw materials may be poised to become the strategic energy commodities of the new era. This is because the success of any country's clean technology industry rests upon the control of and access to commodities such as "high technology metals", which make clean technologies possible to begin with. These high-technology metals range from the rare earth elements (REEs) and platinium group metals to indium, manganese and niobium, all of which are critical to the production of a plethora of technologies required by clean technologies such as automotive catalytic converters, energy storage options and other products designed with energy efficiency in mind. The addition of half a kilogram of niobium for instance, could reduce the overall weight of a car frame by 100 kg due to its strengthening properties, thereby making cars more energy efficient.[2]

9. An undisputed list of globally strategic non-fuel commodities has not been determined by any formal consensus but, the EU, US, Japan, China and South Korea have all established commissions to identify the resources that are key to their security and strategic interests. For example, in 2004 the Japanese government created the Japanese Oil, Gas and Metals National Cooperation (JOGMEC) which is tasked with identifying critical commodities and managing Japan's economic stockpile of rare metals. The European Commission has recommended the launch of a European Raw Material Initiative with the European Commission implementing international and European strategies for securing critical raw materials. In 2008, the US National Research Council's Committee on Earth Resources published a paper titled "Minerals, Critical Minerals and the US Economy" detailing the commodities which are not only critical to the US economy but are a subject of concern due to potential supply disruptions. The table below lists commodities which have been highlighted by these countries:

**Critical Commodities by Country/Region**

| **Japan** | **US** | **Europe** |
|---|---|---|
| **Commodities Currently Being Stockpiled** | **Commodities Identified as Highly Critical** | **Commodities Identified as Highly Critical** |
| ▪ REEs<br>▪ Chromite<br>▪ Manganese<br>▪ Niobium<br>▪ Tantalum<br>▪ Vanadium | ▪ REEs<br>▪ Indium<br>▪ Manganese<br>▪ Niobium<br>▪ Platinum group metals | ▪ REEs<br>▪ Chromite<br>▪ Indium<br>▪ Lithium<br>▪ Platinum<br>▪ Palladium |

*Source: Commission of European Communities. Communication on the "Raw Materials Initiative, National Research Council's Committee on Earth Resources published a paper titled "Minerals, Critical Minerals and the US Economy", 2007*

10. While such lists are reflective of the idiosyncratic vulnerabilities, resource endowments and strategic needs of the various countries that prepare them, there

appears to be a coincidence of demand by major countries for certain commodities. This could be an area of concern if a commodity is 1) prone to supply risk due to difficulties in increasing production quickly should demand increase significantly, 2) prone to restriction because production is concentrated in a small number of mines, companies, or a small number of producing countries and 3) not traded on open markets, or 4) all of the above.

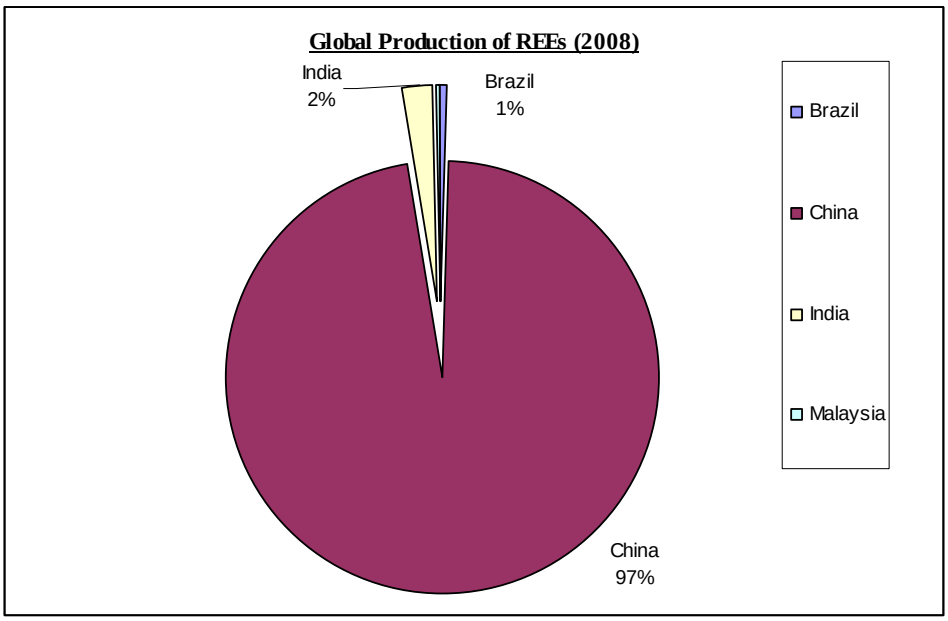
11. These factors set the stage for intense international rivalry for access to critical raw materials and threaten to exacerbate global resource politics, shifting geo-political power to countries rich in critical strategic commodities. This will not be the first time the world has seen such phenomena. As Dr Daniel Yergin notes in his Pulitzer Prize-winning book *The Prize*, oil catapulted "states heretofore peripheral to international politics into positions of great wealth and influence". REE and lithium, which have the potential to become globally strategic commodities in a Clean Tech world, have already been identified and are highly sought after.

**Rare Earth Elements**

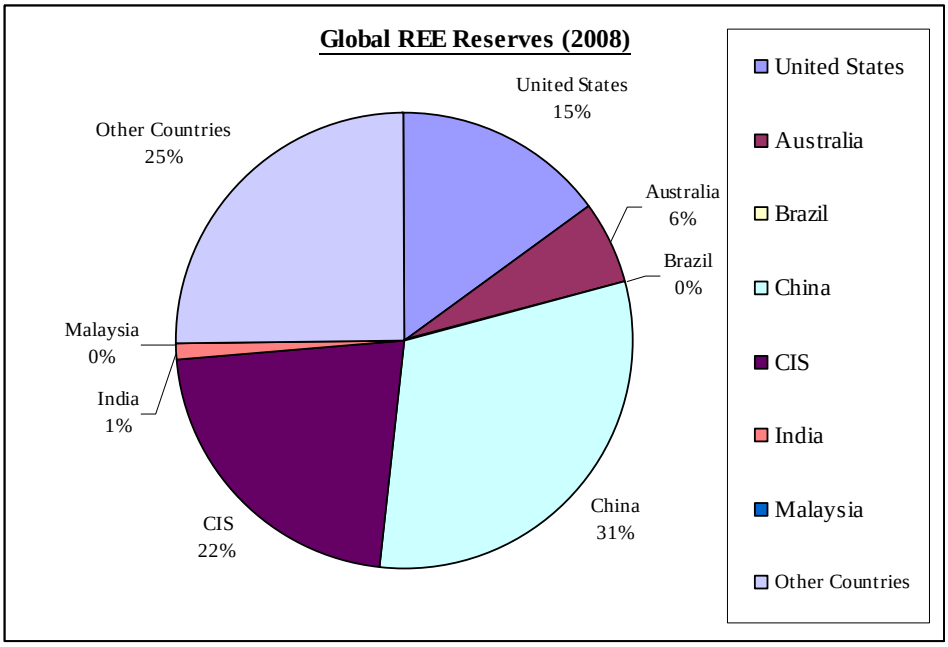
12. REEs, a group of 17 elements, hold the key to many clean technologies. They are the raw materials needed to manufacture the world's most advanced commercialised permanent magnets used in hybrid and electric vehicles, cutting-edge energy efficient magnetic refrigeration, energy efficient light bulbs and wind turbines. Simply put, the production of numerous Clean Tech products would come to a standstill if global supplies of REEs were to suddenly vanish. Approximately 20 kg of REEs are used in a hybrid car such as the Toyota Prius, for the rechargeable battery pack, permanent magnet motor and regenerative braking system. Also, almost 1,000 kg of REEs are used in the manufacture of an efficient 1 MW wind turbine.[3]

**The Rise of Neo-Mercantilism and its Geo-political Counter-weights**

13. In spite of the increased demand for REEs, global production of REEs in 2007 and 2008 stood still at 124,000 tonnes, sparking concerns that shortages might result in production bottlenecks for the Clean Tech sector. Indeed, the amount of REEs available for trade has been falling annually. This is largely because China, which accounts for over 95% of the global production of REEs, has been steadily cutting export quotas by 6% annually for several years due to increases in domestic demand. In addition, although REEs are relatively more abundant than many traditional industrial metals such as iron ore, REEs are highly difficult to extract since it is rare for them to be concentrated in commercially exploitable ore deposits. The bulk of China's REEs are produced in only two areas, while the US production currently relies on two mines, one in Mountain Pass California and the other in Lemi Pass, Idaho.[4] China's state-owned enterprises have entered into discussions to take over several Australian REE mining companies, giving rise to speculation that China intends to extend its monopoly of global REE production and hold the Clean Tech world hostage. This has alarmed Clean Tech industrialists across the globe as they count on access to REEs for the manufacture of their products.




*Source: U.S. Geological Survey, Mineral Commodity Summaries - Rare Earths, January 2009.*




*Source: U.S. Geological Survey, Mineral Commodity Summaries - Rare Earths, January 2009.*

14. In what may be the first salvo in a global trade war over strategic commodities, the Chinese Ministry of Industry and Information Technology has proposed an export ban on REEs in addition to other industrial raw materials. In response, both Europe and the US have lodged complaints against the Chinese with the WTO.

15. According to the United States Trade Representative Ron Kirk, "US industries and workers can compete against anyone if the playing field is level. But China's policies on these raw materials appear to tilt that field in favour of Chinese producers." Meanwhile, EU Trade Commissioner Catherine Ashton said in a statement, "The Chinese restrictions on raw materials distort competition and increase global prices, making things even more difficult for our companies in this economic downturn." Indeed, this is the new game of global strategic resource politics.

16. Whether by accident or by design, China does appear to have developed a compelling industrial strategy best described as a form of neo-mercantilism. By pouring in government support for Clean Tech industries such as wind technology, China has supported the growth of the Clean Tech industry within China. Simultaneously, reductions in exports of raw materials, due in part to rising domestic consumption, have forced foreign Clean Tech companies to set up operations within China to secure access to REEs and other critical raw materials so that they can produce products for sale on the international market. In 2008, 20 new turbine manufacturers set up operations in China bringing the total number to 70. Meanwhile, China's demand for newly installed wind capacity is forecast to be around 10 GW per year between 2011 and 2020.[7] Evidently, China's domestic market is insufficient to support such a large number of wind turbine manufacturers and it is widely expected that China will begin its first exports of wind turbines to the rest of the world by 2009.

17. While the frustration of countries such as Japan, which imports over 90% of its REEs from China is understandable, the WTO may find it difficult to pass a ruling that compels countries to export their natural resources, even if market prices were to be paid for the commodities. Countries have the right to conserve their natural endowments, to pursue industries that best suit their circumstances and to ensure they benefit economically from it. This is, after all, the basis for international trade.

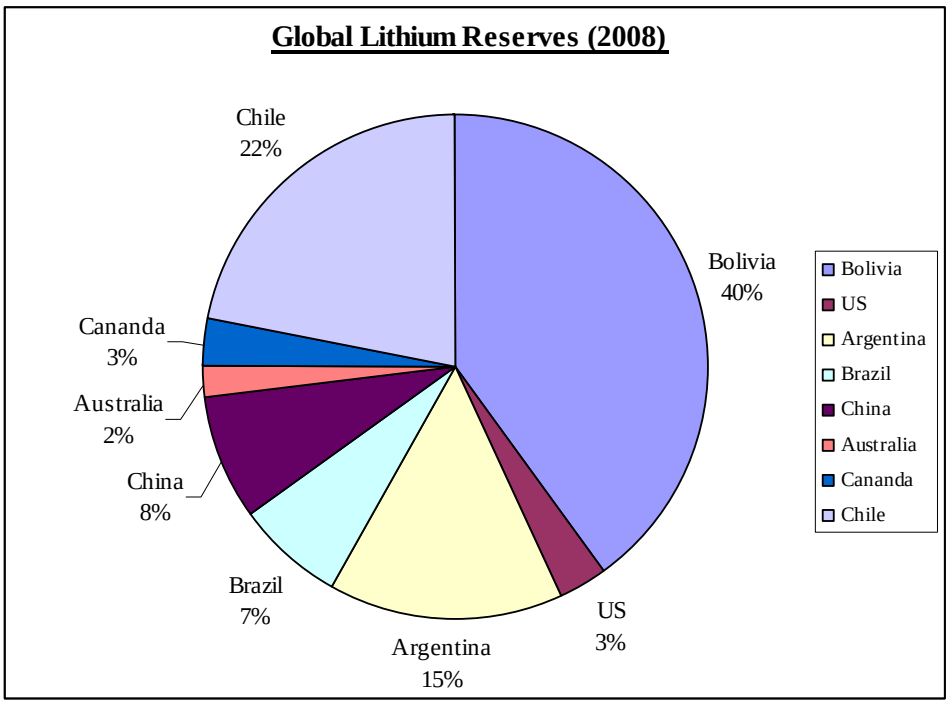
18. In response to China's actions, efforts by private corporations and various countries to open and expand new REE mines in areas such as Malaysia, Canada, Vietnam and Australia have intensified. This may have the effect of shifting the international significance of these countries as the forces of global commerce seek out these newly strategic resources. This emergent trend is best observed in the case of another potentially strategic Clean Tech commodity, lithium.

**Lithium**

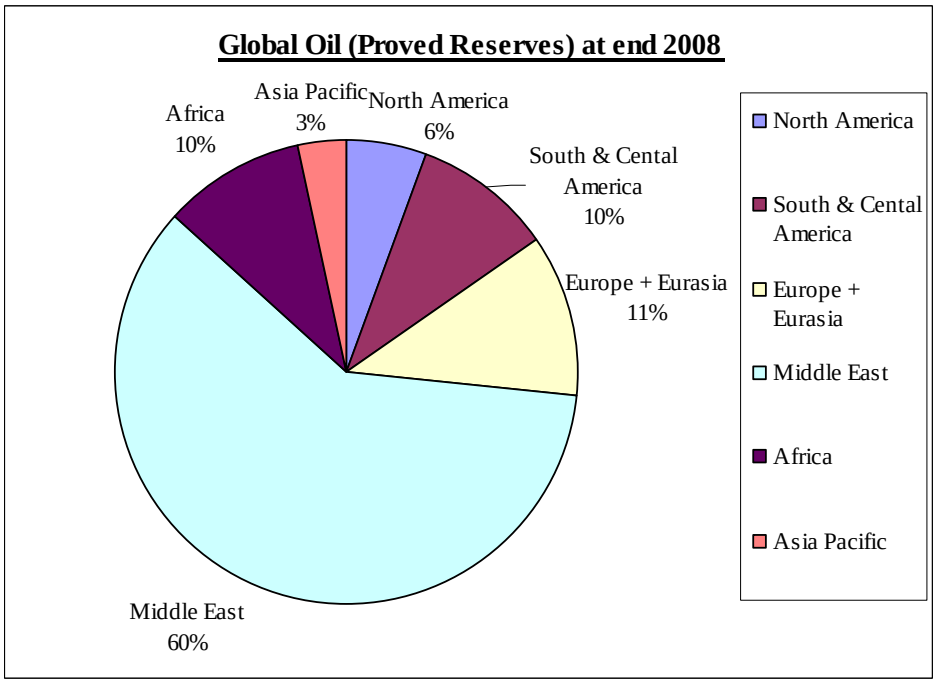
19. The significance of lithium stems largely from its applications in the important field of energy storage as well as the geographical spread of lithium reserves. Currently, 20% of global production is used in the manufacture of batteries and this is set to grow. Lithium ion batteries are the battery technology of choice for future models of electric vehicles as they have higher power-to-weight ratios than alternatives such as the nickel hydride batteries. Between 1997 and 2008, the global demand for lithium grew at 6.7% and is expected to accelerate rapidly in tandem with the demand for electric vehicles and energy storage options according to Sociedad Quimica y Minera de Chile SA, the world's largest supplier of lithium. In a recent communiqué on hybrid electric vehicles (HEVS),[8] the IEA declined to project the penetration of HEVs citing various reasons including the following: "Although most car manufacturers are planning to bring new hybrid models in the

coming years, it is expected that total hybrid car sales will be limited because of limited supply." The supply of batteries was cited specifically as a bottleneck and labelled a practical restriction on what is possible.

20. Chile has 22% of the global reserves and is currently the world's largest producer of lithium but it is Bolivia that is blessed with around 40% of the world's lithium reserves. The remaining 30-40% are spread across the US (2%), Argentina (15%), Brazil (7%), China (8%) and Australia (2%).[9] In other words, four countries in Latin America alone account for over 84% of the world's reserves of lithium, leading some to quip that lithium is the new "oil" in a Clean Tech world. Indeed, just as the internal combustion engine allowed the transference of strategic significance from coal to oil, hybrid and electric transportation may be the vehicles that allow for the transference of strategic importance associated with oil to lithium. For the sake of comparison, 60% of the world's oil reserves are concentrated in the Middle East.[10] In short, the unequal geographical distribution of resources that animated much of the global resource politics since the advent of the oil age is unlikely to decline with our entry into the age of clean and renewable energy. Instead, it is likely to intensify.




*Source: Clean Tech Investor Limited, Clean Tech Infocus: Battery Technology, July 2009.*




*Source: BP Statistical Review of World Energy, June 2009.*

**Climate Change Negotiations - A Chance to Change the Rules**

21. Later this year, over 170 countries will be brought to the negotiating table in Copenhagen to negotiate a revised global agreement for reducing greenhouse gas emissions. What is obvious is that even as countries negotiate to reduce the emissions of greenhouse gases, they are simultaneously seeking to position their own economies to profit from the emergent context thereafter. Climate change negotiations present countries with the chance to fundamentally alter the rules governing global commerce and global geo-politics.

22. Regardless of whether a carbon cap and trade system or a carbon tax regime emerges from global negotiations, what remains true is that countries and industries around the world will have to adjust and accept some form of carbon pricing. The relative competitiveness of countries and their products will be measured in terms of carbon efficiency in addition to cost efficiency. As a result, countries may have to deal with structural changes to their economies and re-allocate resources away from sunset industries in a carbon-constrained world. Nations must be prepared for changes in global commerce and trade patterns that result from decisions made during climate change negotiations. One possibility is that the world could be headed for a period of much greater intra-regional trade if carbon emissions from transportation and shipping raise the prices of globally-traded goods. In addition, details of how much the consumers and producers will have to pay for the carbon emissions incurred during the manufacture of tradable goods is unclear.

23. The climate change agreements are thus contentious because *realpolitik* suggests that some countries will lose out economically, politically and strategically as a result of the changes wrought by climate change agreements and by the conversion to Clean Tech systems. No country is certain how the mechanisms and agreements

resulting from climate change negotiations will eventually impact it. What is clear is that Clean Tech will play the pivotal role in writing the economic rulebook in tomorrow's carbon-constrained world since Clean Tech is at the core of the grand strategy being laid out by the economic and political powerhouses of the day.

**Singapore's Place in the Clean Tech Ballet**

24. How then should a country like Singapore which boasts neither rich endowments of strategic raw materials nor home-grown cutting edge clean technologies position itself for the Clean Tech world? While the measures below are not meant to be prescriptive, they do merit further consideration.

25. On the international front, Singapore will find itself on the side of other developed countries such as the EU members, the US and Japan that will be seeking to import strategic raw materials necessary for Clean Tech industries. In order to safeguard its interests and access to critical raw materials Singapore must lend its weight towards the promotion of global free trade and the minimisation of barriers to commerce and competition introduced by emerging neo-mercantilist industrial strategies. Singapore is presented with the difficult challenge of entering into competition with industrial giants for a piece of the Clean Tech pie. It faces questions on exactly which segment of the Clean Tech market it should target since Clean Tech industries are in various stages of commercial readiness and it is not clear what technologies will be the winners and losers in the Clean Tech world. Regardless of the technologies in play, the level of international competition that Singapore will face is certain to be high.

26. Singapore should seriously consider the possibilities posed by industries that play complementary roles to that of the Clean Tech industry. The recycling and

extraction of metals (mostly iron, copper and aluminium) from discarded end products has already proven to be a profitable business for some Singaporean-based small and medium-sized enterprises such as Union Steel. More support for research into how metals and other valuable commodities could be salvaged and extracted from Clean Tech products, such as electric vehicles and advanced batteries at the end of their life spans, may yield economic benefits to Singapore. To cite a model, 70% of Europe's photovoltavic (PV) manufacturers have already joined PV Cycle, a voluntary programme for PV manufacturers to conduct research into how to make recycling of solar modules a profitable and viable business venture.

27. The recycling of Clean Tech components should reveal itself to be another key to a more sustainable future. Regardless of which economic strategies are eventually adopted by countries big or small, powerful or otherwise, a timeless truth is that unless we learn how to conserve and recycle finite resources we will always be running out of one thing or another. In this regard, the age of Clean Tech will be no different from the age of hydrocarbons.

Sources

1 Global Wind Energy Council, *Global Wind Report*, 2008.
2 Statement by James Tuer, President, Hudson Resources Inc, "Minerals, Critical Minerals, 26 May 2009.
3 Statement by James Tuer, President, Hudson Resources Inc, "Minerals, Critical Minerals, and the U.S. Economy" (2008) by Board on Earth Sciences and Resources (BESR), 26 May 2009.
4 The Gold Report's Interview with Jack Lifton: The Age of Technology Metals, 1 June 2009.
7 Global Wind Report by the Global Wind Energy Council, 2008.
8 IEA Hybrid Electric Vehicle Outlook, March 2009.
9 Clean Tech Investor Limited, Clean Tech Infocus: Battery Technology, July 2009.
10 BP Statistical Review of World Energy, June 2009.

## About the Author

**HUM Wei Mei** is a senior analyst in the Energy Market Authority (EMA) where she conducts analysis of energy policy issues and manages EMA's suite of analytical tools. She is currently working on the development of an Electricity Generation Cost Simulation Model in collaboration with Sandia National Laboratories in the United States. The model is designed to provide an understanding of the policy implications of adopting various electricity generation technologies in Singapore.

Prior to joining EMA, Ms. Hum was a consultant to one of Malaysia's subscription satellite TV providers and to the Chinese operations of one of the world's largest breweries. Her area of specialization includes the design and application of quantitative methods to boost returns on marketing investment for private companies. She has also worked in International Enterprise, Singapore. Her international experience includes postings to China, the ASEAN countries and the United States. In 2004, she was a visiting scholar at the Federal Reserve Bank of Minneapolis.

Ms. Hum is an Adjunct Fellow at the Energy Studies Institute. She has a Master's Degree from Yale University and graduated with a BSc. in Economics (Summa Cum Laude) from the University of Minnesota where she was awarded the Stockman and Fable Prize in Economics.

The Energy Studies Institute welcomes questions, feedback and comments towards its research work produced in various forms. Readers may write to Ms May Koh at esikamm@nus.edu.sg to express their views; citing the reference number of the work. We welcome all inputs directed towards the refinement and enhancement of the institute's research work.



**Energy Studies Institute**
**National University of Singapore**
29 Heng Mui Keng Terrace, Block A #10-01
Singapore 119620
Tel: (65) 6516 2000 Fax: (65) 6775 1831 Http://www.esi.nus.edu.sg