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Moving up the Value Chain : A Study of Malaysia's Solar and Medical Device Industries

THE WORLD BANK

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Moving up the Value Chain: A Study of Malaysia's Solar and Medical Device Industries

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PREFACE

This report responds to a request by the Government of Malaysia to examine how Malaysia can move up the value chain in the solar and medical device industries. The study was conducted within the broader context of the knowledge partnership between the Government of Malaysia and the World Bank, which is centered on the policy challenge of transforming Malaysia into a high-income nation.

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The team is indebted to the Economic Planning Unit (which chaired the steering and technical committees of this project) as well as the Bank Negara Malaysia; the Department of Statistics; the Federation of Malaysian Manufacturers; the Malaysian Investment Development Authority; the Malaysian Productivity Corporation; the Ministry of Energy, Green Technology and Water; the Ministry of Finance; and the Ministry of International Trade and Industry for their guidance and support. The team wishes to express its gratitude to Ms. Liew Siew Lee, Dr. Fatimah Bt. Mohd Amin, Datin Noor Haliza Bt. Mohd Noor, Abd Rahim B. Abd Hamid and Harundin Al-Hafiz B. Mohamad Ali of the Economic Planning Unit for their leadership, advice and collaboration throughout this study.

As part of this project, the team made three study visits to Malaysia. In this connection, the team would like to thank representatives from the following companies, associations and institutions for their hospitality and insights: Alliance Contract Manufacturing; Ambu; Association of Malaysian Medical Industries; AUO-SunPower; B. Braun Medical Industries; Epsilon Medical Devices; First Solar Malaysia; Gading Kencana; Greatech Integration Malaysia; Johnson & Johnson Medical Malaysia; Hospitech Manufacturing Services; IBC Solar Teknik; ITL Asia Pacific; Isotron Malaysia; Kulim Hi-Tech Park; Q-Cells Malaysia; St. Jude Medical Operations Malaysia; SolarTif; Solar Valley; Symmetry Medical Malaysia; Malaysia Building Integrated Photovoltaic (MBIPV) Technology Application; Malaysia Medical Device Association; Malaysian Photovoltaic Industry Association; Teleflex Medical; Tenaga Nasional Berhad (TNB) Hybrid Power; Top Glove; TT Innovation Technologies; Vigilenz Medical Services; and the University of Malaya.

EXECUTIVE SUMMARY

Moving Up the Value Chain: Concepts and Considerations

Through the lens of long-term development, the overall growth performance of the Malaysian economy has been a resounding success story. The Commission on Growth and Development listed Malaysia as one of only 13 countries that registered sustained growth of 7 percent or more for a period of 25 years or longer. Much of this growth occurred on the back of a buoyant manufacturing sector, which was spurred by Malaysia's export-led industrialization model reliant on foreign direct investment (FDI). Multinational firms favored the country for its geographical location, political stability, reliable infrastructure, elastic supply of low-cost labor and attractive incentives. As a result of this success, Malaysia became the region's third-most open economy to trade, with the electrical and electronics (E&E) industry accounting at its peak for approximately half of all trade.

As Malaysia enters the next stage in its development to a high-income nation, the manufacturing sector will yet again need to play a prominent role in securing and enhancing the nation's prosperity. Doing so in today's world of heightened competition will require a change of emphasis: Malaysia's prospective comparative advantage in manufacturing will need to be increasingly redefined in terms of unique value rather than low cost. This will require Malaysian companies stepping to the fore through innovation and the building of a 'Made in Malaysia' brand. It will also require domestic companies to better link up with the well-established base of foreign multinational manufacturers, so as to extract greater value added from Malaysia's integration in cross-border production networking.

For Malaysia to fulfill its high-income aspiration, it will thus need to move up the value chain. Moving up the value chain concerns the process of shifting the productive activity of a nation, an industry or a firm into those goods and services that generate higher value added. Moving up the value chain is a highly complex undertaking: it requires a fundamental reorientation towards innovation as the fundamental driver of growth, supported by a healthy level of investment in human and physical capital. This process should not be confused with simply producing the same mix of products more efficiently and neither should it be construed as implying a shift in focus towards anything high-tech. Moving up the value chain entails new, more complex, and more skill-intensive activities in the manufacturing of products; it requires conducting these at world-class standards of quality, productivity and competitiveness; and, as long as higher value is created, it does not matter whether these final products are low-tech, medium-tech or high-tech.

Looking ahead, as such new industries as solar and medical devices gain prominence in the Malaysian economy and attract a new round of FDI, Malaysia can capitalize on its past successes and lessons of experience by devising new policies for moving up the value chain. The solar and medical device industries provide suitable case studies to study the policy adjustments that might be required to trigger such a process. While the two industries offer interesting similarities, they are at the same time markedly different: the solar industry is relatively new to Malaysia, is concentrated in a select few world-class multinational players and has experienced tremendous growth recently; the medical device industry (MDI) is more mature and also much more heterogeneous, including as well many home-grown local firms with varying degrees of internal capability and external competitiveness.

While many of the elements required to move up the value chain are already present in Malaysia, the challenge is to activate them. Some firms, particularly in the MDI, have made and are making considerable — and quite impressive — progress on their own. What is needed now is a catalyst to enable more widespread and more rapid progress and a facilitator to knit disparate efforts into a strategically coherent program. Government will have a key role to play in this process, but primarily as a convener, facilitator, and perhaps even as an initial small-scale funder. But it should not attempt to control and direct the process. This should be left to industry working groups.

For Malaysia, moving up the value chain in the solar and medical device industries, or in any other industry for that matter, will involve combining several related conceptual tasks into one coherent policy program that entails:

- Exploiting opportunities to develop upstream and downstream linkages between firms in the center of the cluster and firms producing ancillary goods and services. These ancillary goods and services could either be inputs that supply the main firms in the cluster or products that use the output of these main firms to design, market, and produce other goods and services;

- Helping firms move from lower-value added third- and second-tier positions in global supply chains to higher-value added second- and first-tier positions, where relationships are not commoditized and firms are integrated into the quality circle of the firm they supply to;

- Linking isolated firms into clusters, keeping in mind that clusters can be developed in unexpected ways combining seemingly disparate firms into a coherent, well-designed cluster. The government can catalyze cluster formation, but the cluster itself has to be private sector-led;

- Promoting supplier development programs that help firms develop the various types of skills — management, technology acquisition, quality control, strategic planning, etc — to support their move from lower to higher positions in the supply chain;

- Creating a web-based resource to identify and disseminate what firms exist in the region and, most importantly, what their specific capabilities are for producing ancillary goods and services; and

- Fostering the establishment of private sector-led institutions that can help identify technology acquisition opportunities, marketing opportunities, and employee training opportunities.

In what follows, the summary findings of the sectoral analyses are presented, where the cross-cutting recommendations mentioned above will serve as a background. Given the differences across industries and between firms and groups of firms within industries, it is important to recognize that there is no cookbook approach to moving up the value chain. The identification of policy interventions must be based on a detailed understanding of the global industry context, the specific opportunities within the industry, and the specific bottlenecks that may be holding back the process of value creation.

Malaysia's Solar Industry: Findings and Recommendations

The global photovoltaic (PV) industry continues to rapidly evolve and expand around the world. It is widely expected that PVs will be a dominant part of new energy assets deployed in the coming years, and producers around the world are fiercely competing to be the winners in supplying those systems. This fierce competition has led to a relatively steady decline in prices in the PV industry. In spite of this, annual growth rates over the last decade in installed system volume around the world of nearly 50 percent and a global turnover last year of nearly USD75 billion continue to make this a large and highly attractive market.

China and Taiwan (POC) have established low-cost leadership positions in the manufacture of modules and components using the first generation of crystalline silicon-based products, choosing to focus on scale of manufacturing and process innovation versus a strategy of attracting the most innovative products. Malaysia has chosen a different course, having already partnered with a few of the most advanced firms in the world — establishing three gigawatt-scale plants based on crystalline and thin-film technologies in the last couple of years. Malaysia has made substantial progress in claiming global market share for wafer, cell, and module production and is on its way to supply 10 percent of these components globally.

More will be required, however, if Malaysia is going to keep growing its presence in the PV value chain. As the global supply chain consolidates and margins continue to be under pressure, the number of likely winners that will be seeking to establish gigawatt-scale manufacturing plants outside of China and Taiwan (POC) will be limited, and those that are willing to come to Malaysia will be fiercely pressured to keep costs down. Choosing the right manufacturers to back and ensuring that Malaysia remains economically competitive for those manufacturers in the global marketplace will be important to the future success of Malaysia's solar industry.

In addition to capitalizing on future market growth by attracting additional multinational corporations (MNCs) to set up or expand existing operations, Malaysia could expand its focus to include higher value added operations in support of component manufacturing. Two possible pathways exist. The first is to encourage the pre-production areas of development or design or to boost downstream operations in distribution, marketing or sales. However, in the case of Malaysia, foreign PV manufacturers have come in with both pre-production and downstream operations handled in-house, leaving little room for appropriating additional value added. The second pathway is to raise value added through feedstock substitution of imported glass and raw polysilicon, which would also make Malaysia more attractive as a place to establish and retain manufacturing facilities for MNCs. Manufacturers also have requirements for additional consumables and capital equipment to support the manufacturing lines — and these are needs that could be increasingly met by local companies. Using locally manufactured inputs for those production processes should simultaneously allow for meeting cost targets and increasing the capture of value added within Malaysia.

Perhaps the greatest opportunity to extract greater value added lies in downstream applications to install and use solar energy. The value added created in the installation of PV systems far exceeds that in intermediate steps of module manufacturing. This value added is also fundamentally non-exportable as these processes must be performed at or near the site where the system is installed. To activate this potential and starting from the base of Malaysia's aggressive new Feed-in Tariff (FIT) program, Malaysia needs to establish a strong local industry for the use and production of PV systems and electricity that they generate. Malaysia has a history of support for small-scale and off-grid applications of PV, but installed capacity remains low compared to regional peers. For Malaysia, achieving grid parity over the next decade will establish PV as both a low-cost and renewable energy source, while providing a hedge against future price changes for traditional sources of energy.

Malaysia is in a very strong position in the PV industry due to the work that has been done to date to establish local plants by innovative global PV manufacturers. Maintaining that position and extracting further value added will require continued focus on expanding upstream opportunities and expanding downstream deployment. To expand upstream opportunities and downstream deployment, the following issues will need to be considered.

- *Upstream opportunities.* First, caution will need to be exercised when encouraging collaboration or shared services as the emerging global leaders in PV manufacturing remain concerned about protecting their intellectual property rights (IPRs) and maintaining a competitive advantage for as long as possible. Second, despite Malaysia's strong presence in the global PV industry, the industry is relatively new to its domestic manufacturers who might be well-placed to provide local content. Ensuring that local producers are engaged in dialogue with PV manufacturers, establishing training programs, and helping to provide finance for necessary capital equipment will facilitate this process. Third, the single largest consumable cost of a module plant is glass, but as there is no domestic glass manufacturing meeting PV requirements, this needs to be imported;

- *Downstream deployment.* First, while the notion that solar energy is too expensive for domestic use appears to persist, international experience suggests that investment in the local marketplace and a pool of integrators and installers can result in the economies of scale necessary to make solar cheaper to install and use. Second, the vast majority of expenses of PV electricity is paid upfront at the time of installation, creating a large capital requirement and also a need to familiarize banks with the PV market so that they can become enthusiastic suppliers of capital. Third, government procurement can help stimulate the delivery and integration businesses and jumpstart the development of skills and capabilities in the local market. A quick-win would be to mandate that all new buildings include solar generation. Fourth, training programs could be instituted now so that skill shortages will not constrain deployment when demand picks up. Fifth, once solutions have been developed for domestic use, these could be packaged and exported to various countries as export products in the form of kits and integrated services; and

- *Synergizing the up- and downstream.* With Malaysia producing some of the cheapest PV modules in the world, aggressive steps should be undertaken to synergize the upstream and the downstream. This would involve requiring advantaged pricing for modules that are produced in Malaysia and, rather than exported, are used in the domestic market. This could be achieved in a number of ways including bulk purchasing, negotiating an option agreement for local consumption, or making sure that any future value in trade from the Malaysian government allows for some small percent (starting at less than 1 percent) of modules produced in the factory be made available at a favorable price. Alternatively, a domestic content preference in downstream support programs or procurement efforts could be created.

Malaysia's Medical Device Industry: Findings and Recommendations

The medical devices industry in Malaysia is a vibrant conglomeration of several industries that may be grouped in three general categories: rubber and latex products, general manufacturing of medical devices, and foreign MNCs producing mostly export-oriented equipment. In differing ways, Malaysian medical devices companies are poised both to grow rapidly and improve their position in the value chain. Margins in the industry are already reasonably robust but can and will be improved by focusing more on basic research and brand commercialization.

As to the first group of medical device companies, Malaysia is a dominant player worldwide in the rubber products industry and some of its companies are 'top of the line' multinationals. They nevertheless could, and undoubtedly will, improve their position in the value chain if they make further efforts to: develop a 'Malaysian brand' for some of their products; and expand research and development (R&D) programs so as to create new state-of-the-art products, such as new generations of specialized latex and rubber gloves and the creation of disposable, ready-for-use plastic products kits for hospitals and operating rooms.

The second group of medical device companies in Malaysia needs the most assistance in order to continue its growth and movement up the value chain through greater R&D and branding. These are companies that produce the most domestic value added, whether in the orthopedic field or in the creation of machinery to manufacture medical devices or the development of diagnostic kits and surgical instruments. Further development of this group of companies will not only benefit the MDI, but also help create skill-intensive, high-value added manufacturing clusters in the country.

To help these companies develop further, improvements to the enabling environment would be welcome. Taxation and regulation could be streamlined further. Further efforts could be made to ensure the smooth flow of financing to companies in both the start-up and growth phases. Quality assurance standards can be strengthened to protect Malaysia's international reputation as a medical device manufacturer and enhance the 'Made in Malaysia' brand name. Procurement programs could play an important role in developing the sector further. Facilitating local manufacturers' access to the domestic market is often a precursor to being able to access even nearby international markets.

Such companies would also benefit significantly from efforts to strengthen the supply and quality of human capital. In this respect, additional focused training courses at the technical, vocational, and university level, provided by industry-led skill development centers, would be welcome to prepare Malaysian workers to handle increasingly sophisticated, high-value manufacturing, design, engineering and quality control tasks. Assistance could also be provided in the hiring of engineers and scientists as well as their training and retraining so as to strengthen the domestic R&D base.

In addition, the passage of enabling regulation in the sector and facilitation for export is as relevant for these firms as in the case of MNCs operating in Malaysia. There is little doubt that if these companies are helped to grow, perform more R&D and develop local products and a Malaysian brand, the future of the medical devices industry in Malaysia will be assured.

Foreign MNCs — the third group of medical device companies — have shown their preference for operating in Malaysia in many cases because of the infrastructure present and the enabling factors existing in the country. They are an important group of players not only because they provide employment and produce export products of high technological complexity, but also — and just as importantly — because they provide a sort of 'training arena' for Malaysian entrepreneurs. Several such entrepreneurs have left their multinational employers (in both the medical device and electronics industries) and started their own businesses. It is encouraging to note that these spin-offs have occurred in innovative and high-growth subsectors that produce increasingly complex medical devices as well as machinery used in the manufacture of medical devices more generally.

Malaysia should continue to attract MNCs by providing them with an enabling supporting infrastructure and environment suitable to manufacturing and assembling increasingly technologically advanced products. At the same time, MNCs should also be encouraged to increase their R&D capabilities 'in-country' so that greater value added can be extracted domestically. To make this happen, it will be essential that Malaysia ensures that its technical, vocational, and university graduates are trained in subjects immediately relevant to the industry, that the Medical Devices Act is approved as quickly as possible to further enable the Malaysian business environment, and that investment in businesses ancillary to the production of complex products is facilitated.

INTRODUCTION

Through the lens of long-term development, the growth performance of the Malaysian economy over the past four decades has been a success story. The Commission on Growth and Development listed Malaysia as one of only 13 countries that registered sustained growth of more than 7 percent per year for 25 years or longer.[1] This was accompanied by significant structural change as the economy evolved from one dependent on the production of mostly unprocessed mineral and agricultural export commodities — palm oil, natural rubber, tropical timber and tin — into one dominated by manufacturing and services.

This growth performance was particularly evident in the manufacturing sector, which was spurred by an export-led industrialization model reliant on foreign direct investment (FDI). Malaysia managed to attract large investment inflows from multinational corporations (MNCs), which favored the country for its geographical location, political stability, reliable infrastructure, elastic supply of low-cost labor, and attractive tax and non-tax incentives. The manufacturing sector witnessed a tremendous expansion, reaching a peak contribution of some 31 percent of economy-wide value added before the recent global financial crisis. Malaysia also became third-most open economy in Asia to trade, with the trade in goods representing some 186 percent of gross domestic product (GDP) and the electrical and electronics (E&E) manufacturing subsector accounting for approximately half of all this trade.

These trends have however produced mixed results:

- On the one hand, as the Growth Commission noted, between 1967 and 1997, per capita income rose from USD790 to USD4,400 (as measured in constant 2005 dollars) and aggregate poverty levels declined commensurately. In addition, foreign investors brought the latest manufacturing technology to Malaysia and, as a result, the technological sophistication of factories located in Malaysia as well as the products manufactured and exported increased substantially. Foreign investors in Malaysia were no longer producing and exporting simple products like plastic toys and unprocessed raw materials. Instead, they were producing and exporting hard disk drives, modems, and other sophisticated electronic equipment; and

- On the other hand, despite Malaysia's success in expanding the scale of the manufacturing sector and the advances in the technological complexity of both inputs and outputs, manufacturing operations remained primarily concerned with assembly-based manufacturing where the skill intensity of operations and processes is relatively limited.[2] Relatedly, indigenous firms have shown limited integration into cross-border production networking and relatively few firms have successfully transformed themselves into self-standing brands with global or regional reach. In other words, they have had only limited success in moving up the value chain.

[1] Commission on Growth and Development (2008). *The Growth Report: Strategies for Sustained Growth and Inclusive Development.* Washington, D.C.: The World Bank. Available at: www.growthcommission.org.

[2] For more information, see World Bank (2010). *Malaysia Economic Monitor — Growth through Innovation*. Washington, D.C.: The World Bank.

Looking ahead, as such new industries as solar and medical devices gain prominence in the Malaysian economy and attract a new round of FDI, Malaysia can capitalize on its past successes and lessons of experience by devising new policies for moving up the value chain. For example, there is a growing recognition that despite Malaysia's solid manufacturing performance, Malaysia has been less than successful in translating the growth of its manufacturing sector into domestic value added. Tapping into this unrealized potential is however easier said than done — especially given that today's environment is fundamentally different than a decade or two ago. With the emergence of economic powerhouses in the region, the competition for talent, trade and FDI is now much more intense than before. Countries around the region are also updating their policy frameworks so as to enhance their own level of external competitiveness. Against the backdrop of a more competitive regional environment, fundamental policy changes will therefore be required for Malaysia to fully reap the opportunities available in the solar and medical device industries.

How can Malaysia extract greater value added from its manufacturing sector? This is the fundamental question that this study attempts to address in response to a request from the Government of Malaysia. In doing so, this study focused on two specific industries: the solar industry and the medical device industry (MDI). For each of these industries, the study addresses two sets of questions: First, what is Malaysia's current position in the global value chain, what are the opportunities available to extract greater value added and what are the main challenges? Second, for Malaysia to exploit the opportunities and overcome the challenges identified, what policy adjustments, if any, will be required?

This study is as much a process as a product. This report is the outcome of the study. The report sets out a conceptual framework, examines the global industry context, analyzes Malaysia's position in the global value chain, identifies industry opportunities and bottlenecks, and suggests policy adjustments. This study is however more than just a report. The study is also accompanied by a process of capacity building to train policymakers and industry participants in global value chain analysis, so that this work can be updated, extended, and replicated to other industries. The study also constitutes an attempt to promote a novel way of thinking about identifying and seizing value chain opportunities in ways that emphasize bottom-up, decentralized, collaborative and consultative approaches.

What motivates the choice of the solar and medical device industries? The two industries provide interesting case studies in the following two respects:

- The two industries offer interesting similarities: they are both to a certain extent offshoots from Malaysia's established capabilities in the semi-conductor industry; they have both benefited from significant inflows of FDI; and, as will be argued in this report, they both offer significant opportunities for further development. These similarities are useful in highlighting future industrial development opportunities in the product and process space, where Malaysia's current capabilities are taken as the initial point of reference; and

- The two industries are also very different. The solar industry is relatively new and concentrated in a few multinational players; it has also grown extremely rapidly in recent years, with Malaysia now among world's top manufacturers of solar panels. The MDI is a more mature and less homogenous industry than the solar industry; it is supported by a larger participation of home-grown local firms with varying degrees of technological sophistication, internal capability and external competitiveness. The differences between the two industries are useful to contrast how policy adjustments will need to be tailored to specific opportunities and challenges in individual industries.

How does this study relate to Malaysia's broader structural reform agenda? First and foremost, the study touches upon the core of Malaysia's ambition to become a high-income economy by the year 2020. Moving up the value chain lies at the heart of the productivity agenda articulated in Malaysia's Economic Transformation Program (ETP). In this respect the study builds on the two constituent components of the ETP: the cross-cutting recommendations under the New Economic Model (NEM) and the sector-specific recommendations made under the National Key Economic Areas (NKEAs). It also builds on earlier policy frameworks such as the Third Industrial Master Plan (IMP3). It should therefore come as no surprise that several of the recommendations presented in this study are in sync with existing frameworks and new initiatives, as there is no need to reinvent the wheel where the current set of policies are conceptually adequate. In such cases, the study serves to underline the importance of these frameworks and initiatives and the need to implement them whole-heartedly. In addition, however, the study also proposes a reorientation of approach in several dimensions. These novelties constitute the essence of the report and will be elaborated in what follows.

The remainder of this report is structured in three distinct parts. The first part sets the stage for the sectoral analysis: it introduces the concept of moving up the value chain, it motivates why this matters and especially why this matters at the current juncture, and it provides general approaches that can be considered in identifying opportunities and analyzing bottlenecks to realizing these opportunities. The second and third parts provide the sectoral analysis — first the solar industry and then the MDI. The sectoral analysis will apply the concepts introduced earlier to the two industries, analyze Malaysia's current position of the two industries in the global value chain, highlight opportunities, identify challenges and, where warranted, provide recommendations for policy adjustment.

MOVING UP THE VALUE CHAIN: CONCEPTUAL DISCUSSION

What is meant by 'moving up the value chain'? What does it mean and, perhaps equally importantly, what does it not mean? Why should Malaysia be concerned with moving up the value chain? Why does it matter especially at the current juncture? What are the key policies that could be implemented to facilitate the process of moving up the value chain? These are some of the questions that will be addressed in this section.

What It Is and What It Is Not

Moving up the value chain concerns the process of shifting productive activity of a nation, an industry or a firm towards the production of goods and services that generate higher value added. While at the surface this might come across as a fairly straight-forward process, moving up the value chain is an inherently complex undertaking. It requires a fundamental shift in the sources of growth and competitiveness. To move up the value chain, competitiveness can no longer be measured merely in terms of the volume of goods and services that can be produced at the lowest possible cost. Instead, it needs to be measured by the amount of domestic value added that can be generated by globally competitive firms operating in Malaysia. This in turn necessitates a reorientation towards innovation as the fundamental driver of growth, supported by a healthy level of quality investment in human and physical capital.

Moving up the value chain should not be confused with merely producing the same mix of goods and services in more efficient ways. To see why this is not necessarily the case, it is useful to provide the example of Malaysia's solar industry. The solar panel producers currently operating in Malaysia all employing world class, automated assembly operations. The workers in these factories are probably as efficient and productive as the workers in any solar panel factory in the world. But if most of the workers in those factories are merely tending imported automated machines and generating little value added during the production process, their world class efficiency, measured in terms of the hourly (or weekly, monthly, or annual) value or volume of photovoltaic (PV) cells or panels produced per worker, will not move Malaysia towards high-income status.

Along a similar vein, moving up the value chain should not be confused with shifting the composition of output from low-tech to high-tech goods and services. How much value added a country generates is much more important than whether the final product is classified as low-tech, medium-tech, or high-tech.[3] If value added is high, even resource-based exports can translate into higher profits, better-paid jobs, and higher standards of living. But if the value added is low, even a high percentage of high tech exports need not provide a sufficiently large boost to per capita income.[4] As the chart below illustrates, Argentina,

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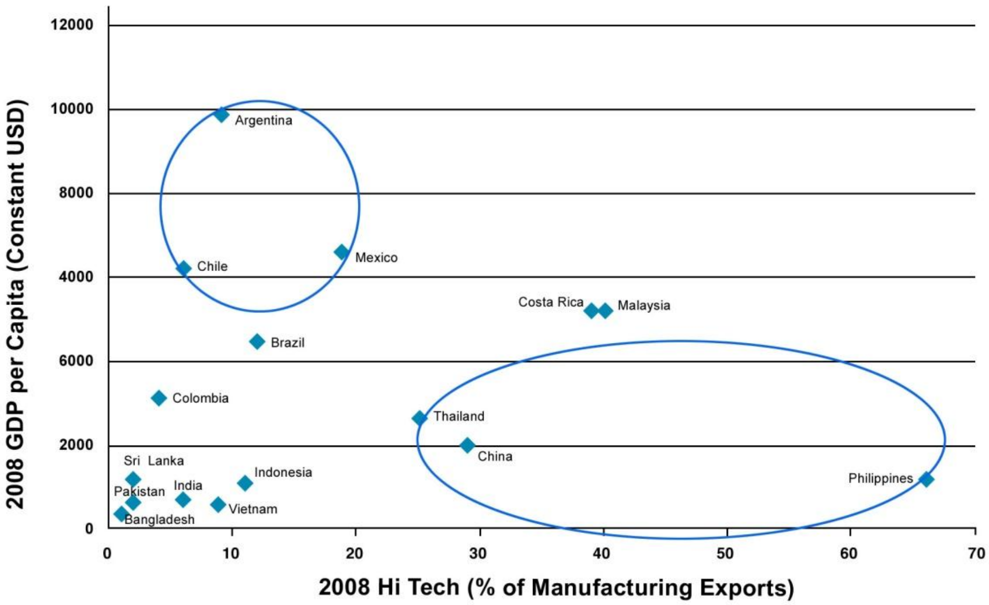
[3] For detailed discussions of these issues, see De Ferranti and others (2002). *From Natural Resources to the Knowledge Economy*. Washington, D.C.: The World Bank, and also Lederman and Maloney (2007). *Natural Resources: Neither Curse Nor Destiny*. Palo Alto: Stanford University Press.

[4] The case of the iPhone is instructive. Virtually all iPhones sold in the US are assembled in China from components imported from a diverse group of countries. The manufactured price of an iPhone shipped from China is just under USD200. But the value added in China by low wage assembly workers is only USD6.50. All of the remaining value is generated by firms and workers located elsewhere. In other words, even though iPhones are labeled as 'Made in China' most of the value added does not have a Chinese origin. For a more detailed discussion of the

High-tech Does Not Always Equal High-income



Source: World Bank Development Data Platform, World Development Indicators (2010).

Mexico, Chile and Brazil have all much higher per capita income levels than several Asian countries with much higher levels of high-tech exports (measured as a percent of total manufactured exports). These countries also generate much higher value added per worker in agriculture, industry, and services, which is the key to their relative success.

The assertion that high-tech need not correlate with high income epitomizes Malaysia's dilemma. As the following chart indicates, Malaysia has a higher share of high-tech exports than the United States, Singapore, South Korea, and Finland. Yet Malaysia's per capita income level is significantly lower. The reason is that Malaysia historically specialized in low-wage, low-value added assembly operations whereas Singapore, the United States, South Korea, and Finland specialized in higher-value added, knowledge-intensive design, engineering, branding, and marketing functions. The critical task for Malaysia is therefore not necessarily to switch the sectoral composition of what it does but rather to extract greater value from whatever it does — in other words, what matters most for moving up the value chain is not whether the final product is labelled high tech, low tech, or natural resources, but the amount of value added generated in Malaysia.

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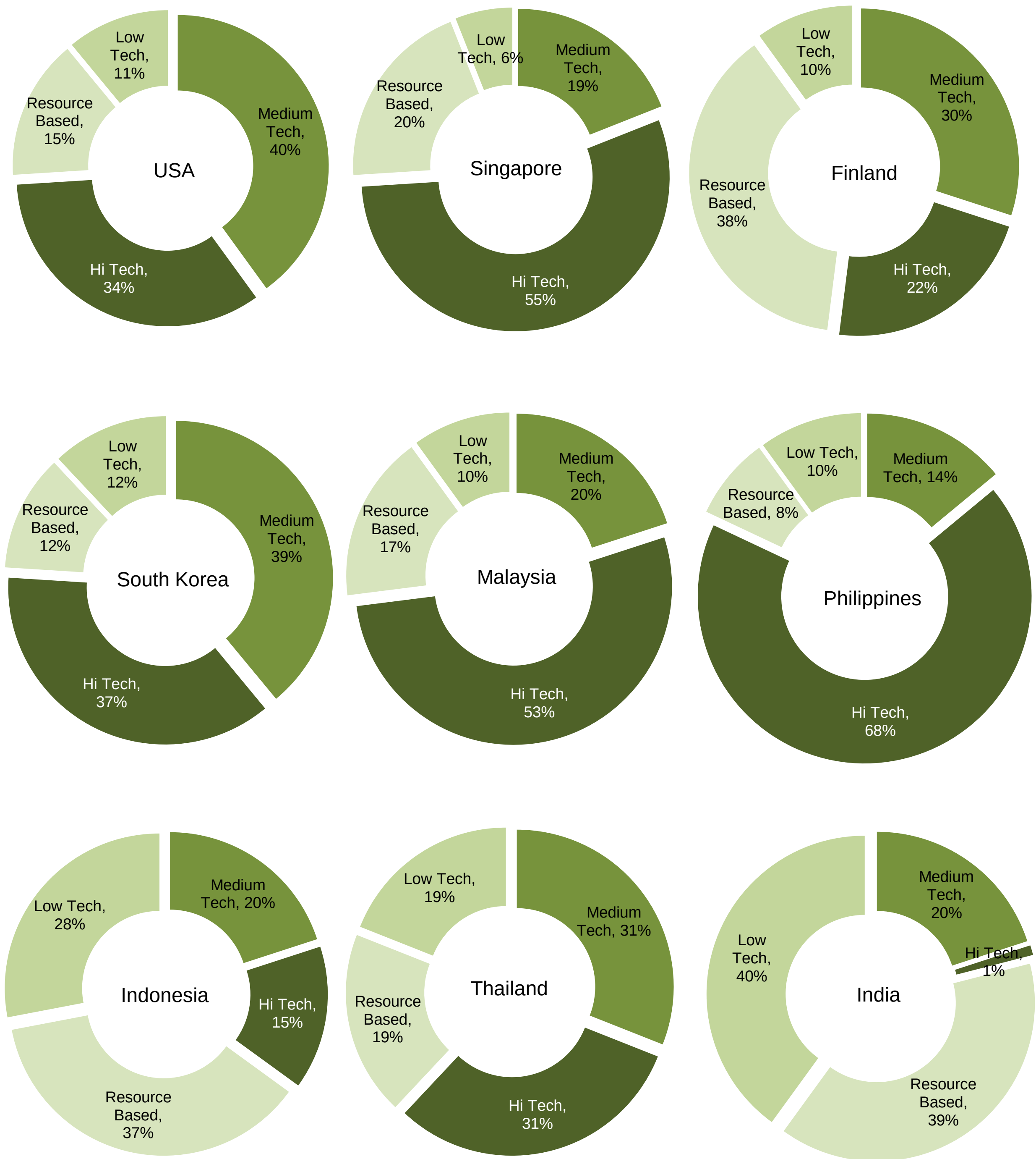
value added associated with iPhones, see Xing and Detert (2010). *How the iPhone Widens the United States Trade Deficit with the People's Republic of China.* ADBI Working Paper 257. Tokyo: Asian Development Bank Institute. Available at: http://www.adbi.org/working-paper/2010/12/14/4236.iphone.widens.us.trade.deficit.prc/.

The Technology-Intensity of Exports Varies Widely Across Countries

Type of exports, SITC-2, 2004, based on COMTRADE



Source: World Bank Development Data Platform.

Why Moving Up the Value Chain Matters

Malaysia has booked significant success already in moving up the value chain as it diversified its economy and expanded into upper-middle income status. The Commission on Growth and Development listed Malaysia among a group of 13 countries which have achieved a sustained period of rapid growth (defined as 7 percent or greater for more than 25 years) and rising per capita income (Table). In almost every one of these countries, a dramatic shift occurred in the composition of production and exports. The goods and services that dominated their export basket at the beginning of their growth spurt were simpler, lower-value added products. By the end of their growth spurt they were exporting more complex, higher-value added goods and services. In other words, these countries did not generate sustained growth by producing ever increasing quantities of the same goods and services but by moving up the value chain.

Countries That Experienced Record Growth

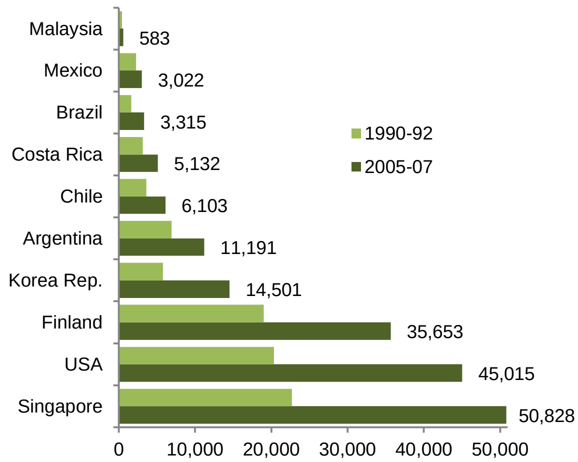
Economy	Period of high growth	Per capita income at the beginning and 2005	
Botswana	1960-2005	210	3,800
Brazil	1950-1980	960	4,000
China	1961-2005	105	1,400
Hong Kong SAR, China	1960-1997	3,100	2,990
Indonesia	1966-1997	200	900
Japan	1950-1983	3,500	39,600
Korea Rep.	1960-2001	1,100	13,200
Malaysia	1967-1997	790	4,400
Malta	1963-1994	1,100	9,600
Oman	1960-1999	950	9,000
Singapore	1967-2002	2,200	25,400
Taiwan (POC)	1965-2002	1,500	16,400
Thailand	1960-1997	330	2,400

Source: World Development Indicators.

These successes notwithstanding, there is still a large unrealized potential that Malaysia could tap into. As the charts below suggest, higher-income countries generate much more domestic value added per worker in agriculture, industry, and services than either middle- or low-income countries. This is not a spurious correlation, but a direct cause and effect between greater value added per worker and higher per capita incomes. As the right-hand panels in the charts suggest, Malaysia's value added performance compares favorably with other Southeast Asian nations and some of the Latin American counterparts. Unsurprisingly, however, value added in Malaysia still remains well below levels observed in higher-income economies, such as the United States, Singapore, Finland and Korea as well as most Organization for Economic Co-operation and Development (OECD) countries.

Agricultural labor productivity is low given its Malaysia's income level…

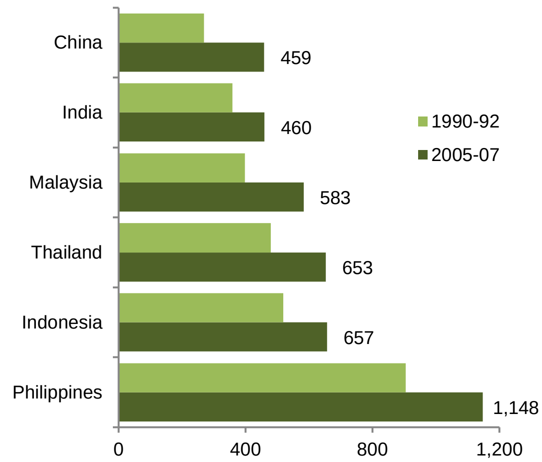
Agricultural Value Added Per Worker in 2008 (USD 2000 Prices)



Note: The numbers show values in 2005-07.
Source: World Development Indicators.

… and is comparable to labor productivity of lower-income countries in the region

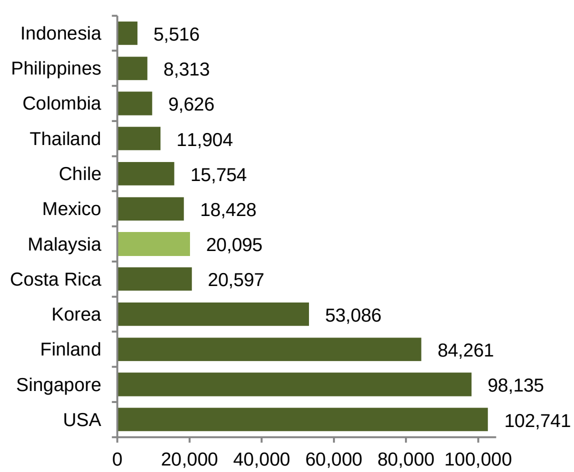
Agricultural Value Added Per Worker in 2008 (USD 2000 Prices)



Note: The numbers show values in 2005-07.
Source: World Development Indicators.

Labor productivity in manufacturing suggests significant upside potential …

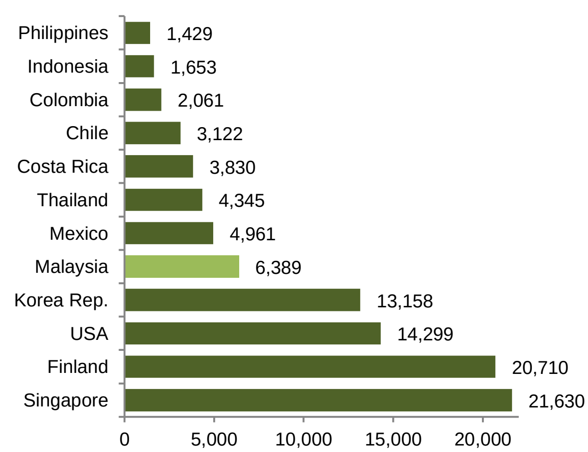
Manufacturing Value Added Per Worker in 2008 (USD 2000 Prices)



Note: Data on total employment by economic activity from ILO are unavailable for India, China, Argentina and Brazil.
Source: World Development Indicators and World Bank staff calculations.

…and so does labor productivity in services

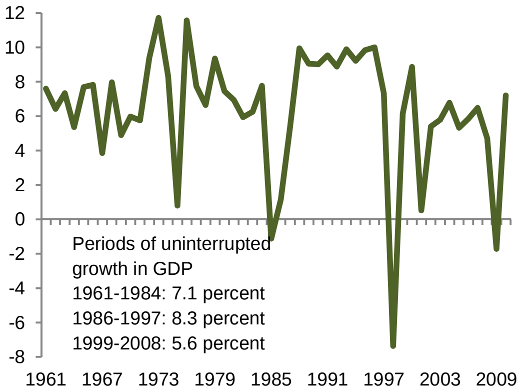
Services Value Added Per Worker in 2008 (USD 2000 Prices)



Note: Data on total employment by economic activity from ILO are unavailable for India, China, Argentina and Brazil.
Source: World Development Indicators and World Bank staff calculations.

Malaysia's historical growth is high but trended down after the 1997-98 East Asian crisis

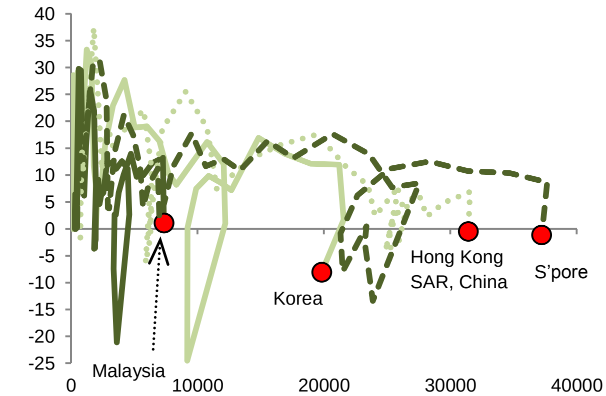
Real Gross Domestic Product (GDP) Growth, Percent



Source: WDI and World Bank staff calculations.

The Malaysian economy appears stuck in a middle-income trap

GNI Per Capita Level for the Horizontal Axis, and Annual GNI Per Capita Growth for the Vertical Axis, 1962-2009



Source: WDI and World Bank staff calculations.

Moving up the value chain is central to Malaysia's aspiration of joining the league of high-income economies. Malaysia seems stuck in a middle-income trap, the predicament that prevents middle-income countries from fulfilling the next step in their development path towards high income (charts above). This has manifested itself in the growing inability to remain competitive as a high-volume, low-cost producer coupled with the difficulty to break into fast-growing markets for knowledge- and innovation-based products and services.[5] The implication is that, despite past growth successes, living standards as measured by per capita gross national income could have been significantly higher. In this respect, the comparison with South Korea is instructive: whereas four decades ago South Korea was markedly poorer than Malaysia, South Korea's per capita income is now three times higher than Malaysia's.[6]

A number of internal and external factors add urgency to the need for Malaysia to move up the value chain and hereby protect and enhance its level of external competitiveness. The key internal factor concerns the observation that, following the Asian financial crisis, the underlying dynamism of Malaysia's economy appears to have weakened. This is reflected in measures of total factor productivity (TFP) which slowed significantly, as well as in a broad set of innovation indicators (chart below, left).[7]

Among the external factors, the emergence of China and India on the global stage has increased the competitive threat — even though counterbalancing this are the opportunities arising from intra-regional

[5] World Bank (2010). *Malaysia Economic Monitor — Growth through Innovation*. Washington, D.C.: The World Bank.

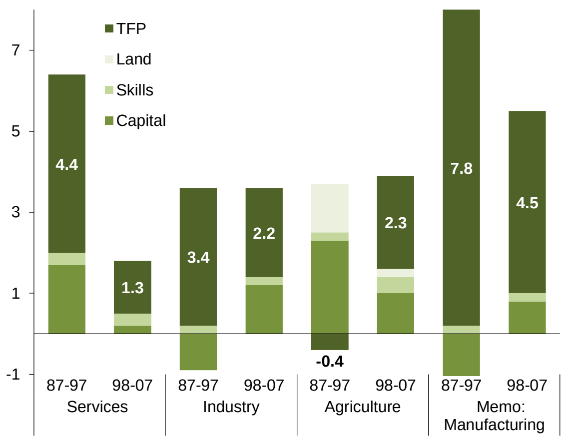
[6] Economic Planning Unit (2010). *The Tenth Malaysia Plan.*

[7] Productivity developments calculated based on: World Bank (2007). *Measuring the Contribution to GDP and Productivity of the Malaysian Services Sector*. A project in collaboration with the EPU. For a comprehensive review of innovation indicators such as R&D spending, patenting, scholarly output, etc, see World Bank (2010). *Opus Citatum.* Washington, D.C.: The World Bank.

trade creation. As the global rebalancing process continues to unfold, export demand from advanced economies may also be less buoyant going forward, creating additional export competition (chart below, right). Further, competition for FDI is intensifying, especially as the geographical center of gravity is increasingly shifting to China. As labor markets become more globalized in tandem with stronger demand for skilled labor, the cross-border competition for talent is also increasing.

Productivity gains slowed after the Asia crisis

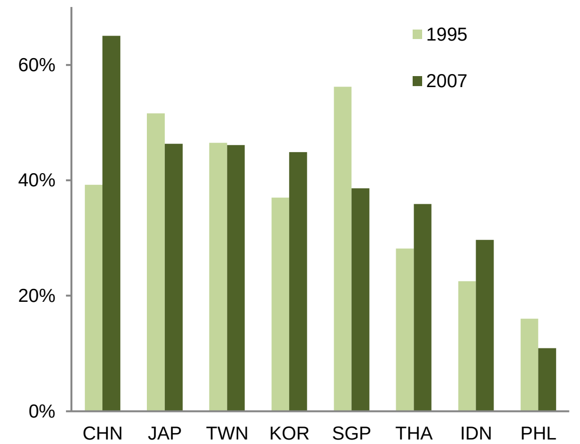
Contributions to Labor Productivity Growth of Total Factor Productivity (TFP), Land, Skills and Capital, Percentage Points



Source: World Bank (2008). *Measuring the Contribution to GDP and Productivity of the Malaysian Services Sector.* Washington, D.C.: The World Bank.

Competition for trade has intensified, particularly with respect to China

Overlapping Trade Value Share between Malaysia and Selected Countries, Percent



Source: UN Comtrade; Yusuf and Nabeshima (2009). *Tiger Economies under Threat. A Comparative Analysis of Malaysia' Industrial Prospects and Policy Options.* Washington, D.C.: The World Bank.
Note: PHL data is for 1996; TWN data is for 1997.

All of the above — the competition for trade, FDI and talent — mean that the challenge of moving up the value chain will need to be met in an environment that is more competitive than it was a decade or two ago, which adds urgency to develop coherent and deliberate tactics and strategies for moving up the value chain. More than ever before, success will be conditional on making progress relative to a rapidly moving frontier, as heightened competition in today's global marketplace is triggering powerful incentives for countries around the world to innovate and reform.

How Moving Up the Value Chain Can Be Facilitated

How can Malaysia move up the value chain? Moving up the value chain entails doing new, more complex things and doing them at world class standards of quality, productivity, and competitiveness. This shift in focus entails a change in philosophy, policy, tradition, and customs. For example:

- Instead of relying on foreign investors to import mass production manufacturing technology and to integrate the country into the global economy, a country moving up the value chain will need to focus on enhancing the technological and organizational capacity of local firms so that they themselves have the capacity to design, produce and market more knowledge intensive, higher value added products;

- Policy will have to focus on developing local capabilities and entrepreneurship and helping these local firms insert themselves into global value chains, which may entail attracting venture capital (VC), entrepreneurial mentors, quality control experts, and technology acquisition capacity rather than foreign investors looking to establish low-cost assembly operations;

- Moving up the value chain entails consulting extensively with stakeholders and establishing business-science-university-government councils to ensure that education and research programs are geared towards the needs of these emerging sectors; and

- Moving up the value chain also entails giving research institutes and universities the autonomy they need to react quickly and flexibly to changing needs and demand.

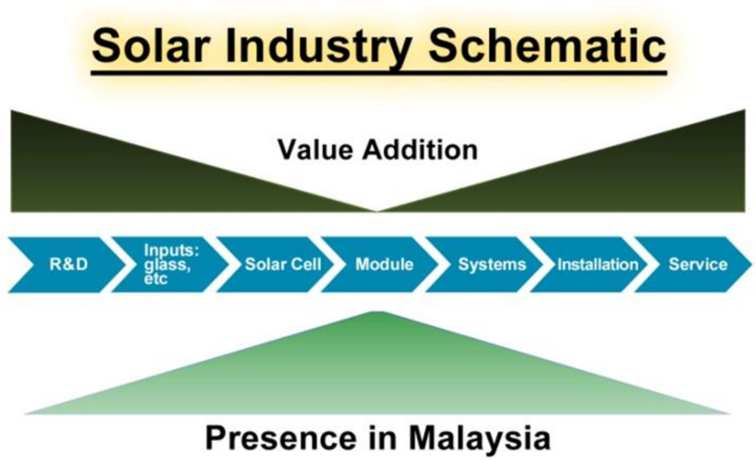
All of these shifts in mindset and innovation processes are much more challenging, but no less important, than providing tax incentives and an acceptable business climate for foreign investors.

There are three complementary routes to move up the value chain. Successful countries do not choose between them. Rather, they pursue all three options simultaneously. In what follows, we will consider the three routes consecutively and highlight why these are relevant for Malaysia's solar and medical device industries.

Developing Upstream and Downstream Capacity

One route for moving up the value chain is to develop domestic capacity in high-value added segments of the global value chain. In the case of Malaysia, this would entail developing both upstream and, especially, downstream capacity.

This is particularly relevant for the solar industry where it would entail moving upstream into glass production and perhaps selected research and development (R&D) niches and downstream from solar cells to modules, systems, installation, and service. As the diagram below illustrates, most firms operating in the Malaysian solar industry are involved in the production of solar cells. Unfortunately, this is also the segment that generates the least value added in Malaysia.



For example, as the solar chapter of this report explains in more detail, a solar cell that sold for USD1.50 per watt in 2009 would be worth USD2.50 per watt when it is installed in a solar module and close to USD5.50 per watt when it is installed at the generating site. In other words, there is nearly USD4.00 of additional value added between production of the solar cell and its installation at the final generating site. To date, only a small fraction of this downstream value added is currently captured by Malaysia and very few of these skill-intensive jobs are performed by Malaysian workers in Malaysia. However, if Malaysian firms can be induced to move downstream from cell production to module production and installation, Malaysia can begin to capture this additional value added.

In the absence of a domestic market for modules and installation, it will be difficult for Malaysian firms to gain a foothold in these market niches. Not only will they lose the domestic market, but they are likely to lose the chance to gain a foothold in the much larger and rapidly growing Southeast Asian solar energy market, where Chinese and Thai firms may be poised to leverage their large and rapidly growing domestic market for solar power and solar power installations into export domination as well. Once again, Malaysia will be consigned to the low-value added assembly stage, while the higher value added activities are conducted elsewhere. From this perspective, the Feed-in Tariff (FIT) that Malaysia recently adopted[8] should not be viewed merely as a parochial electricity sector issue but as one element of a broader national strategy to foster the development of a domestic market for solar power and the production of ancillary goods and services and to help Malaysia move up the value chain.

In medical devices, for example, Malaysia has already begun to move from producing relatively simple plastic extrusion tubes and parts to assembling these tubes and parts into sterilized, FDA and EU-licensed kits for surgery, kidney dialysis, etc. This relatively simple shift has enabled Malaysian firms to capture the extra value added available from downstream production. However, as the medical devices section will explain in more detail, Malaysia is only now beginning to exploit these downstream activities. Much more can be done and, like the solar sector, promoting domestic demand, in this case via targeted government procurement programs, will be an essential first step in unlocking this potential and helping Malaysian firms to capture the extra value added available from moving up the value chain.

[8] For details, see Energy World (2011). *Malaysia Adopts Sophisticated System of Feed-in Tariffs*. April 28, 2011 at http://www.renewableenergyworld.com/rea/news/article/2011/04/malaysia-adopts-sophisticated-system-of-feed-in-tariffs.

Promoting Supplier Development and Cluster Formation

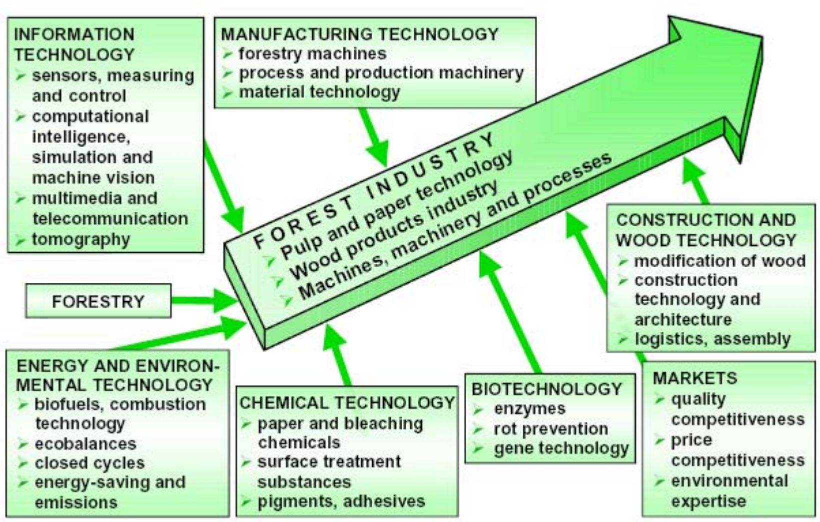
A second route for moving up the value chain is to accelerate supplier development and cluster development. Supplier development relates to the fact that firms operating anywhere along the upstream and downstream continuum require a wide range of inputs. In the solar sector, for example, these inputs can range from relatively sophisticated engineering services that program and maintain robots on the automated solar panel manufacturing assembly line to the production of cables and metal parts required to assemble solar panels into modules and frames for installation.

> The need for improvements in the production of machinery for production and for handling of materials in the production process has been clearly identified in the IMP3. The approach that would bring quick wins for the development of SMEs from any selected sector is a highly focused supplier development program. Such a program should include sector specific certification, and should be supported by a National Data Base of SMEs listing capabilities and capacity. A good example of such a database can be found at www.czechinvest.org. For FDI there should also be an after-care department to encourage existing and new investors to bring in their first- and second-tier suppliers.

These inputs are not usually considered to be part of the upstream and downstream continuum of the solar industry. Yet, manufacturing these ancillary inputs or providing such support services offers an ideal, and as yet untapped, opportunity for Malaysia to increase the domestic value added spawned by the solar and medical device industries.

Moreover, if Malaysia develops the capacity to supply goods and services to MNCs and domestic firms operating in Malaysia's solar and medical device industries, it is a relatively short step from there to selling similar goods and services to firms in other sectors and exporting these goods and services to firms operating in a wide range of sectors in other countries. This in turn can lead to the formation of a metal working cluster, a machine tool cluster, an engineering services cluster, and numerous other clusters. Each of these clusters represents an opportunity to augment the value added generated in Malaysia and therefore, is part and parcel of the process by which countries move up the value chain.

Forest Cluster Structure in Finland



Finland's forestry sector cluster is an ideal conceptual model for Malaysia. As the diagram above illustrates, cutting down Finnish trees is a relatively small segment of the Finnish forestry industry cluster. Most of the value added, and Finland's reputation as an innovative, high-tech nation, derives from its mastery, and export, of the wide range of skill-intensive, high-value added ancillary goods and services associated with the forestry sector.

Malaysia should strive to emulate Finland by developing similar clusters in the medical device and solar industries. This will entail (i) building domestic capacity, rather than focusing only on FDI, (ii) exploiting opportunities in upstream and downstream support activities (cables, metalworking, extrusion machinery and processes, high precision machine tool design and operation, etc.) that, in the first instance, would appear to have no direct relationship either to medical devices or solar panel production, and (iii) as will be explained below, supporting supplier development programs that help forge strong economic bonds between firms in these seemingly diverse upstream and downstream sectors.[9]

Exactly how much value added will be generated by these ancillary activities depends on the nature of the relationship between Malaysian firms on the one hand and their MNC and domestic customers on the other hand. As the diagram below illustrates, third-tier suppliers produce generic products which add very little to the value of the end product and are offered by a multitude of alternative suppliers. These third-tier suppliers are generally selling to first or second-tier suppliers which, in turn, sell to and deal directly with the final customer — generally an MNC. Third-tier suppliers compete mainly on the basis of price provided they can meet minimum quality standards and guarantee timely delivery. Their margins and value added are generally low. Firms located on this rung of the supply chain are relatively powerless. They face a continual battle to remain in business and generate the least domestic value added.

First-tier suppliers, by comparison, deal directly with the MNCs. They produce more complex, higher value added products and have a more trust-based and skill-based (as opposed to merely a price-based) relationship with their customers. They have progressed much further up the value chain. If Malaysia wants to move up the value chain, it should implement targeted supplier development programs that are explicitly designed to help firms build the capacity they need to transition from third-tier to second and first-tier suppliers.

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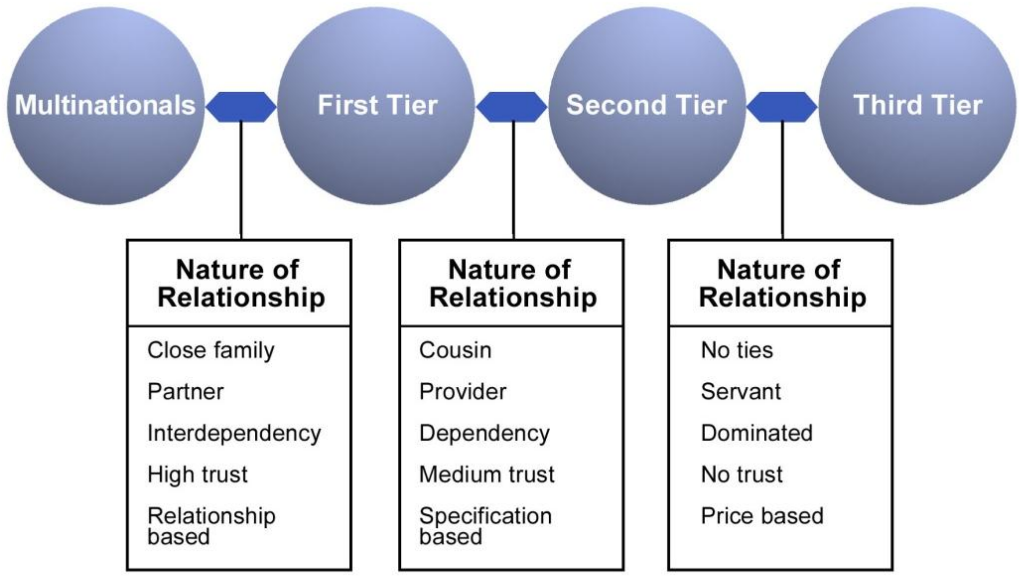
[9] For a summary of supplier development programs that would be especially well-suited for Malaysia, see the discussion in Watkins and Ehst, *Science, Technology and Innovation: Capacity Building for Sustainable Growth and Poverty Reduction*, World Bank, 2008, p. 109-112. Also see the presentation by John Varney at the February 2007 World Bank Global Forum on STI Capacity Building for Sustainable Development, available at http://go.worldbank.org/NTGW92RA60.

A Taxonomy of Supply Chain Relationships



The supplier development programs which are advocated here are different from conventional linkage programs in the IMP3 in so far as there is a great emphasis on the development of relationships with multinational companies. The private sector has a major role in such programs since it participates directly in a steering group and an advisory panel. Meetings between the multinationals and the small and medium enterprises (SMEs) take place on a regular basis. Additionally special events such as reverse exhibitions are arranged. These exhibitions differ from trade fairs in that buyers from big companies show potential suppliers products and services which they are looking to source locally.

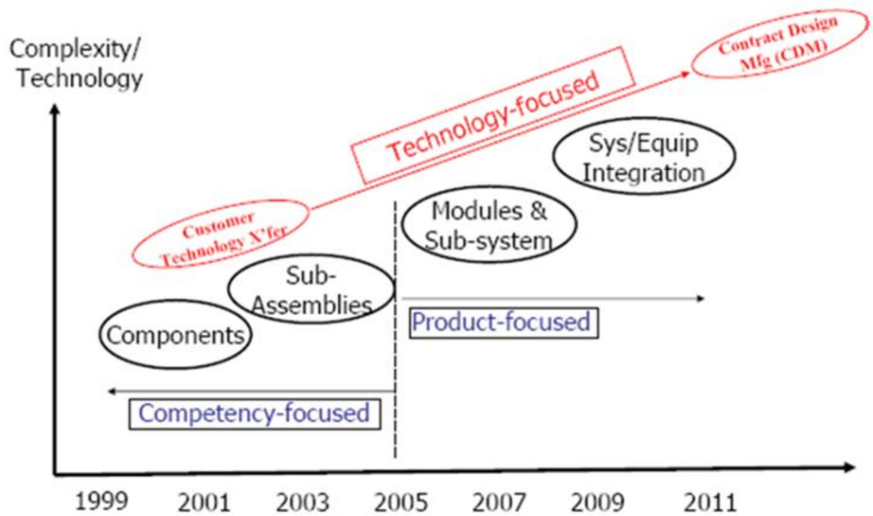
As the diagram below suggests, firms can progress from third to second to first-tier suppliers by building up their competencies so that they can perform higher value added tasks and produce higher value added goods and services for their MNC customers. A typical route would take a firm from a third-tier producer of components to a first-tier supplier of integrated systems. Firms in this first-tier position manage a diversified range of second and third-tier suppliers. They are also involved in such higher value added activities as design, procurement, testing and evaluation. To move along this schematic road map firms need a strategic vision and a step-by-step plan for implementing that vision. That implementation plan would include such items as training workers, building the capacity to manufacture and design more complex products, and doing all this in close cooperation with customers.

Management must look in two directions simultaneously — outward to the market and inward to the firm. Not every firm has the capacity to look in two directions simultaneously and manage the complex adaptation process. However, supplier development programs, targeted skill development programs similar to those being implemented in the Northern Corridor, and specialized industrial technology outlook/intelligence institutions[10] can help SME managers handle these complex chores. To be successful,

[10] A discussion of lessons of experience gleaned from similar technology acquisition institutions in Korea, China, Thailand, and Colombia is available in Watkins and Ehst, *op. cit.*, p. 113-124. Also see the presentations by Sungchul Kim, Sergio Trinidade, Maria del Pilar Noriega, and Peter Brimble at the February 2007 World Bank

global experience suggests that these programs should be designed and operated as public-private partnerships operated with close collaboration between the private sector and the program managers. Where necessary, the Government can act as a catalyst, helping to organize and even to provide seed funding for the initial operations. But despite any initial government support, the programs should operate independently of the government and, after a brief initial start-up period lasting no more than two or three years, should be supported entirely by private sector membership dues and fees.

R&D and Technology Road Map



Moving Along the Smile Curve

A third route for moving up the value chain is to develop high-value activities within the boundaries of the firm. This process can be illustrated with reference to the 'smile curve', a concept depicted in the diagram below and first developed in 1992 by Stan Shih, the founder of Acer, a Taiwan-based electronics company. Shih noted that mass production assembly operations were the least profitable segment of the electronics industry. The most profitable activities were found at either end of the production process — either upstream in R&D and design, or downstream in marketing, branding, systems integration and etc. "If this phenomenon is presented in a graph with a Y-axis for value added and an X-axis for value chain (stage of production), the resulting curve appears like a 'smile'."[11]

Moving along the smile curve and moving from third- to second- to first-tier supplier are closely related processes and concepts. The supply tier concept refers to a firm's position in an MNC supply chain. The smile curve refers to the value addition generated by a particular type of activity. Firms in a third-tier supplier position are generally performing activities located at or near the bottom of the smile curve. As noted above, they are generally competing for contracts on the basis of price and do not have a close

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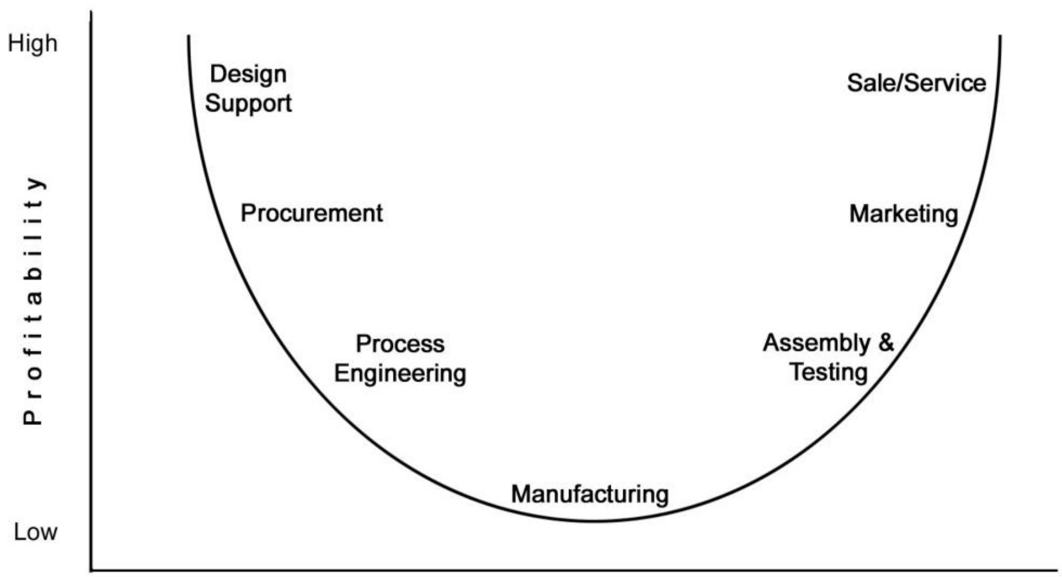
Global Forum on STI Capacity Building for Sustainable Development, available at http://go.worldbank.org/NTGW92RA6.

[11]Two especially interesting articles on the smile curve can be found at http://people.hofstra.edu/geotrans/eng/ch5en/conc5en/commoditychainsaddedvalue.html and http://laofutze.wordpress.com/2010/06/20/acer/.

relationship with their customer. They can, and frequently are, replaced when a lower-cost supplier is available. However, as firms move up the supply chain tiers, they perform more complex tasks which also entail a corresponding move along the smile curve. Not only are they performing more complex tasks that generate more value added, but they occupy a more privileged position in the supply chain and, as a result, are less likely to be replaced the moment a marginally lower-cost producer comes along.

Smile Curve: Value Added Opportunities within the Firm



Similarly, moving along the smile curve and finding upstream and downstream niches in electric cables, solar modules, sophisticated machine tool operations, etc. are also closely related concepts. As the smile curve suggests, mass producing solar panels or even cardiac pace makers may not generate much value added in Malaysia, despite the fact that these are science-intensive, sophisticated high-tech products. Most of the value added is generated someplace other than where all the components are assembled into a final product. But firms that can design and market solar modules or that can design, package, and market solar-powered devices that can be sold in emerging markets to villages that have no immediate prospect of being connected to a central grid will have accomplished two things simultaneously: First, they will have moved to a more advantageous position along the smile curve and second, they will have helped to generate clusters of related industries.

MOVING UP THE VALUE CHAIN IN THE SOLAR INDUSTRY

Turning now to the solar industry, this section identifies opportunities and challenges on the basis of the concepts discussed earlier. In what follows, the global industry structure is first described. Malaysia's position within the global value chain is then discussed. Next this section examines the opportunities that could be reaped by moving up the value chain in the solar industry. This is followed by a discussion of the main bottlenecks to reaping the opportunities. Finally, this section provides policy suggestions specific to the solar industry to address the bottlenecks.

The Global Solar Industry Structure

In what follows, we first describe the PV industry as it stands today. We then discuss how the industry might be expected to evolve in the near term as well as in the longer term.

The Global PV Industry Today

The discussion below first provides a description of the cross-border supply chain, the historical cost and price drivers, the breakdown of current global production and the breakdown of current and historical global demand.

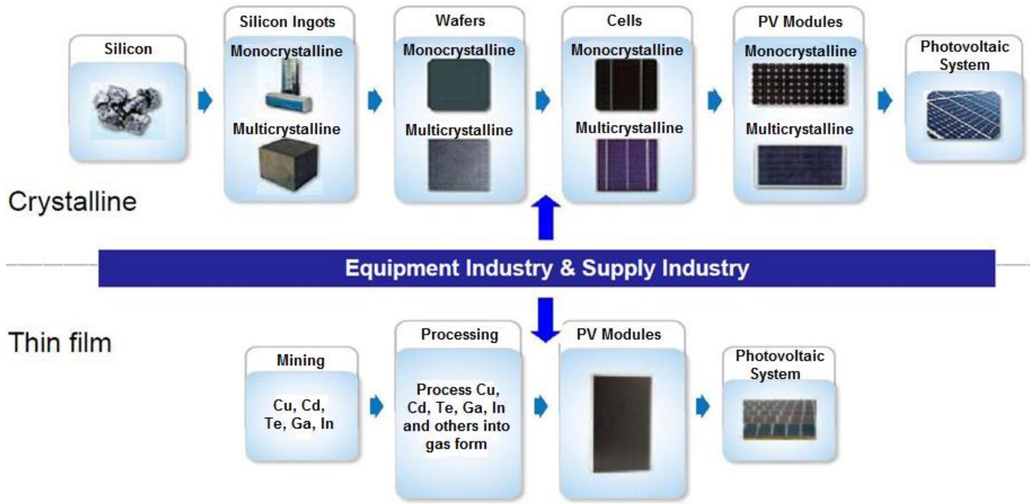
Supply Chain Description

The global PV supply chain consists of many steps from raw materials to finished systems installed and generating electricity. The basic steps include development of suitable raw materials, processing those raw materials into PV materials, sandwiching those materials into a PV module, and installing that module into a completed system in a location where solar energy can be harvested.

It is useful to separate the manufacturing process for the two main technology pathways used for PV manufacturing, and the chart below shows these two supply chains. The dominant technology today is based on crystalline silicon, a highly purified form of silicon. This supply chain has relatively more steps to cast ingots, slice wafers, dope cells, and assemble modules. It also involves substantial capital expenditures for the equipment required to accomplish all of these steps. The result, however, is a reliable product with decent conversion efficiencies that is more readily accepted in the marketplace, despite the relatively higher costs.

The second technology pathway involves a technology known as thin-film PV. This supply chain is much shorter as raw materials are deposited directly on glass, reducing the number of process steps and the equipment required to produce modules. Currently, thin-film PV production results in a lower efficiency product, but at a substantially reduced cost to manufacture. Longer term, efficiencies may continue to rise for certain types of thin-film technology (but not all of them), and cost leadership should persist.

Supply Chain Flow – Global PV Industry



Source: Malaysia Building Integrated Photovoltaic (MBIPV)

As shown on the chart above, other elements are required to complete the global supply chain for PV. These include:

- Manufacturing equipment — a substantial amount of equipment is required for the many process steps in making PV. This equipment includes precision devices that are able to do casting, pulling, wafering, deposition, laminating, and testing. Much of this equipment is specialized, but some is general including specifically testing equipment;

- Manufacturing facility and local labor to staff it — a suitable facility for fabrication is required and substantial staff levels are needed to move material in, through, and out of the facility. Additional infrastructure may be required to draw power, water, and transportation access to a given facility;

- Financial capital — financial capital is required for many stages in the PV supply chain, but is most important in the capital-intensive establishment of the facility including manufacturing equipment. It is also important that adequate working capital (WC) be supplied to manage the optimal flow of material through the facility and minimize costs by bulk ordering while waiting for receivables to be paid from customers; and

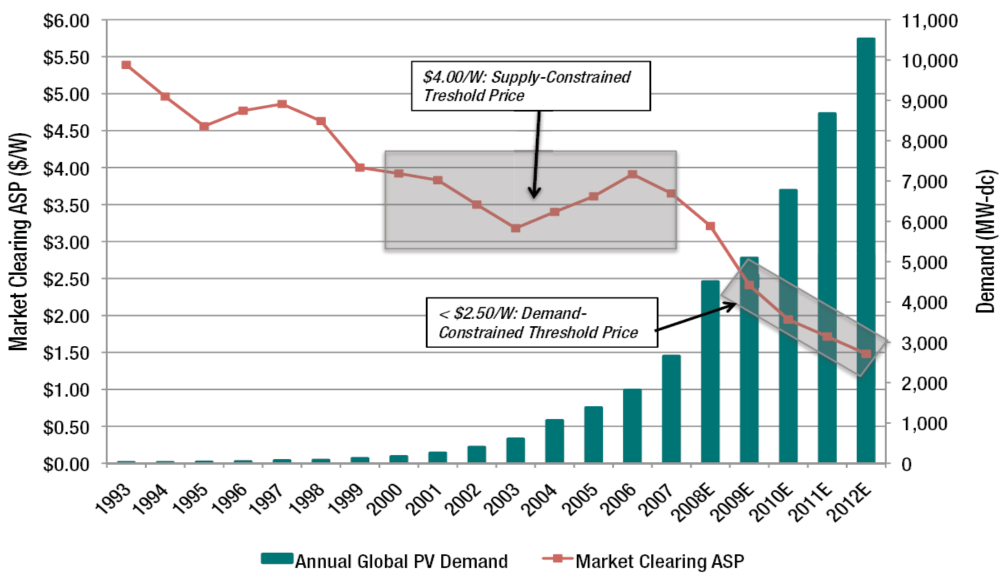
- Customer finance — given the capital-intensive nature of PV systems to customers who are effectively purchasing 2 to 3 decades of electricity in the cost of the initial system, it is important that this second level of financial capital be considered in the global supply chain. In fact, over the life of a PV manufacturing plant, the cumulative capital to pay for the installation of systems using the plant's output could be between 15 and 30 times the amount of capital required to set up the plant originally.

All of the items above should be considered when thinking about the global supply chain, its opportunities and bottlenecks.

Historical Cost and Price Drivers

Prices in the PV industry, as measured at the module specifically, have been steadily falling for the last 30 years, with some brief periods of noise around that trend line. Costs have fallen due to a combination of factors including technology improvement, efficiency of use of materials, and increased scale of global manufacturing. The chart below shows the growth in global volumes of PV module production since 1993 and the corresponding fall in market clearing average selling prices (ASP).

Market Clearing Module Average Selling Prices and Annual PV Demand, 1993-2012



Source: GreenTech Media (GTM) Research

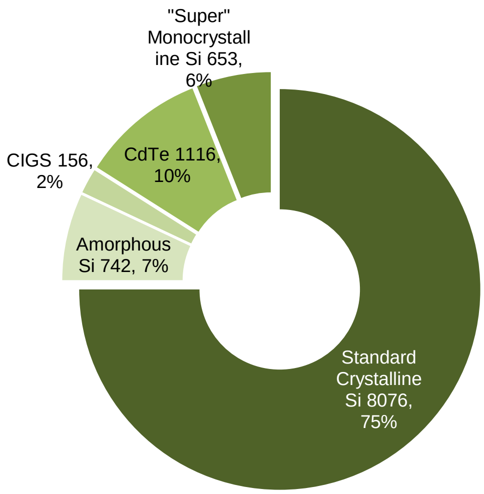
Notable market dynamics have occurred since 2000, with the dramatic increase in demand from FIT programs in Europe creating supply constraints throughout the entire global supply chain, most specifically in the upstream polysilicon manufacturing required for crystalline modules. High prices led to substantial profits for existing manufacturers and a rush of new entrants into the global PV production industry, many of these in China and Taiwan (POC). Supply growth outpaced demand growth from 2008 to 2010, and prices fell dramatically back to the long-term downward trend line. Prices should continue their long-term decline of 5 to 6 percent per annum going forward.

Breakdown of Current Global Production

Due to the dynamics described above, global PV production today continues to be dominated by crystalline silicon PV technologies, with about 75 percent of the global market share — even though that number has been falling from a peak of 96 percent in 2004.

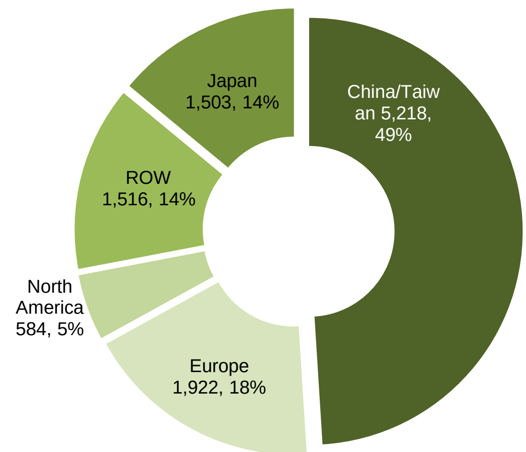
About half of the global production now comes from China or Taiwan (POC), up from nearly none as recently as 2005. Despite that dramatic growth, production has increased across all regions including Europe, North America, Japan, and many other places including Malaysia.

Global PV Cell Production by Technology (MW-dc), Share, Percent



Source: GTM Research

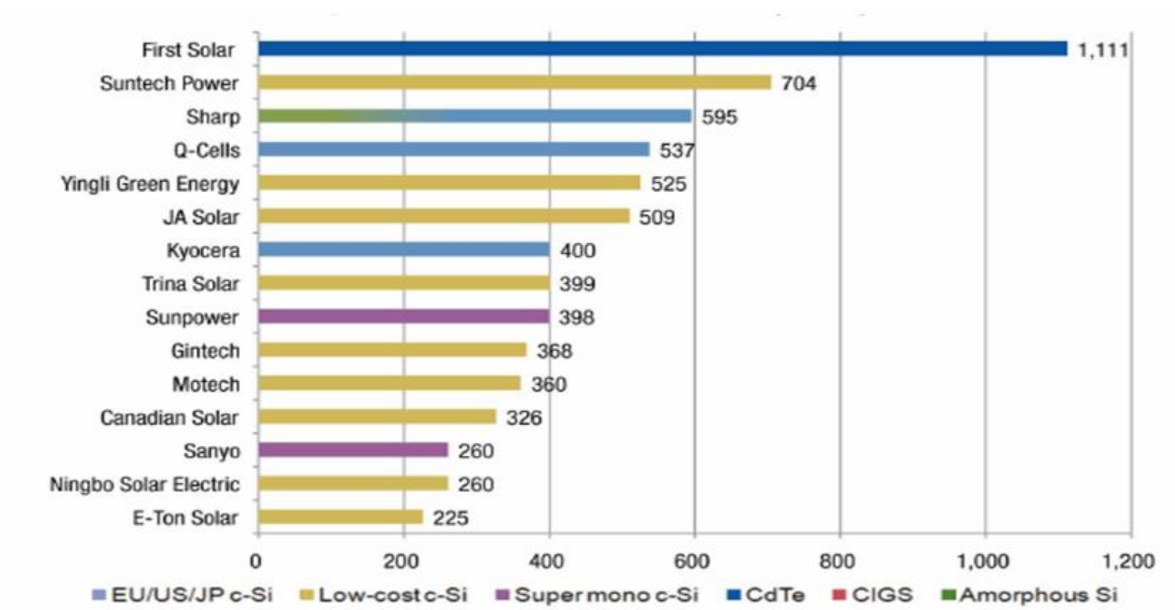
Global PV Cell Production by Region (MW-dc), Share, Percent



Source: GTM Research

The next chart shows the breakdown of the top 15 manufacturers of cells worldwide in 2009. The color of each bar shows which technology that manufacturer makes, with yellow and light blue being the dominant crystalline silicon PV technology. Dark blue and green represent thin-film technologies, while purple bars represent high-efficiency silicon from manufacturers like Sunpower. Nine of the top 15 manufacturers are in China or Taiwan (POC), all of which produce crystalline silicon PV.

Top 20 Cell Producers—2009 Production (MW-dc)

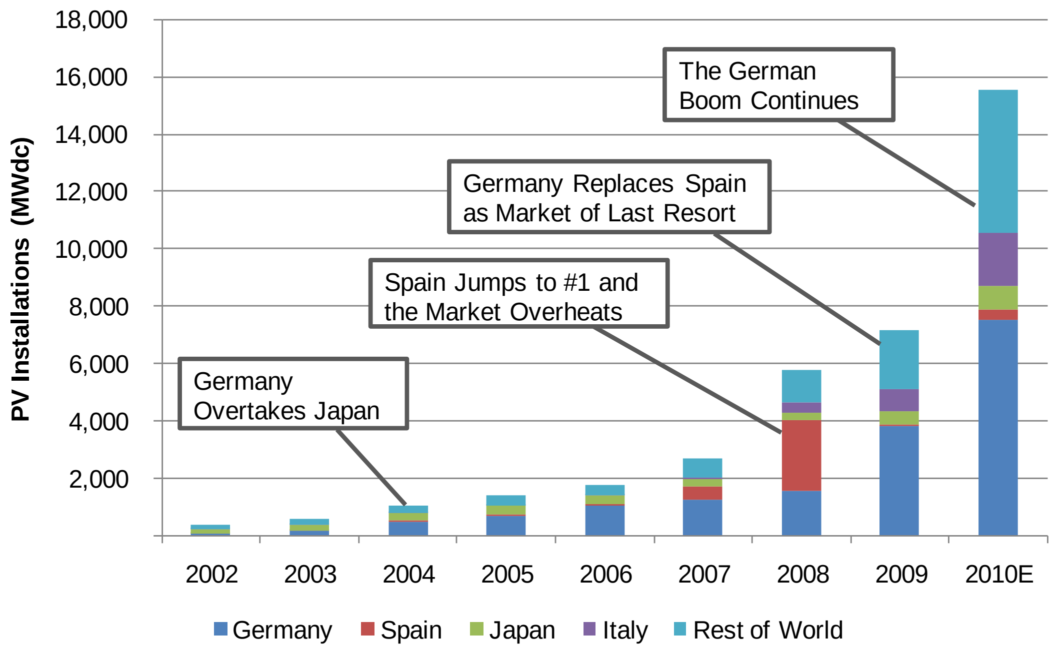


Source: GTM Research.

Breakdown of Historic and Current Global Demand

Demand growth for PV has been driven predominantly by policy-led programs in various countries over the last decade. Starting in the late 90s in Japan, the Sunshine Program was used to stimulate domestic consumption of PV, while simultaneously helping to establish Japanese manufacturers of silicon and PV as global leaders — a position they held until the middle of the last decade. Then, in 2004 Germany established a FIT that paid system owners a premium for the electricity generated by their systems. Spain, Italy, France, Greece and many other European countries copied this program, with Spain's incentives among the richest in Europe. Spain's program was so rich, in fact, that it led to a curtailment in 2008 from which the Spanish market has yet to recover. The US market has also grown on the back of a government-sponsored tax incentive program, as well as state programs such as those in California and New Jersey.

Annual PV Demand by Major Market, 2002-2010



Source: GTM Research.

The combination of all of these programs has led to a sustained growth in demand of over 50 percent per annum for a decade. Through 2010, Germany has continued to be the engine of global growth for PV, though has begun to see domestic pressure for limits to the size of the PV market. Other countries in Europe are experiencing similar domestic pressure for limits to the amount of money supplied to support PV growth, particularly when much of the cost of that system is in imported modules and other components. France, in particular, has limited the importation of Chinese modules, while Ontario and other jurisdictions have local content requirements for their systems.

The Global PV Industry Through 2013

Over the last decade, the global PV industry has been in a state of constant dynamic change, the most recent being: 1) a rapid fall in module and system prices since 2008; 2) the emergence of Chinese and Taiwanese PV manufacturers; and 3) the rise of thin-film technologies. The next few years will see a continuation of these trends, the strength of which will be determined by the level of global demand set by the combination of many national PV support programs in Europe and elsewhere.

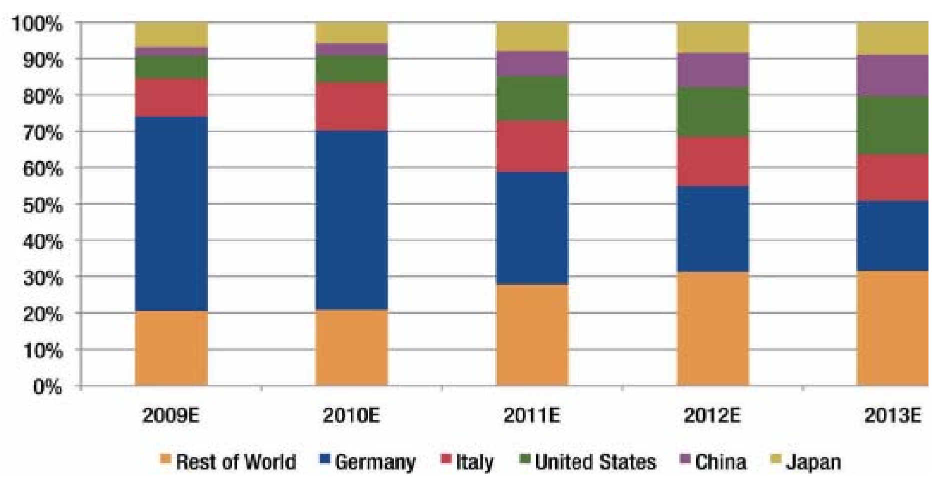
Much of the global forecasting presented here relies on the author's work in the sector through GreenTech Media, which collects primary data on the global PV industry supply chain and economics. These forecasts are among the most robust developed worldwide and are used by major manufacturers to understand supply and demand dynamics throughout the supply chain. More information on the analysis and methodology can be obtained at http://www.gtmresearch.com/.

The main drivers that emerge from the analysis and forecasts are discussed below.

Near-Term Driver #1—Slowing Demand Growth due to Market Maturation and Limits to Existing National Support Programs

Demand growth will continue to slow in Europe as the powerful drivers of Germany and Italy see diminished growth rates. The chart below shows German contribution to global PV demand dropping from 60 percent to about 20 percent over five years, with Italy cresting out at around 15 percent. Despite slowing growth in the largest markets, global demand should grow to between 15 and 20 GW by 2013, representing a low double-digit growth rate worldwide. Diversification of demand across many markets is a long-sought and highly desirable outcome.

Market Share of Global PV Demand by Major Market, 2009-2013



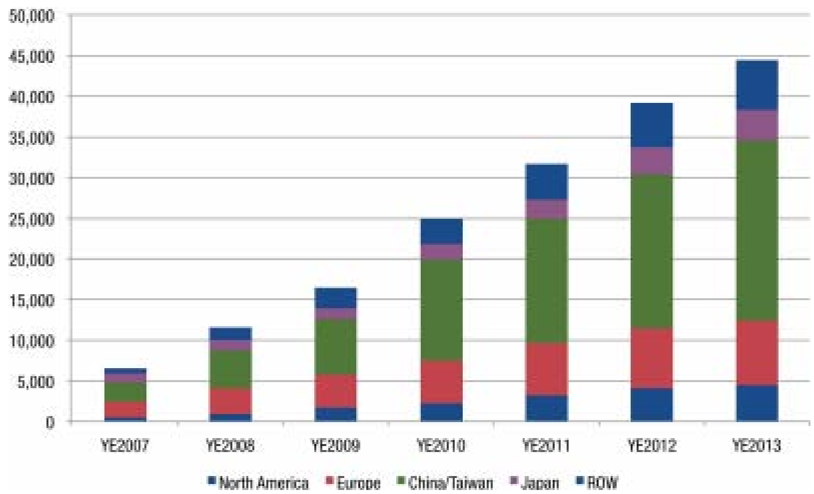
Source: GTM Research.

The real impact of declining growth rates will be continued downward pressure on module prices and margins. This has the dual effect of driving manufacturers to be highly cost efficient through vertical integration, scale, and technology, as well as advancing market adoption by broadening grid parity in many markets. Each of these is discussed in detail below.

Near-Term Driver #2—Rising Asian Production Share

Based on detailed forecasts of the global supply chain for PV, it is likely that Chinese and Taiwanese manufacturers will continue to grow and provide the lowest cost crystalline silicon-based products. This will squeeze out a number of marginal manufacturers in Japan and Europe, subject to the changes in relative exchange rates discussed below. Many of the remaining manufacturers in North America, Japan, and Europe will pursue thin-film technologies as a way to stay competitive. For the same reason, they will also look to outsource manufacturing to places both inside China and beyond.

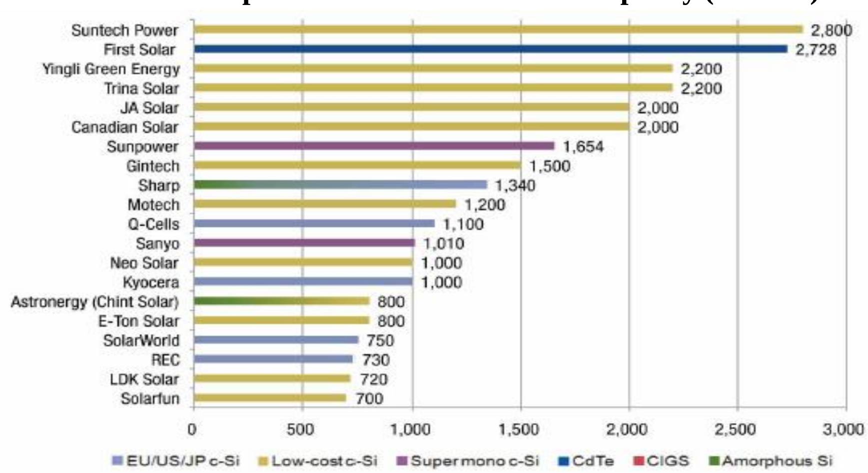
Global PV Module Capacity by Region, 2007-2013E (MW-dc)



Source: GTM Research.

The chart below shows the projected top 20 producers in 2013 by cell capacity. Chinese and Taiwanese players will dominate the list with five of the top six slots. First Solar and Sunpower round out the top seven, with nearly all of their manufacturing taking place in locations like Malaysia, the Philippines, and Vietnam. Thin-film technologies remain relatively small, less than 700 MW capacity, but a look at the next 20 producers beyond the top tier would show many thin-film manufacturers on the list.

Top 20 Cell Producers—2013 Capacity (MW-dc)



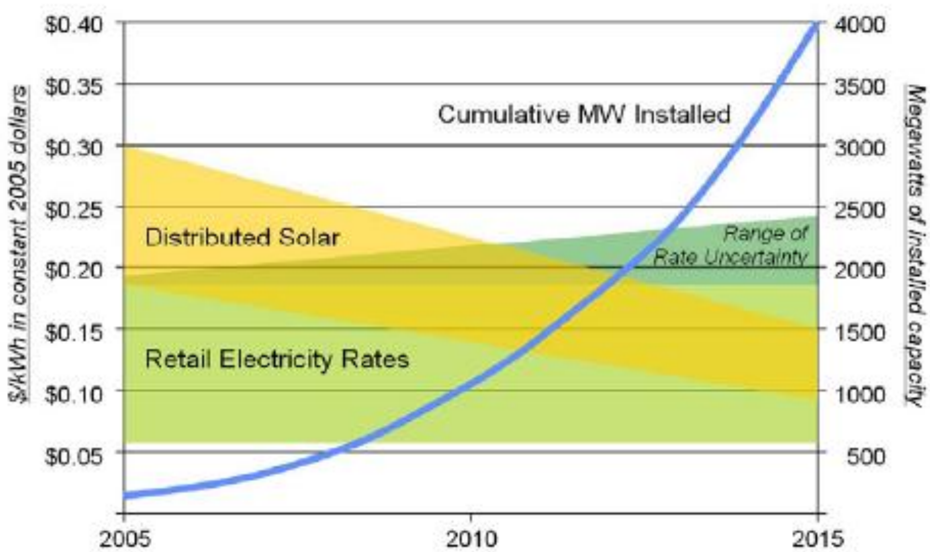
Source: GTM Research.

Near-Term Driver #3—Broad-Based Grid Parity in Many Markets by the Middle of the Decade

Many markets are slated to achieve grid parity — the point at which distributed solar drops to the level of retail electricity rates — in the next few years. Driven by falling system prices, as well as flat to rising delivered electricity prices in most markets, grid parity is coming quickly to many countries in Europe and many states in the United States.

Thanks to high retail electricity prices and current PV support programs, Italy and Japan are likely to achieve grid parity soonest, perhaps by this year for lots of applications. Germany, France, California, New Jersey, and many other jurisdictions will likely see the emergence of grid parity by the middle of the decade. A chart showing US grid parity through 2015 is shown below.

Projected Cost Reductions for Distributed Solar PV Assuming Deployment Targets Are Met



Source: National Renewable Energy Laboratory (NREL) and industry data.

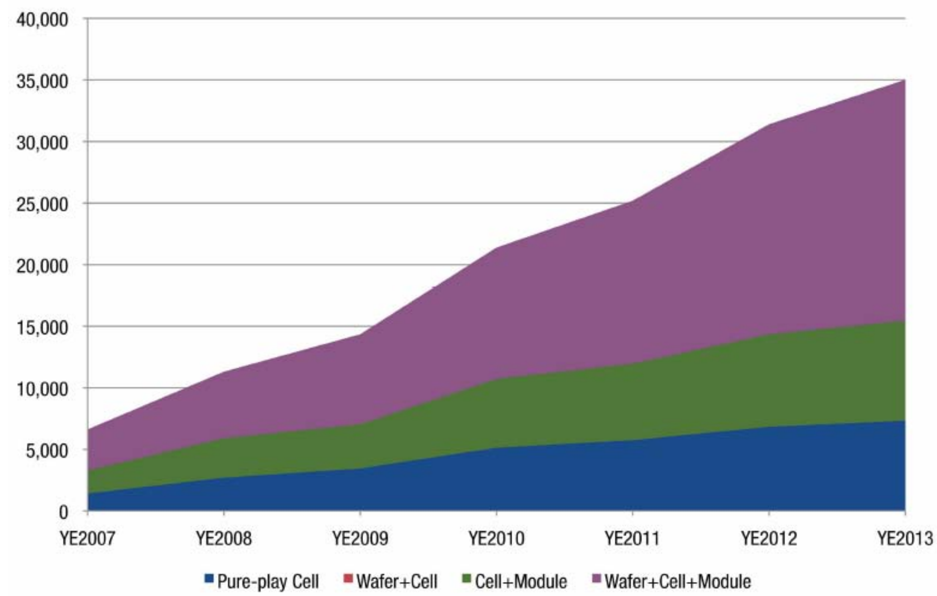
The important thing to understand about grid parity is that it does not guarantee immediate uptake of a lot of systems, but it does change the economic calculus to allow component manufacturers, systems integrators, and capital providers to begin to see a period of rising economic value added from the installation of systems. Additional volumes in the local market should help to continue driving prices down and increasing the pool of profits, incentivizing more demand without any additional government support or intervention. Beyond grid parity, real economic surplus begins to accrue to the local economy.

Near-Term Driver #4—Continued Vertical Integration of Manufacturers

Manufacturers are desperate to continue to drive down the cost to produce modules. Beyond just technical innovation on their products (product innovation), it is often possible to reduce the cost of manufacturing by reducing the number of process steps or material transfers within the production process (process innovation). The best way to do this in the PV industry is to vertically integrate the production processes that are often today handled in separate facilities.

The most logical integration today for crystalline PV manufacturers is from the ingot to the wafer to the cell. Some manufacturers, such as LDK in China produce polysilicon, ingot, and wafers. Others, such as Suntech or Trina buy wafers and process them all the way to modules. The chart below suggests that over the next few years the trend will continue to favor companies that produce all the way to the module. Most Chinese manufacturers, and all thin-film manufacturers, meet these criteria. In contrast, both of the crystalline silica and PV manufacturers in Malaysia only produced to the cell level and then export those cells to module factories in other places.

Crystalline Si Cell Capacity by Degree of Vertical Integration, 2007-2013E (MW-dc)



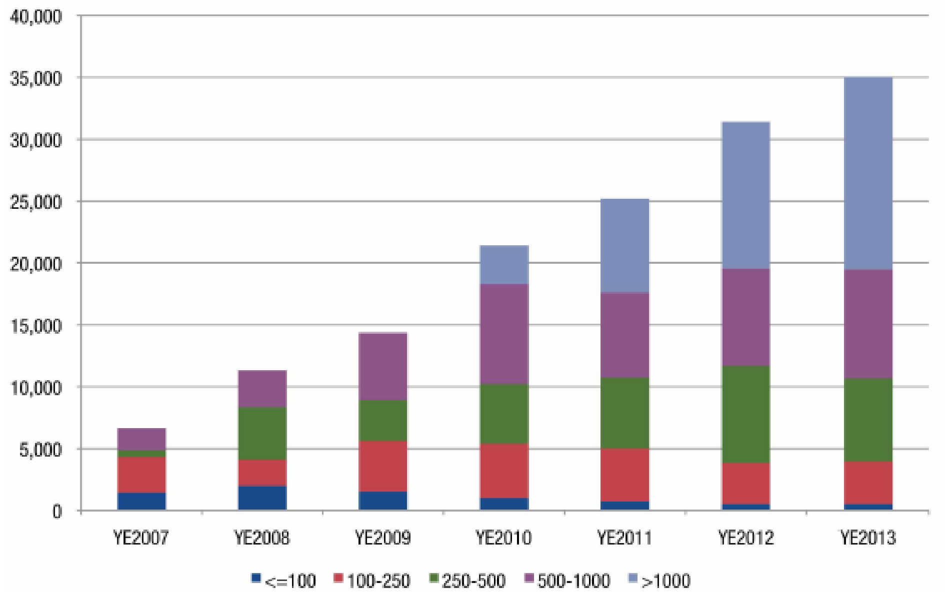
	YE2007	YE2008	YE2009	YE2010	YE2011	YE2012	YE2013
Pure-play Cell	1,414	2,708	3,450	5,141	5,751	6,840	7,330
Wafer+Cell	0	0	0	0	0	0	0
Cell+Module	1,885	3,198	3,599	5,588	6,226	7,520	8,130
Wafer+Cell+Module	3,321	5,404	7,299	10,662	13,219	17,039	19,554
Total	**6,620**	**11,310**	**14,348**	**21,391**	**25,196**	**31,399**	**35,014**

Near-Term Driver #5—Massive Scale Component Manufacturing Plants Required to Achieve Continued Cost Reductions

In addition to the growth of vertical integration within manufacturing facilities, the scale of those facilities is being used as a way to drive down costs. The chart below suggest that by 2013 around half of the production worldwide will be in facilities of more than 1 GW of annual PV production, with the bulk of the rest in factories of at least 250 MW of production per year. Current plans for expansion at the existing largest producers in the world substantiate this view. As can be seen from the top 20 Cell Producers in 2013 chart above, the mega plants of China and Taiwan (POC) are the ones with the most aggressive growth plans among all producers.

The combination of increasing vertical integration and increasing scale points to a world of gigawatt scale fully integrated factories driving the cost to produce PV down through 2013. While many of these factories are located in China and Taiwan (POC) currently, Malaysia and Japan also have meaningful contributions to this category. It is currently unlikely, but not impossible, for manufacturers in Europe or North America to also build similar factories, though they would likely be thin-film factories and may have lower minimum economic units to achieve cost advantages.

Crystalline Si Cell Capacity by Fab Size, 2007-2013E (MW-dc)



CRYSTALLINE SI CELL CAPACITY BY FAB SIZE							
	YE2007	YE2008	YE2009	YE2010	YE2011	YE2012	YE2013
<=100	1,423	1,980	1,519	978	716	470	470
100-250	2,886	2,126	4,080	4,399	4,281	3,340	3,480
250-500	560	4,194	3,310	4,835	5,710	7,845	6,680
500-1000	1,751	3,010	5,439	8,079	6,889	7,890	8,830
>1000	0	0	0	3,100	7,600	11,854	15,554
Total	**6,620**	**11,310**	**14,348**	**21,391**	**25,196**	**31,399**	**35,014**

The Global PV Industry Beyond 2013

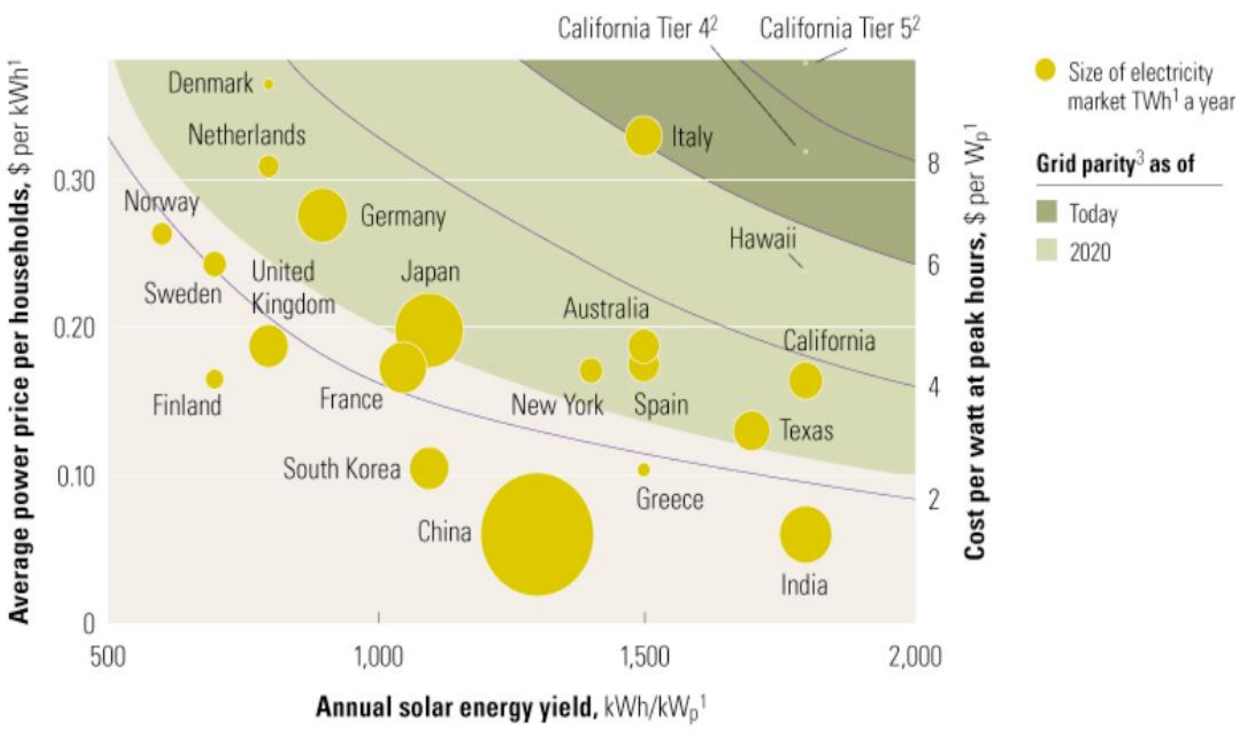
Beyond 2013, a number of long-term secular trends will continue to drive growth in the global PV industry, though it is likely that fundamental macroeconomic shifts and a broadening technology palette will create a more diversified global manufacturing base. Main long-term drivers include:

Long-Term Driver #1—Grid Parity Continues to Strengthen Globally

One of the most powerful defining trends of the next decade in the global energy industry will be the emergence of grid parity, the point at which locally generated electricity becomes cheaper than delivered grid electricity, in many of the major markets for electricity around the world. This process is already happening in substantial markets like Italy, California, Japan, as well as many island nations and locally independent grids. By 2015, much of Europe is expected to achieve grid parity, beginning in the high-value peak power generation markets and moving down the value curve to an ever-increasing share of the market. Beyond grid-dominated markets, hundreds of millions of potential users in the developing world that already find value in PV will see the systems become more affordable.

The chart below from McKinsey Global Institute shows the system price curbs where grid parity occurs in various markets. Today's prices for large systems at USD4.00 per watt will continue to fall to less than USD2.00 per watt by 2015, opening up a number of additional markets. Most of the markets identified below are also experiencing rising electricity prices, which will only accelerate and embed solar as the most cost-effective option for these markets.

The Growing Competitiveness of Solar Power



The impact of this inevitable march toward broader grid parity is twofold. First, volumes of solar PV manufactured and installed worldwide will continue to rise, with growth rates expected to remain robust for a long time. The market could easily achieve 100 GW of annual installations by 2020, according to a number of forecasts. Second, the price of solar components and installation labor will need to come down in order to continue opening up additional markets. Detailed analysis of manufacturing costs, scale, and margins suggests that sufficient cost-reduction opportunities exist, but falling prices and low but reasonable margins will have an impact on the global manufacturing supply chain.

Long-Term Driver #2—Emergence of Other Low-Cost Manufacturing Centers

Beyond China and Taiwan (POC), the two main growth engines of PV manufacturing, a number of other locations are vying for companies to establish PV manufacturing centers. Malaysia has shown to be one of the most desirable, landing over 3 GW of annual cell or module production in the last few years. Other traditional outsource centers include the Czech Republic, Thailand, India, and the Philippines, while emerging centers of South Korea and Vietnam are attempting to win new factories with aggressive policies. Below is a brief description of the strengths and weaknesses of each of these.

Traditional Centers:

- *Eastern Europe* — a number of companies have set up module fabrication plants in the Czech Republic, with smaller facilities in some other Eastern European countries. These jurisdictions usually have much easier coordination with corporate headquarters and primary factories in Germany or other European countries. They also have the advantage of being seen as 'domestic' versus Asian manufacturers, an issue that is increasingly debated in the context of tariff or support schemes for domestic installations;

- *Thailand* — Thailand has a history of support for small-scale thin-film manufacturing. It has also in the last few years developed a strong domestic installation business, and is looking to install multiple gigawatts of PV for domestic use in the next few years. This large local market has encouraged a number of smaller manufacturers to set up or expand facilities in Thailand;

- *India* — India has many meaningful manufacturer of PV for almost 2 decades, and at one time was the world's third-largest producer of PV. Major Indian industrial conglomerates, including Moser Baer, have made substantial investments in PV manufacturing. At the same time, recent program developments in India have targeted tens to hundreds of gigawatts of PV over the next decade due to the good domestic fundamentals for PV including strong solar resources, and many distributed villages and micro-grids that would be enhanced by inclusion of solar energy; and

- *Philippines* — though the Philippines does not have a strong domestic demand for PV, it was an early location for outsourced manufacturing of PV for Sunpower. Beyond the first two fabs, Sunpower elected to move further manufacturing to Malaysia. This, along with a lack of other manufacturers choosing to locate in the Philippines, may suggest that there are limits to the desirability of the Philippines going forward.

Emerging Centers:

- *South Korea* — South Korea and its large conglomerates are quietly moving deeper into the PV space. They expect to set up substantial manufacturing in order to compete with the Chinese and Taiwanese, though large manufacturers are still in the process of trying to establish the technology platforms they will use for this rollout. It is most likely that any MNC activity in Korea would be done as a joint venture with domestic conglomerates, versus a standalone foreign company, and this will limit the number and types of companies that will be willing to set up facilities in South Korea; and

- *Vietnam* — the closest competitor to Malaysia, both geographically and from a value offering, is probably Vietnam. While not as technically robust as Malaysia, Vietnam offers low-cost labor and decent assembly and logistics infrastructure. It has also aggressively pursued companies to establish facilities, and most notably First Solar will be establishing a manufacturing facility there in the coming months.

In the end manufacturers have very different preferences regarding what is important when establishing a foreign manufacturing facility. It will be important to understand both what the most desirable manufacturers consider important in choosing a location, as well as what Malaysia's unique value offering is when setting strategy for attracting additional MNC investment.

Long-Term Driver #3—Technology Shifts to Second- and Third Generation PV with Lower Capital and Fabrication Costs

Over the next decade, the drive for continued cost-reduction will lead to a shift in technologies toward second and third generation PV due to a combination of lower manufacturing cost and lower cost to establish facilities, both of which are important to different constituencies.

As mentioned above, achieving increasing grid parity in many markets will necessitate falling system prices. With half of the cost of a PV system in the cost of components, those component prices will need to come down. While crystalline silicon-based PV will continue to fall in price, advanced thin-film technologies and potentially third generation high-efficiency and low-cost technologies will emerge to meet that need.

A second important consideration has to do with accessing enough capital to build manufacturing facilities in the world of falling PV prices and margins. There is a wide disparity today of the cost to build manufacturing capacity by technology. A polysilicon-based supply chain could cost as much as three dollars per watt to build manufacturing capacity versus today's thin-film plants which cost around one dollar per watt. Future technologies will continue to drive down this manufacturing cost for existing technologies, but emerging technologies that are highly ‘capital efficient’ may see their desirability and market share grow simply due to that characteristic. Subsidy support dollars to establish a manufacturing facility will also go a lot farther for such capital efficient manufacturers.

Long-Term Driver #4—Limits to Vertical Integration May Appear, Particularly for Crystalline PV Manufacturers

One counter-trend that may emerge in the crystalline supply chain, or even select thin-film manufacturers, is that the cost of manufacturing modules and shipping the full glass package to the end markets will continue to need to be compared to the cost of manufacturing cells abroad and packaging them into modules for use in the local market. Also, domestic demand programs such as Ontario, France, or even the United States under the buy America provision, might lead certain markets to require domestic content in manufactured goods.

Many considerations and forecasts go into this calculation including economies of scale in manufacturing glass, cost of transport, losses and additional process steps in transfers, size and volatility of local market demand, etc. For thin-film manufacturers that deposit directly on glass, such as First Solar, there is no opportunity to disaggregate these two steps. Therefore, access to low-cost glass, either locally manufactured or imported, becomes very important for manufacturing economics.

The combination of all of these pressures for some local manufacturing, must be offset against the advantages of large-scale vertically integrated manufacturing. In the end, lowest delivered cost of electricity will be the primary driver of demand and large-scale vertically integrated manufacturing should continue to be the best way to deliver that. However, some states of the world would see limits that would curtail that advantage.

Malaysia's Position in the Global Industry Structure

Malaysian PV Companies

Malaysia already has a strong position in the global PV industry, having established major manufacturing facilities just in the last few years. The country has made substantial investments to attract some of the prime manufacturers across a range of technologies including First Solar, Sunpower, and Q-Cells.

- *First Solar* is the world's leading manufacturer of PV, and is also the low-cost producer using thin-film technology. The plant is currently targeting over 1.4 GW of capacity, and will employ nearly 4000 people when fully ramped. The technology requires fully integrated modules to be produced, but First Solar currently imports glass, its largest cost component, from abroad;

- *Sunpower*, in combination with its new partner AUO, will establish up to 1.4 GW of manufacturing capacity in Melaka's Solar Valley. This facility is currently planning only to manufacturer from imported ingots to cells, and will ship those cells abroad for assembly into modules. The technology has a much higher cost than first solar, and produces a product that is of higher value as well. As such, it attracts more labor input per unit than thin-film technologies, but is at risk of losing market share to cheaper competitors in the crystalline space as well as thin-film;

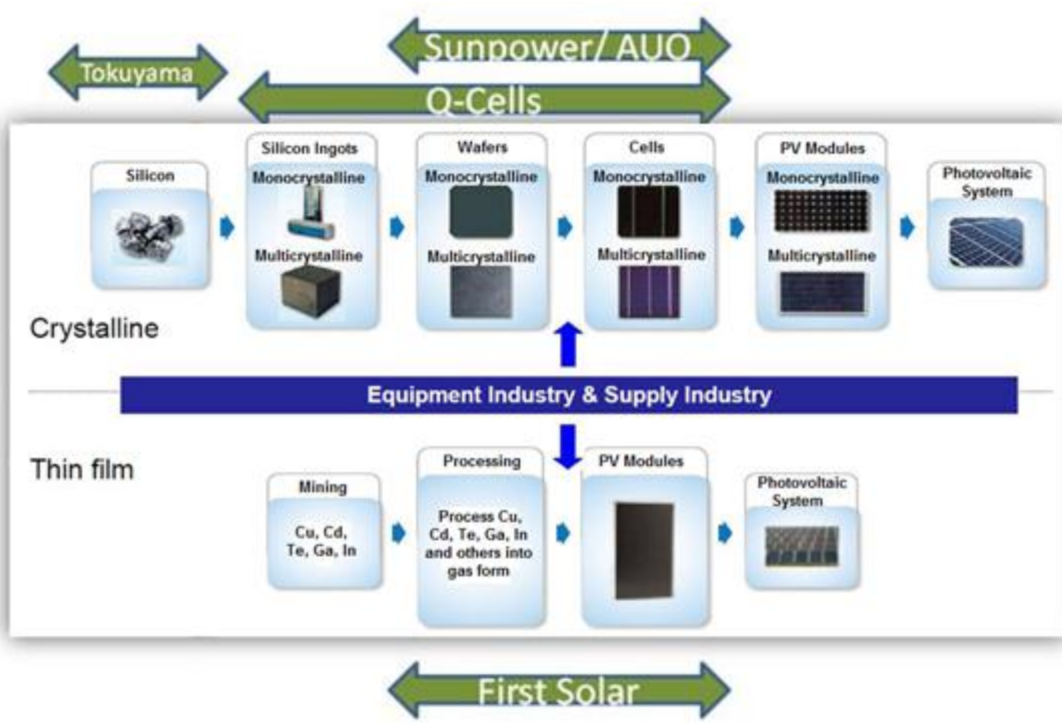
- *Q-Cells* has established an integrated wafer and cell manufacturing plant, similar in structure to Sunpower. Q-Cells is one of the largest cell manufacturers in the world, and moved its manufacturing to Malaysia in order to retain its cost leadership position while maintaining the development of advanced technologies from its home base in Germany; and

- *Twin Creeks* is a new US-based thin-film manufacturer that has received support to establish a facility in Perak. Twin Creeks is not a well-established global player yet, and much is yet unknown about their technology or prospects for serious ramp-up.

Using locally available and stranded hydropower in Sarawak, Malaysia has also established a small polysilicon plant with Tokuyama. The size of this plant is not yet of the scale of most major polysilicon plants around the world, but local hydro-resources and a need for high value added jobs in Sarawak combined to make this plant feasible.

Company	Origin	Location	Manufacturing	Capacity/ Yr	Employees	Start of Operation
First Solar	USA	Kedah, Kulim HTP	Thin Film Modules	1,500 MW	3,500	2008
Q-Cells	Germany	Selangor, SP2	C-Si ingots C-Si wafers, and cells	800 MW/ 500 MW	3,500	2009
Sunpower/ AUO	USA/ Taiwan	Melaka, Rembia	High Efficiency C-Si ingots, wafers, and cells	1,500 MW	5,500	2010
Tokuyama	Japan	Sarawak, Bintulu	Polysilicon	3,000 m.t.	500	2011
Twin Creeks Technologies	USA	Ipoh	C-Si cells and modules	500 MW	???	2012

Source: MBIPV Report, July 2010 with some modification from recent public data.



Local Suppliers to Support Manufacturing

Interviews with supply chain participants suggest that manufacturers use different levels of domestic content to support the establishment and operation of their manufacturing facilities. Sunpower suggested that they use a substantial amount of local content, where available at the appropriate level of quality and cost. They also suggest that they would be interested in continuing to develop domestic manufacturers to the required cost and quality levels, and have a deep experience doing this in the Philippines.

First Solar has a much more integrated manufacturing process, copied from its existing facilities in the United States and Germany. The company obviously uses a lot of local labor for construction and operations, but local content is limited in engineering and technology. There is substantial opportunity in import substitution of glass, subject to the availability of natural gas to power such a plant, and an appropriate MNC partner to establish the facility.

Some additional needs by major manufacturer include:

- *First Solar* — glass (efforts underway to establish glass factory in Malaysia), automation equipment (partly supplied by Great Tech, a local company);

- *AUO-SunPower* — additional vendors for machining, testing, non-critical process engineering R&D. Mostly, they need to qualify local vendors to the same quality and delivery standards of Philippine suppliers currently being used;

- *Q-Cells* — glass predominantly; and

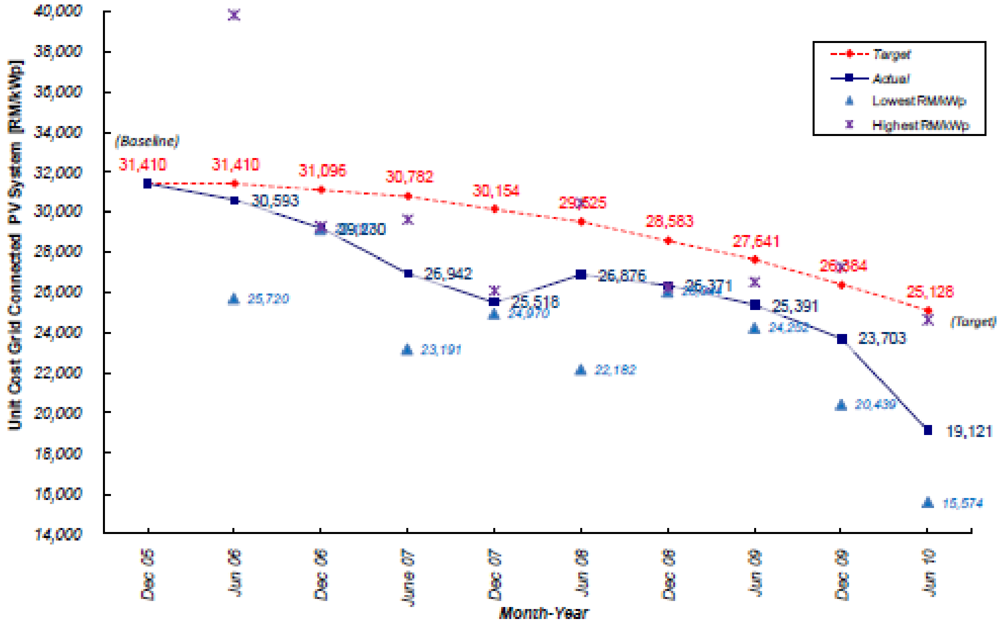
- Inspection machines and other equipment for quality control — *TT Vision* (a local company) is producing such machines for manufacturers in China but not yet supplying to the MNCs in Malaysia.

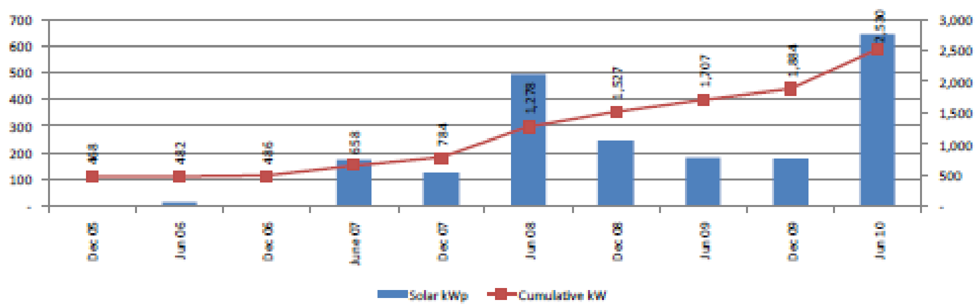
Other inputs and downstream products should also be evaluated for inclusion in the local solar cluster development. These include products that can provide opportunities to local companies such as inverters, charge regulators, aluminum frame, plastics, EVA, junction box and etc. However, each of these would require careful evaluation for long-term value benefits and defensible rents before committing substantial capital resources to their support.

Malaysian PV Installations

Malaysia has a history of support for small-scale and off-grid applications of PV. The chart below shows Malaysian PV installations to date by both volume and cost. The cost of PV systems has actually fallen faster than targeted in the original subsidy support programs, showing steady progression downward and falling to under RM20,000 per kilowatt by June of 2010.

Unit Cost of Grid-Connected PV System in Malaysia





Over 2.5 megawatts of PV have been installed to date in grid-connected systems, with another 8 MW installed in off grid systems. Compared to regional counterparts like South Korea (452 MW), India (180 MW), and China (311 MW), these are very low levels – but would need to be adjusted for country size, electricity use, and income differentials in order to be truly comparable. Even so, the scale of rollout would trail regional players. Thailand has signed nearly 2 GW of contracts to install solar PV in the last few years, and China and India have developed a backlog of many gigawatts each for installation over the next few years.[12]

Public Sector and Association Support

Malaysia has an emerging set of institutions designed to support the local PV industry. One such institution is the Solar Energy Research Institute (SERI), which was established on 1st July 2005. It conducts research and owns the necessary fabrication and testing equipment to perform research on solar PV among other solar and solar-integrated solutions. More information is available at http://www.ukm.my/SERI/index.html.

[12] http://www.renewableenergyworld.com/rea/news/article/2010/12/thailand-4300-mw-of-renewables-with-feed-in-tariffs?cmpid=rss

Key Opportunities

Clearly from the trends in the global marketplace described above, the global solar energy industry will continue to grow, even as it gets more competitive. In the last few years, Malaysia has shown substantial progress in claiming market share for wafer, cell, and module production and is on its way to potentially supplying 10 percent of these components globally.

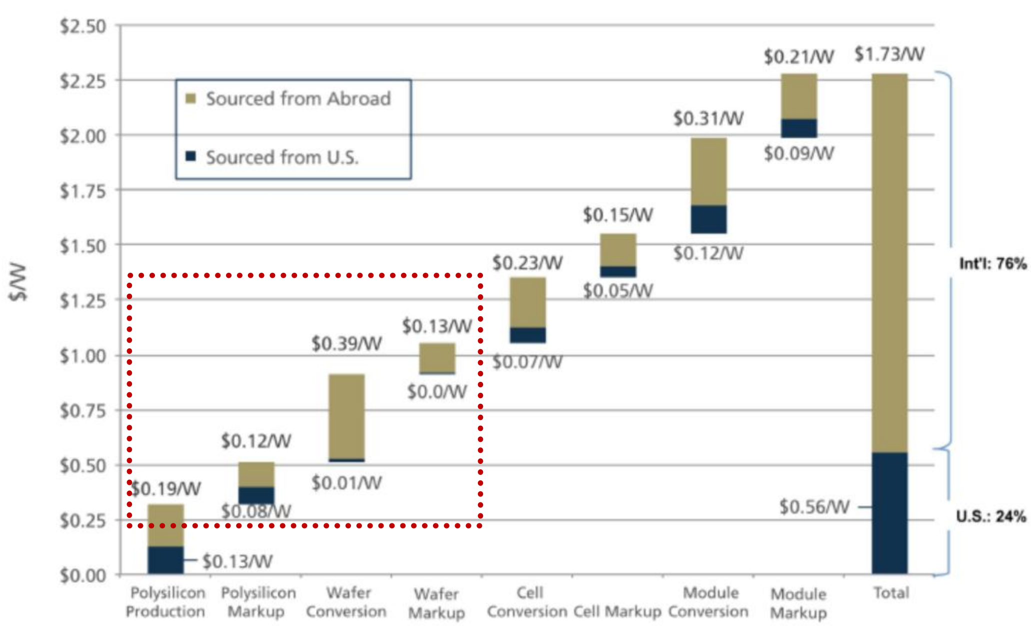
In order to continue taking advantage of the market growth, Malaysia needs to capitalize on its existing manufacturing base of both solar components and broader electronics to attract additional MNC manufacturers to set up or expand existing operations. Equally important, the focus should be expanded to include higher value added services in support of component manufacturing as well as downstream applications to install and use solar energy, where substantial value add can be achieved.

Opportunities in Additional Component Manufacturing

The chart below shows the relative turnover for each of the component types of a typical crystalline silicon module from the point of view of a purchaser in the United States. This chart is interesting because of the degree of imported value add that a typical module contains that is sourced in the United States. Much of the polysilicon and a meaningful portion of the equipment that goes in the manufacturing of PV comes from the United States. The rest of the value add (76 percent) would come from the foreign manufacture of modules such as one of the many Chinese, Taiwanese, or Malaysian manufacturers.

For the two large crystalline silicon manufacturers in Malaysia, Q-Cells and Sunpower, the value added turnover pool is limited to the portions of the supply chain between the wafer and the cell as highlighted in the red box on the chart.

Crystalline Silicon Module Value Creation, 2009



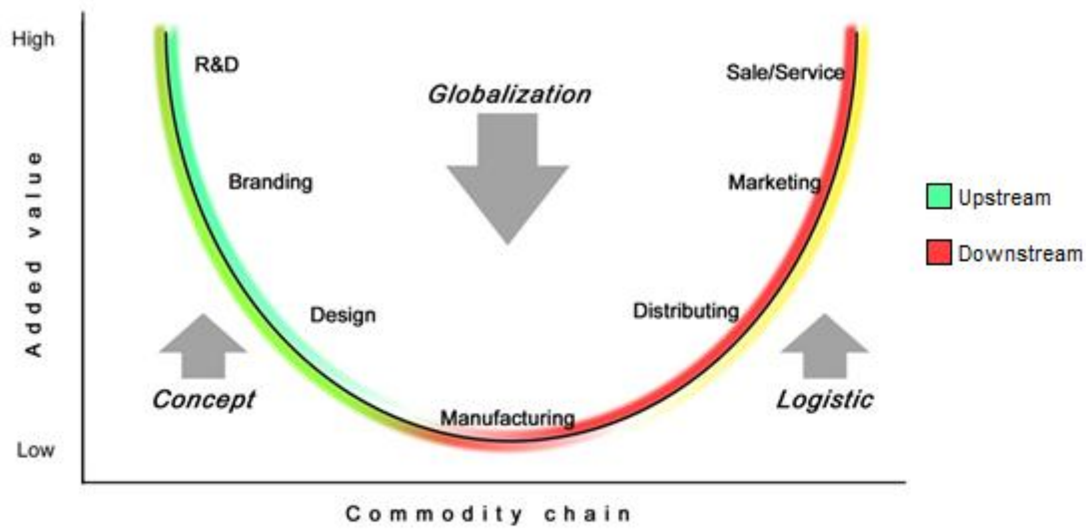
Source: GTM Research

Combining an understanding of the dynamics in the supply chain value map with market drivers leads to a few specific conclusions. First, the amount of total economic value add between the wafer and the module stands at about USD1.00 per watt today and is falling over time. A substantial amount of that economic value add is exported in the form of profit, capital equipment, and imported feedstocks. The remaining portion is available to support labor in the Malaysian economy, but will constantly be under pressure of compression going forward.

In conclusion, continuing to attract high volume manufacturing will be a better way to increase the amount of economic value added available to Malaysia from PV component manufacturers. Market growth requires additional factories, but at ever competitive prices.

Opportunities in Additional Value within Component Manufacturing

Two possible pathways exist to capture more value add within component manufacturing of any industry, and specifically the PV industry. The first is demonstrated by the smile curve which suggests that low-cost manufacturing can lead to either more value added content than manufacturing in the pre-production areas of development or design or in the downstream distribution, marketing, or sales. In the case of Malaysia, foreign PV manufacturers have come in with both the beginning and the end of the smile curve handled in-house by the same manufacturer, leaving very little room for appropriating additional value added.



The second primary form of value absorption is import substitution. Increased value add from import substitution is most easily accessible through feedstock substitution, which will serve the dual purpose of increasing the pool of economic value added available to the Malaysian economy and making Malaysia more attractive as a place to establish and retain manufacturing facilities for MNCs. In terms of the total value of imports, module manufacturers are dominated by the requirement for *imported glass*, while cell manufacturers primarily need *raw polysilicon*. Both types of manufacturers have requirements for additional *consumables* (such as laminates, tabbing and stringing, etc.), some of which may already be available through the electronics industry established in Malaysia.

Beyond imported consumables, manufacturers require a substantial investment in capital equipment to build their manufacturing lines in Malaysia. Most of this capital equipment is either high-end precision equipment specifically designed by MNCs for deposition (and integral to their competitive advantage) or is process equipment that is bundled by the general contractor for facilities construction, often a multinational engineering firm that sources components from around the world. Each MNC facility has a different combination of capital equipment needs that are designed in at the time of construction, and generalization or broad market opportunity is hard to identify.

Other potential sources of economic value add would be to capture additional economic rent from branding or differentiation as a result of Malaysian source. The main vehicle for doing this would be domestic firms establishing credibility abroad, a difficult proposition as long as all of the substantial manufacturing is being conducted by foreign MNCs.

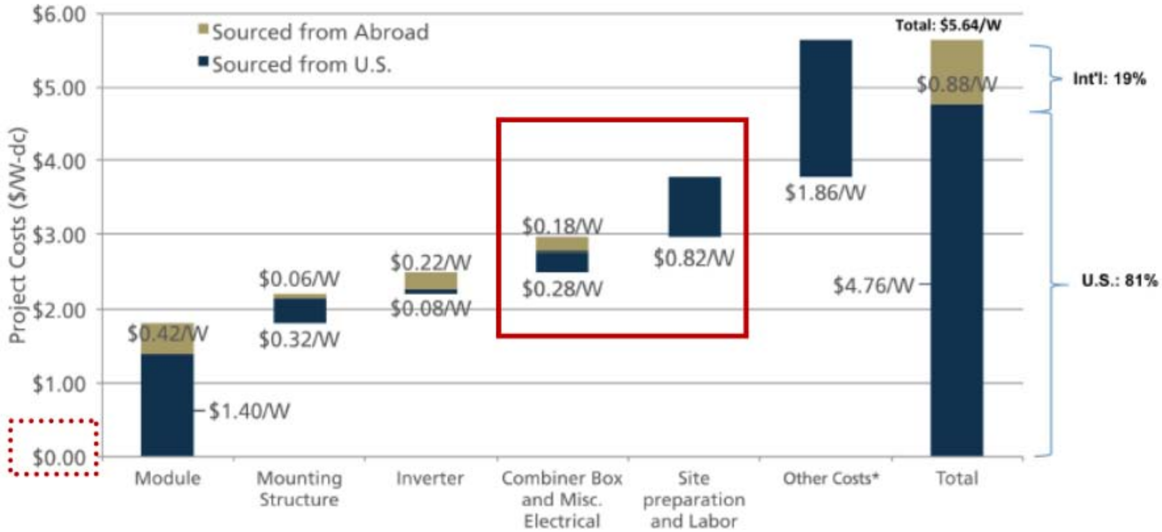
Opportunities in Downstream Installation

Beyond the combination of capturing more of the pool of economic value added within the module and a larger volume of modules being produced in Malaysia, there is a tremendous amount of economic value add available in the installation of modules and systems for domestic consumption.

The chart below suggests that there is a substantial amount of labor, logistics, and business processes involved in the installation of PV systems that far exceeds the amount available in intermediate steps of module manufacturing. It also has the advantage of being fundamentally non-exportable, as these items must be performed at or near the site where the system is installed. In total, these components exceed USD2.50 per watt for the large commercial installations, and can be as much as double that for an efficient residential or off grid application.

The larger red box on the chart shows the amount of value add available for domestic installations versus the small red box with dotted lines on the left showing value add for the module components available to current crystalline silicon manufacturing in Malaysia. Other interim components like mounting structures or miscellaneous electrical components can further add to that large pool of domestic content for installations.

Domestic Value Creation, Thin Film PV System, 2009



Source: GTM Research

Note: *Includes: permitting, legal, engineering, financing, distribution and value chain mark-up

Obviously the low volume of domestic installations limits the pool of profits available, until that volume can grow. A chart in the previous section shows that volumes continue to increase, and recent reports suggest that the market could achieve 11 MW of installations in 2011.[13] While this may seem low in terms of total domestic capacity, recent experience in the Chinese market shows how quickly things can grow from a small base.

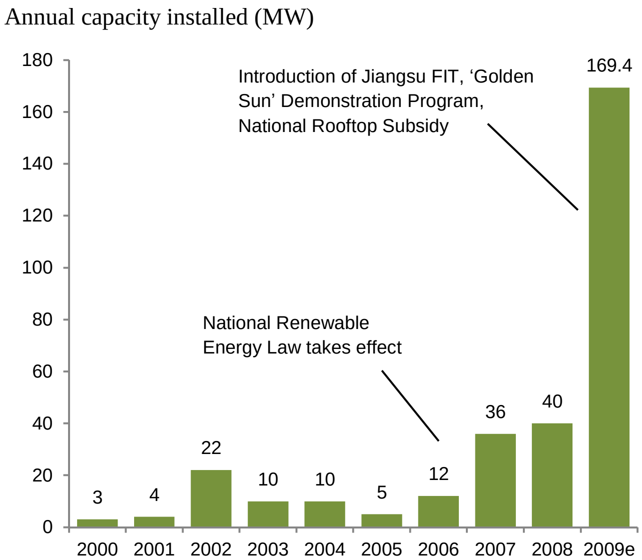
Highlight: Chinese Demand Growth

The chart below shows annual PV demand for China since 2000, with a description of the policy programs that help support that growth. It shows a good story of market growth potential over short time horizon. As recently as 2006, China had consistently averaged less than 15 MW of domestic installations. In 2007 and 2008, they were 40 MW or less which would be below Malaysia's current rate on a population adjusted basis.

The establishment of a FIT in 2009 saw substantial increase in the domestic installations, led by large industrial systems in the far West, though additional programs are coming online to support distributed applications in the commercial and residential sectors. A number of other countries in the region are establishing FITs, and many best practices guides are available to access the experience of those efforts.

[13] http://biz.thestar.com.my/news/story.asp?file=/2010/11/22/business/7459156&sec=business

Annual PV Demand and Policy Timeline in China, 2000-2009



Source: GTM Research

Key Bottlenecks

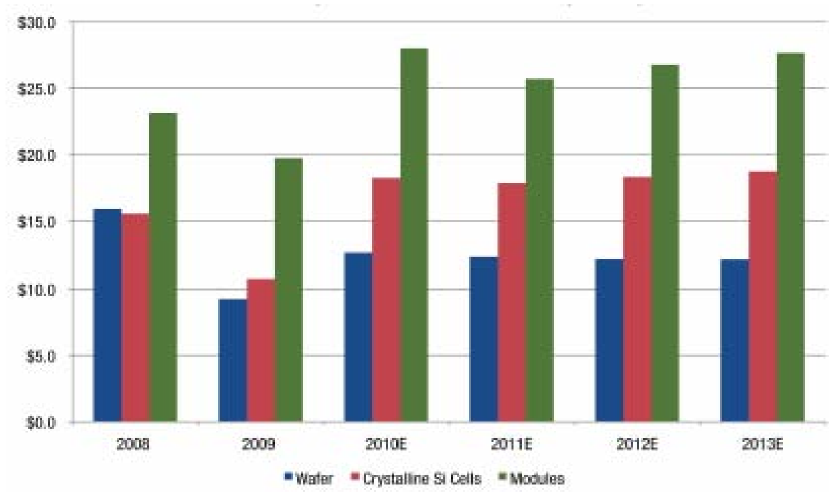
As Malaysia is essentially a price taker for solar manufacturing, it will be important to continue to remain a competitive manufacturing center in order to attract and retain large component factories. Most of the forces that will create constraints on the global marketplace are external.

External Bottlenecks

Bottleneck #1—Total Global PV Revenues Stagnate Even While Volumes Rise

As described in previous sections, global volumes of PV should continue to increase in line as demand continues to increase in both the developed and developing world. Grid parity will continue to be strengthened around the world, but simultaneously requires increased volumes and reduced prices.

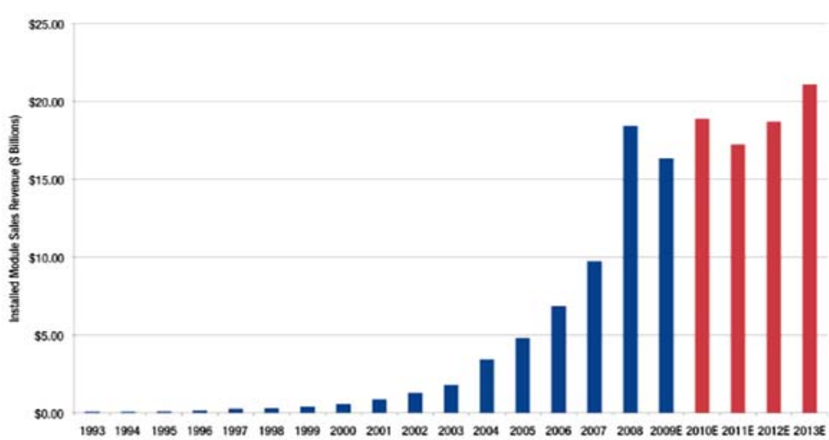
Global PV Component Revenues, 2008-2013E (million USD)



	2008	2009	2010E	2011E	2012E	2013E
Shipments (MW)						
Wafer	6,334	8,895	15,026	16,642	20,484	23,138
Crystalline Si Cells	5,721	7,668	13,368	14,569	17,877	20,285
Crystalline Si Modules	5,024	6,267	11,691	12,452	15,046	17,231
Thin-film Modules	920	1,784	3,060	3,981	5,216	6,124
Modules	5,945	8,051	14,750	16,433	20,262	23,356
ASPs ($/Wp)						
Wafer	$2.51	$1.04	$0.85	$0.75	$0.60	$0.53
Crystalline Si Cells	$2.72	$1.41	$1.36	$1.22	$1.02	$0.92
Crystalline Si Modules	$4.15	$2.41	$1.98	$1.64	$1.38	$1.24
Thin-film Modules	$2.47	$2.59	$1.57	$1.34	$1.14	$1.03
Revenue ($ Billion)						
Wafer	$15.9	$9.3	$12.8	$12.4	$12.3	$12.3
Crystalline Si Cells	$15.6	$10.8	$18.2	$17.8	$18.3	$18.7
Crystalline Si Modules	$20.9	$15.1	$23.2	$20.4	$20.8	$21.3
Thin-film Modules	$2.3	$4.6	$4.8	$5.3	$5.9	$6.3
Modules	$23.1	$19.7	$28.0	$25.7	$26.8	$27.7

Source: GTM Research

Global Installed Module Sales Revenue, 1993-2013E



Source: GTM Research

Above is a forecast for how much component volumes and revenues will change by 2013. Single-digit growth in total turnover is more likely to be the case going forward than the strong double-digit growth that has occurred for the last decade.

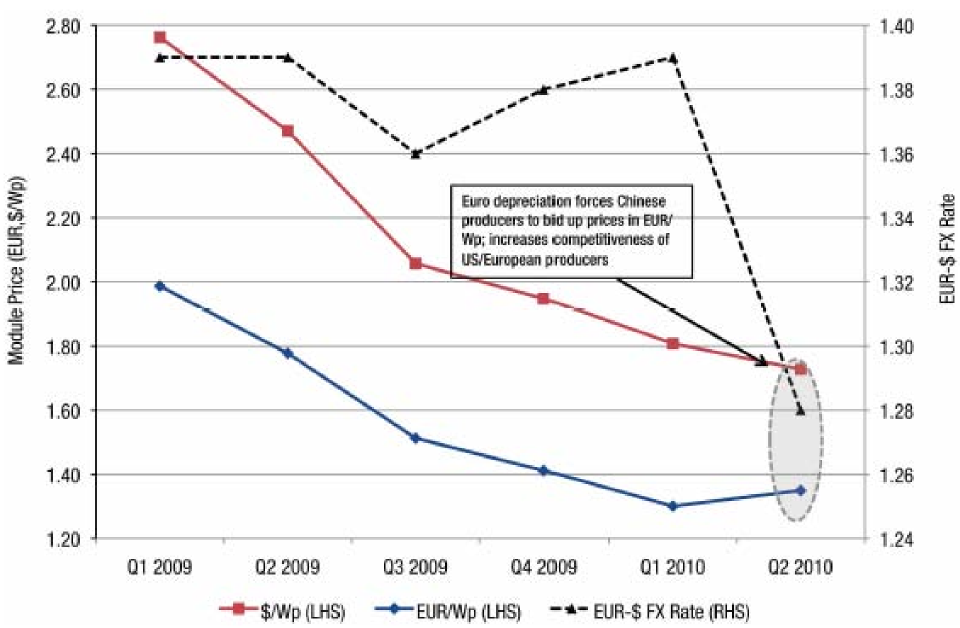
Some relief on the downward pressure of prices should occur as rising grid electricity prices allow grid parity to occur sooner and with greater strength in the markets of Europe and North America. However, strong competition for suppliers of components, particularly from China and Taiwan (POC), will keep the pressure high.

Bottleneck #2—Exchange Rates Will Change Competitive Dynamics among Europe, US, China, and Other Regions

There is substantial potential for a global disruption in exchange rates over the next few years. Already, many nations are engaged in a war of rhetoric over currency as an export support tool, and difficulties in fiscal imbalances in both Europe and the United States suggest that downward pressures on those currencies relative to China and other Asian currencies will persist.

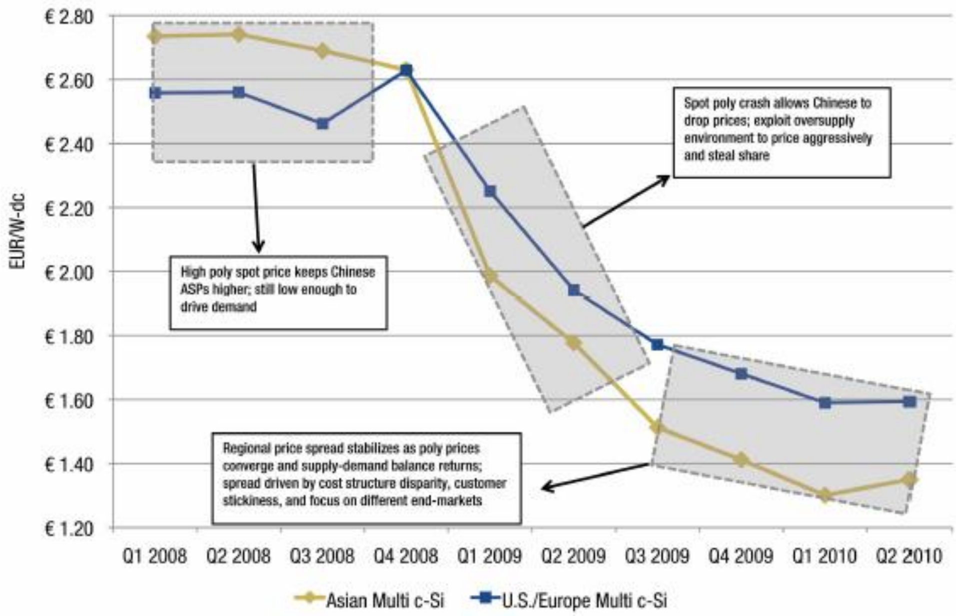
Given that the PV industry is highly globalized, with significant trade flows, currency exchange rates can have a material impact on prices across the value chain. The figure below displays the effect of the Euro/US exchange rates on Chinese crystalline module prices (sold primarily into Europe) over the last year and a half. Cost for Chinese module producers are usually denominated in dollars, while the sales are in Euros. The significant appreciation in the euro over 2010 forced Chinese producers to raise prices in Euros to protect their gross margins.

Effect of Exchange Rate on Chinese Multi c-Si Module Average Selling Price, Q1 2009-Q2 2010



Source: GTM Research

Chinese c-Si vs EUR/US c-Si
Average Selling Prices, Q1 2008-Q2 2010



Source: GTM Research

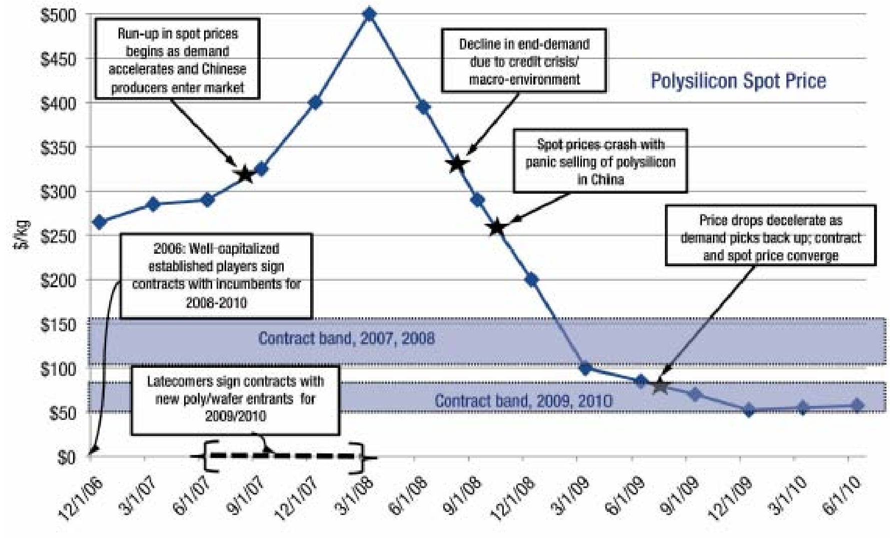
Continued downward pressure on the euro, or the dollar, would make modules produced in those locations more competitive versus Chinese imports. How Malaysia's currency does versus both Western counterparts as well as China, will determine its relative economic advantage as a cost center. In the most severe case, a breakup of the Euro union or dramatic downward revaluation exceeding 20 percent would see a shift toward Europe as a location for manufacturing.

Bottleneck #3—Limited Value Add in Polysilicon due to Ample Global Supply

Polysilicon will experience similar pressures over time, and the largest manufacturers are establishing facilities today that cost well in excess of USD1 billion to set up. The minimum economic unit, i.e. the smallest plant that can economically be run and compete in the global marketplace, is now well in excess of 10,000 metric tons per year. This is far larger than any contemplated plant in Malaysia.

In addition, the collapse in global polysilicon prices since the fourth quarter of 2008 has significantly reduce the amount of value added in this part of the supply chain. The chart below shows the chronology of the polysilicon market dynamics, and many of the global cell and module dynamics discussed above will continue to keep polysilicon prices and margins low for an indefinite period of time.

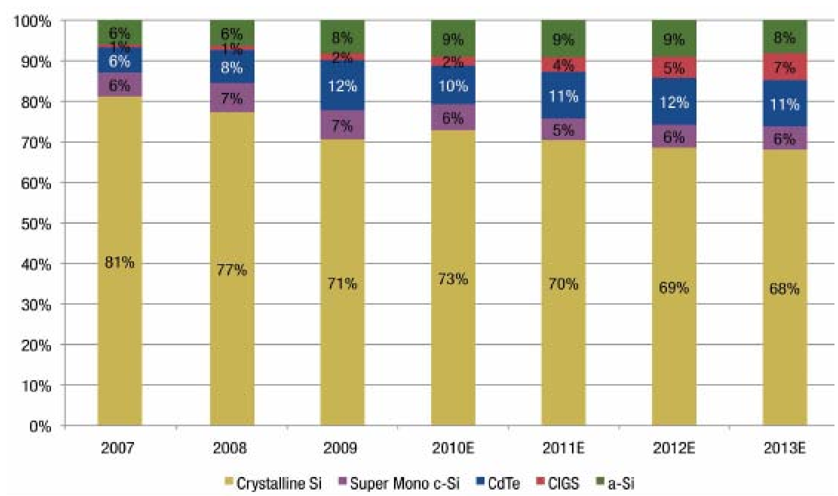
Chronology of Polysilicon Market Dynamics, Q4 2008-Q2 2010



Source: GTM Research

Another limit to the demand for polysilicon will come from increasing penetration of thin-film technologies in the marketplace. The chart below shows a forecast of market dynamics and shifting market share towards second-generation thin-film technologies and away from crystalline silicon-based technologies. Cheaper manufacturing of cells and modules, less capital required to set up manufacturing facilities, and smaller minimum economic units for those factories all will contribute to this trend.

Module Market Share by Technology, 2007-2013E



	2007	2008	2009	2010E	2011E	2012E	2013E
Standard Crystalline Si	81%	77%	71%	73%	70%	69%	68%
Super Monocrystalline Si	6%	7%	7%	6%	5%	6%	6%
CdTe	6%	8%	12%	10%	11%	12%	11%
CIGS	1%	1%	2%	2%	4%	5%	7%
a-Si	6%	6%	8%	9%	9%	9%	8%
Thin-Film Share	12.9%	15.5%	22.2%	20.7%	24.2%	25.7%	26.2%

Source: GTM Research

Internal Upstream Bottlenecks

Large global manufacturers are very concerned about locating in jurisdictions that meet a variety of, sometimes conflicting, needs. MNCs certainly want to keep domestic construction and labor costs low, but also must be concerned about issues of logistics and transport, availability of low-cost domestic inputs, and protecting their property investments. Malaysia has attracted a number of top international companies because it scores well on many of these, but a few challenges remain in attracting additional manufacturers or expanding the contribution to those manufacturers' production.

Bottleneck #1—Emerging Global Leaders Very Concerned about Intellectual Property (IP) Protection and Domestic Competition

All manufacturers are concerned about driving costs down, but are also concerned about protecting their IP and maintaining a competitive advantage for as long as possible. The most advanced and aggressive manufacturers that are looking to substantially grow their technology are either Chinese-based companies pursuing low-cost strategies or advanced European and American firms with second-generation thin-film technologies trying to compete with their Chinese counterparts.

A large number of companies looking to compete with Chinese manufacturers are very concerned about establishing plants or joint ventures in China, precisely because of concerns over IP protection. Many of these companies, particularly those that chose to set up shop in Malaysia, maintain strong reservations about working in a jurisdiction with lots of cross pollination or opportunities for appropriation of process or product IP. These companies have well-established technologies and advanced tooling that they would like to keep proprietary. In order to do so, they have steered clear of Chinese initiatives, favoring less risky locations that offer the same low-cost labor opportunity. In fact, the most extreme interpretation of this situation suggests that a dearth of domestic competitors is one of the most attractive features of locating in Malaysia.

The bottleneck that emerges is one where manufacturers are going to be very reluctant to share technical information, even when their product needs overlap. It also may lead to a situation where manufacturers prefer dedicated first-tier suppliers, rather than sharing the benefits of how they perform their production with other users of the suppliers. Caution should be exercised when trying to encourage collaboration or shared services in order to ensure that manufacturer still feel adequate protection and security for their IP.

Bottleneck #2—Relatively New Relationship between MNCs and Local Content Providers Limits Absorption of Higher Value Add in Second- and Third-Tier Inputs

Despite Malaysia's strong presence in global PV manufacturing, it is still relatively new to Malaysia and its domestic manufacturers who might be well-placed to provide local content into the factories. Discussions with Sunpower suggested that it took a number of years in the Philippines to accurately train and certify local manufacturers on components of the required quality. While Sunpower would like to use more local content, it will take time to do the same qualifications for domestic Malaysian suppliers.

This is not to suggest that local manufacturers are not capable of meeting the needs of MNC producers, simply that they have not yet developed the precise requirements and trust with the manufacturers in order to provide critical inputs. Helping to make sure that local producers are engaged in dialogue with PV manufacturers, establishing training programs, and helping to provide finance for necessary capital equipment would be instrumental in speeding up this process.

Bottleneck #3—Dearth of Domestic Glass Manufacturers

The single largest consumable cost of a module plant is glass, and with no domestic glass manufacturing that meets manufacturers' requirements all of this needs to be imported. As First Solar has the only module plant to date, the impact is limited to this company. However, Q-Cells and Sunpower both produce a large number of cells that could also be assembled into modules if the economics and availability of low-cost inputs allowed it. Any future expansion of thin-film manufacturing, regardless of which company was producing it, would most likely require glass for the module as well. The amount of glass that could be consumed is substantial and might even exceed in value add the PV itself.

From discussions with EPU and others, it seems that a number of attempts to co-locate a glass plant near the First Solar plant have occurred. While most people recognize the potential for value add of such a plant, there is little optimism that the required inputs of that plant — specifically large quantities of natural gas to power the process — can be obtained locally. It is believed that the primary obstacle to obtaining natural gas for glass plants is pre-commitments to other domestic consumption and international export contracts. This should be looked at in more detail.

Internal Downstream Bottlenecks

The focus for Malaysian PV has been on upstream manufacturing and attracting MNC factories, and less work has been done on downstream value capture. As a result, more substantial bottlenecks exist and much more work has to be done in order to establish a marketplace.

Bottleneck #1—Lack of Domestic Market for PV

Aside from a small off-grid program discussed above, very little work has been done to develop the domestic consumption of PV. A strong belief pervades observers in Malaysia that solar energy is too expensive to be useful for domestic use. This belief is an obstacle for the kinds of work that are required to continue to drive costs down to grid parity and beyond. Only an investment in the local marketplace and a pool of integrators and installers can help to achieve the economies of scale necessary to make solar cheaper to install and use.

The 'unit cost of grid connected PV systems' chart in the section above shows two very important points about the cost of PV systems: 1) that PV systems can achieve substantial cost reductions, even on small incremental volumes of annual installations, and 2) that the cost reductions typically exceed expectations set out at the beginning of these programs. Many other countries in the region and at similar levels of development around the world have established domestic programs and learned valuable lessons about appropriate program design and implementation.

The combination of low-cost Malaysian modules and a well-designed program for PV deployment at the distribution and utility scale levels would create substantial value add for generations to come. The value add from both the local inputs required to deploy systems and in the consumption of local and low-cost electricity would persist in scope and is fundamentally non-exportable.

Bottleneck #2—Lack of Bank Financing to Pay for Installations

Due to the nature of PV installations, the vast majority of expenses of PV electricity are paid upfront at the time of installation of the system. This creates a very large capital requirement for installation, but provides a very stable and easily measured value stream that can be used to support credit for such a capital requirement.

In order to adequately grow downstream in the PV market, some form of finance will be required in order to spread the cost of capital over the lifetime of the system. Banks are currently not familiar with the technology or risks associated, but experience elsewhere in the world suggest that once they become comfortable they are enthusiastic providers of this type of capital. Unfortunately, without encouragement from the public sector and a stable marketplace in which to lend funds it is unlikely that banks will quickly get behind PV technology and may prove powerful bottleneck in downstream development.

Policy Recommendations

Aggregating the understanding of the global marketplace for both PV components and installed systems leads to some very specific policy recommendations to overcome bottlenecks and to continue to expand the pool of value add in the Malaysian PV industry.

These recommendations have been broken out by upstream and downstream recommendations to differentiate the two markets and understand that these are functionally different problems. Within each of these two categories of recommendations, they are further broken out into market and smile curve recommendations. Specifically, market recommendations are how to expand the size of the value added pool, while smile curve recommendations are those that will allow domestic manufacturers to capture a higher proportion of that pool.

Upstream Market Recommendations

Recommendation 1a—Vertically Integrated Manufacturers Will Be the Main Drivers of Component Value Add

The global supply chain of PV components will continue to consolidate around the top 15 to 20 producers worldwide in an effort to continue to drive down costs and prices for manufacturing those components. The majority of those top producers will continue to reside in China unless a substantial change in the currency rates change the competitive landscape away from advantage in China. As a result, most global value add for PV components not manufactured by Chinese national firms will be concentrated in less than 10 major companies headquartered in the United States, Japan, and Europe. These companies will all need low-cost manufacturing centers with adequate technical capabilities and local talent to staff them.

Malaysian authorities should actively court the three major global players that already meet this description, as well as the remaining players that will need similar capabilities. In the absence of success in bringing these gigawatt scale manufacturing plants to Malaysia or retaining the expansion of existing plants, Malaysia will have a very hard time supplementing or replacing the amount of value add that they represent.

Recommendation 1b—Find and Actively Recruit MNCs with Common High-Value Components To Incentivize Building Additional Integrated Manufacturing Capacity

While not all cell technologies are the same, some commonalities may occur within technology bucket such as crystalline silicon or thin-film. Unfortunately, as described in the bottleneck section above, many companies are going to be concerned about sharing the proprietary aspect of their deposition technology with local competitors. Some work should be done to determine common inputs within the second- and third-tier suppliers as a way to incentivize additional manufacturing to be placed in Malaysia and retain existing production.

The one area where common high value components could be used across all module manufacturers or cell manufacturers that would consider module packaging as an extension of their current operations is in glass manufacturing. Glass is a common input for all modules though some quality and materials characteristics differences do exist. It is entirely likely that glass will persist as a large component in module manufacturing well beyond the advancement of deposition technology into later generations, and could serve to retain PV manufacturing in Malaysia over many generations of the technology.

Conversely, this argument does not apply to polysilicon manufacturing. For reasons that have to do with minimum economic unit size of a polysilicon plant as well as the value-to-weight ratio of polysilicon, it is not likely to be a good long-term defensible source of economic value add or compelling local component for retaining PV cell and module facilities the way glass would be. Locally manufactured glass does provide an economic benefit, while locally manufactured polysilicon does not.

Upstream Smile Curve Recommendations

Recommendation 2a—Target Ancillary Services to Support Domestic Component Manufacturing

Malaysian economic development staff should be actively pursuing conversations with existing manufacturers to determine what kind of inputs and consumables into facility construction and operation might be made locally as import replacement for things already consumed.

This initiative will require:

- Determining items that are currently being sourced externally, and matching it to available or potential domestic sources of similar content;
- Potentially deeper conversations with international subcontractors such as engineering firms, design firms, and construction companies that are actually engaged in the bulk of procurement

decisions across various stages of completion; and

- Helping to bridge the skills gap of local providers to the required content quality and performance characteristics through training, certification, and access to capital investment when required. It might be quite helpful to establish a directory of component and service providers with capabilities in collaboration with MNCs.

Recommendation 2b—Promote Initiatives to Integrate Manufacturers into a Forum for Discussion of Common Inputs that Require Local Capacity Development

Existing initiatives for Malaysian trade associations should be broadened as a forum for further discussion on community engagement. If solar corridors are going to be effective, some forum will be necessary to overcome the geographic distances between various companies and the natural aversion to collaboration among globally competing firms.

Downstream Market Recommendations

Recommendation 3a—Dramatic Extension of Domestic Demand Stimulation- Advanced FIT Program

Compared to upstream market development, downstream development for the use of solar energy is practically nonexistent. The use and cumulative installation of PV systems creates local infrastructure for providing energy solutions that not only continues to drive down the cost of installing solar in perpetuity, but also creates capabilities that will be available as supplemental distributed generation and storage technologies emerge to complement solar generation. Without a strong commitment to domestic installations, these capabilities will not spontaneously emerge for a long time, leaving substantial economic benefit unavailable to the local economy.

Substantial improvement in PV deployment can be achieved, if properly designed, with a minimal of excess cost or dead weight loss by following models that have been developed in China, Thailand, Korea, and California. It should target across the three main sectors of utility scale PV, distributed residential and commercial PV, and off grid systems with storage. While FITs may seem optimal based on experience in Germany and Italy, advanced auction mechanisms should also be considered to ensure the responsible use of available public funds.

One currently favored proposal to accomplish this goal is a FIT mechanism, a type of stimulus program used successfully in Germany, Italy, and a number of other jurisdictions. While some of these programs have had mixed success, much has been learned about good program design over the last decade. Design elements of the most successful programs include:

- They are volume-based not price based, which leads to cheaper and less negative repercussions such as over-funding and consumer backlash (California);

- Spread volumes over installation types (California and Germany);

- Stable and predicatable with incentives to move quickly (Germany and Japan);
- Price high enough to provide fair equity return, subject to financing (Many);
- Easy access to the grid interconnect (Germany); and
- Availability of low-cost finance (Germany and Japan).

Recommendation 3b—Domestic Programs Are the Only Way to Achieve Grid-Parity

With module prices falling quickly, some people suggest that incentive programs might be unnecessary to stimulate domestic uptake of PV systems. This is not true due to a couple of misperceptions about falling PV prices.

First, PV module prices are set globally and falling at the rates discussed, but they only make up about half of the cost of an average system. The other half is often referred to as the balance of systems (BOS). The BOS components mostly involve labor, installation, racking, and other solutions that are locally sourced — as opposed to modules that are defined globally. While volume drives down costs in both, it is only domestic volume that drives down BOS costs, and without major incentive programs for domestic installations grid parity cannot be achieved. Fortunately, as described above, nearly all of that domestic content creates domestic income and is subject to a local jobs and income multiplier effect.

Second, achieving grid parity is not sufficient, by itself, to guarantee PV uptake by a local market. Many other obstacles exist in nascent markets including risk perceptions, lack of access to finance, maintenance infrastructure, etc. that a well designed domestic incentive program can overcome in the short run. The recommendations of program design above are designed to help overcome these obstacles based on the experience of many other markets from Japan to California to Germany. Once both grid parity and appropriate market institutions are established, the market will be able to function without further support from the government, but domestic incentive programs are key to getting to that point quickly and efficiently.

Recommendation 3c—Engage Utilities in a Process of Mutual Benefit around PV Installations, without Compromising Ability to Deliver Low-Cost Solutions

Experience in other countries suggests that utility engagement is a strong enabler of a successful PV deployment program. Utilities are appropriately concerned about adequate security and operation of grid systems, and have the largest collection of local talent around electrical engineering, infrastructure, and customer engagement. Put to work productively, these resources can be a substantial asset in accelerating PV deployment and reducing costs. Handled incorrectly, utilities can either waste resources and cost the system cost for PV installations to rise unnecessarily or can make interconnections and financial relationships difficult or impossible.

Recommendation 3d—Expand Access to Finance for Each of the System Types Being Supported through Demand Programs

Given the capital-intensive nature of PV system installation, few programs are successful without supplemental financing designed specifically for PV technology and available for prospective customers. The elements of a good PV finance product will recognize the stable value that PV systems can provide when backed by solid tariff regimes from the utility or government, and will provide a low cost of capital due to the certainty such schemes provide. Government guarantees can further bring down the cost of financial capital, and streamline application processes will help to improve the chances of any specific transaction being completed. Similar financing components, alongside their tariff in rebate programs, are credited with helping both Japan and Germany rapidly expand their domestic PV market.

Elements of support are already in place in Malaysia, such as the Green Technology Financial Scheme (established early January 2010). This scheme provides soft loans to companies supplying and utilizing green technology.

Recommendation 3e—Use Government Procurement to Stimulate Domestic Demand

The government and military in any jurisdiction often represent the largest energy consumers by far. These energy consumers can become a critical first customer for emerging delivery and integration businesses, helping to jumpstart the development of skills and capabilities in the local market. An easy way to implement such a program with little resistance would be to mandate that all new buildings or substantial renovations of existing buildings include solar generation (and perhaps even energy efficiency measures to reduce generation requirements) as an element of that construction. This would allow for a phased rollout, and success in the program may encourage later changes to a more aggressive retrofit plan.

Recommendation 3f—Establish Favorable Pricing for Domestic Use of PV from Existing or Potential New Manufacturers, Helping to Lower Cost of Installations

Malaysia produces the cheapest PV modules in the world at the First Solar plant in Kedah. Sunpower cells are some of the most efficient available anywhere and could be packaged into low-cost modules None of the modules produced by either company are used locally. Aggressive steps should be taken to provide advantaged pricing for modules used in Malaysia that are produced in Malaysia. This could be achieved in a number of different ways including bulk purchasing, negotiating an option agreement for local consumption, or making sure that any future value in trade from the Malaysian government allows for some small percent (starting at less than 1 percent) of modules produced in the factory be made available at a favorable price.

A second way to do this without requiring the consent of current or prospective manufacturers would be to create a domestic content preference in downstream support programs or procurement efforts. These would result in a small premium being paid for electricity that uses domestically manufactured components, justified by the additional value add of domestic labor content in the manufacture of those modules.

Downstream Smile Curve Recommendations

Recommendation 4a—Institute Training Programs to Ensure Local Skills are Available to Meet Demand Growth

Should domestic use of PV begin to ramp dramatically in line with the experience of other countries, labor and skills would likely present the next bottleneck in deployment. A number of skills will be required to install PV systems that may not currently be in abundant supply or ready to instantly port over for use, including wiring and racking, engineering and design, and system monitoring and certification. These skills are well understood in other places and training programs can be made available to people with similar skills or appropriate qualifications to gain precise capabilities in the solar sector.

Recommendation 4b—Develop Prepackaged Solutions for Export to Markets in the Developing World

Once solutions have been developed for domestic use — particularly those that are unique to any of the income and physical infrastructure level of Malaysia, the geography and ambient weather conditions, or the large proportion of off grid and village level systems — these solutions could be packaged and made available as export products in the form of kits or integrated services. A number of surrounding countries throughout all of Southeast Asia, and as far away as Africa, could benefit from the IP of optimal system design and installation under similar circumstances.

Ancillary components might be required to help facilitate an export strategy for these solutions including trade finance, export encouragement, foreign office support, and additional training and certification. Given the likely strong growth of energy demand in most of these markets and dearth of alternatives available to them, being able to deliver solar products and solutions is likely to be a growth market for a long time to come.

Moving Up the Value Chain in the Medical Device Industry

Turning to the medical device industry (MDI), this section follows the same structure as the discussion on the solar industry. In what follows, the global industry structure is first described. Malaysia's position within the global value chain is then discussed. The next section examines the opportunities available for moving up the value chain. This is followed by a discussion of the existing bottlenecks that may be blocking Malaysia from capturing these potential benefits. The final section offers policy suggestions specific to the MDI for removing these bottlenecks so that Malaysia can achieve its full potential as a major player in the global MDI.

The Global Medical Device Industry Structure

The Wide Span of the Medical Device Industry

The MDI is not homogeneous. In fact, it is a not really an industry at all, but a number of research, development and manufacturing industries all involved in various activities that support human health care. It spans an extremely wide range of industries from rubber and latex, textiles, machinery and engineering support and electronics. The key products that comprise the MDI include surgical appliances and supplies, surgical and medical instruments, electro-medical equipment, in-vitro diagnostic (IVD) substances, irradiation apparatus, dental and ophthalmic goods.

Within Malaysia, the MDI includes firms producing basic hospital supplies such as gloves and bandages, others producing orthopedic devices and yet others involved in the development and manufacture of extremely complex instruments such as defibrillators, magnetic resonance imaging (MRI) equipment and radiation therapy devices. In addition, there are firms that manufacture incubators for new-born babies, dialysis machines, hearing devices, dental implants and many more 'aids' used for the improvement of human health. Finally, there are diagnostic companies that discover and produce tests and kits to discover and analyze illnesses.

The main types of medical device companies are categorized by the North American Industry Classification System (NAICS) codes as follows:

339113 Surgical Appliances and Supplies Manufacturing
339114 Dental Equipment and Supplies Manufacturing
325413 In-Vitro Diagnostic Substances Manufacturing
339112 Surgical and Medical Instrument Manufacturing
339115 Ophthalmic Goods Manufacturing
334517 Irradiation Apparatus Manufacturing
334510 Electro-medical and Electrotherapeutic Apparatus Manufacturing

- Surgical appliances and supplies (NAIC 339113) is the largest medical device subsector, about 28 percent of the total measured by value of shipment (VOS), globally. The category covers a wide range of products, including artificial joints and limbs, stents, orthopedic appliances, surgical dressings, disposable surgical drapes, hydrotherapy appliances, surgical kits, rubber medical and surgical gloves, and wheelchairs;

- Surgical and medical instruments (NAIC 339112) are the second-largest subgroup (about 26 percent of VOS) of the MDI. The category includes anesthesia apparatus, orthopedic instruments, optical diagnostic apparatus, blood transfusion device, syringes, hypodermic needles, and catheters;

- IVD substances (NAIC 325413); about 10 percent of the total measured by value of shipment for medical devices include chemical, biological or radioactive substances used for diagnostic tests performed in test tubes, Petri dishes, machines, and other diagnostic test-type devices;

- Electro-medical equipment (NAIC 334510) manufacturers; the third-largest subsector accounts for about 19 percent of VOS, produce a variety of powered devices, including pacemakers, patient-monitoring systems, MRI machines, diagnostic imaging equipment (including informatics equipment), and ultrasonic scanning devices;

- Irradiation apparatus (NAIC 334517); accounts for about 8 percent of VOS includes X-ray devices and other diagnostic imaging, as well as computed tomography (CT) equipment;

- Dental equipment and supplies (NAIC 339114); about 5 percent of total measured by VOS consists of equipment, instruments, and supplies used by dentists, dental hygienists, and laboratories. Specific products include dental hand instruments, plaster, drills, amalgams, cements, sterilizers and dental chairs;

- Ophthalmic goods (NAIC 339115); about 5 percent of total measured by VOS include eyeglass frames, lenses and related optical and magnification products; and

- Dental laboratories (NAIC 339116); about 4 percent of total measured by VOS include crowns, dentures, bridges and other orthodontic products.

According to Espicom Business Intelligence, the size of the MDIs worldwide and including all the categories enumerated above is USD223.3 billion in total revenues in 2009 with a recent growth rate of nearly 6 percent per annum during the last 3 years. This is only a fraction of the total revenues of companies in the health care industry, however, which totaled almost USD6 trillion during the same year.

More than 75 percent of global health care industry revenues come from such sub-sectors as Cardiology, Dialysis, Radiation Therapy and ultrasound, incubators, and other complex medical devices such as MRI and X-ray machines. It is in these ‘sub-industries’ that most of the value added is produced. The MDIs make up only a fraction of the total spending in Health Care. But medical device companies have been growing at a faster rate than pharmaceutical companies during the last 5 years, worldwide.

The Global Setting

Industry Characteristics

The US, EU and Japanese MDIs are known for producing high quality products using advanced technologies resulting from significant investment in R&D. There were approximately 5,300 medical device companies in the U.S. in 2007, for example, mostly SMEs. In 2007, approximately 73 percent of medical device companies in the United States had fewer than 20 employees, with 15 percent having as many as 100 employees. Medical device companies are located throughout Europe, Japan and the US, but are mainly concentrated in specific regions known for other high-technology industries, such as microelectronics and biotechnology. These factors are also found in the Malaysian MDI and such parallels probably bode well for the domestic development of domestic companies in the country.

Major US, European and Japanese medical device companies include Medtronic, GE Healthcare Technologies, Johnson & Johnson, St. Jude, Boston Scientific, Baxter, Becton Dickinson, Beckman Coulter, Abbott Labs and Stryker Corporation. In Germany there are Siemens, and Braun, the latter with a longstanding presence in Malaysia, in Japan Hitachi, Medical Corporation, and Toshiba are the most important and in the Netherlands Philips Electronics stands out, while Covidien is a US company based in Bermuda.

The following trade associations closely follow the MDI in the US: Advanced Medical Technology Association (AdvaMed), Medical Device Manufacturers Association (MDMA), Medical Imaging Technology Association (MITA), Dental Trade Alliance (DTA) and the International Association of Medical Equipment Remarketers & Servicers (IAMERS).

In Europe some of the major European Medical Device Industry Associations are: European Medical Technology Trade Association (EUCOMED), European Diagnostic Manufacturers Association (EDMA), European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR), European Hearing Instrument Manufacturers Association (EHIMA), European Federation of National Associations and International Companies of contact lens (and lens care) manufacturers (EUROMCONTACT), European Industrial Federation committee on Medical Technology (EUROM VI), and The Federation of the European Dental Industry (FIDE).

The trade associations for Japan are the following: Japan Industries Association of Radiological Systems (JIRA), Japan External Trade Organization (JETRO), Japan Medical Devices Manufacturers Association (JMED), and the Japan Federation of Medical Devices Associations (JFMDA) was founded in February 1984 by fifteen associations engaged in the development, production and distribution of medical and health-care devices, equipment, instruments and materials.

Announcements of progress in medical technology that allow for earlier detection of diseases and more effective treatment options are now almost daily occurrences. Particularly notable technological advances in the industry in recent years included new developments in neurology (e.g. deep-brain-stimulation devices for treating symptoms of Parkinson's), cardiology (e.g. artificial device designed to replace diseased heart valves) and Health IT (e.g. ‘data liquidity’ to facilitate information sharing, wireless telemedicine devices, systems designed to track the cardiac activity of patients with implanted medical devices). Scientists have used nano-sensors for the quick detection of cancers through blood tests, with nano-material also enabling the release of medicine at targeted organs. Collaborations have led to advances in biomarkers, robotic assistance, implantable electronic devices, liquid bandages/wound dressings and ingestible diagnostic devices (capsules).[14]

Minimally invasive surgery has also seen major gains — an exciting example of this trend is an endoscopic technique that integrates nanotechnology and diagnostic imaging. Capsule endoscopy, which involves swallowing a tiny wireless camera pill that takes thousands of pictures as it travels through the digestive track, gives physicians more detailed information about hard to navigate sections of the digestive tract compared with earlier endoscopic technologies. The ability to navigate and detect conditions in the small intestine is the most promising aspect of this new technology; providing physicians with greater ability to diagnose conditions such as intestinal tumors and Chron's disease.

Global Competitiveness

The United States is both the largest producer and consumer of medical devices. The US medical device market was valued at more than USD100 billion in 2008, roughly 42 percent of the world's total. US exports of medical devices in the key product categories identified above were valued at approximately USD31.4 billion in 2008 and imports were valued at USD33.6 billion. Over the past decade the value of imported medical devices has steadily increased, gradually eroding the previous trade surplus. This is primarily the result of two factors. The first is outsourcing by US MNCs like Medtronic which establishing manufacturing and assembly facilities in Malaysia, China, and other lower cost emerging markets. However, like the iPhone example cited above, most of the skill-intensive, high value added activities — e.g., engineering, design, marketing and branding — is, for the moment, still generated in the US. The second is the shift in the production of lower tech products — e.g. surgical gloves and instruments — from the United States to lower cost locations like China.

The surgical and medical instruments category comprises the largest trade category within the medical device sector. This category includes numerous price-sensitive lower- technology devices where lower cost imports find it easier to gain a foothold in the US market. This is especially relevant for Malaysia, as it produces many of the price sensitive equipment and instruments and therefore is more likely to suffer from a shift in production to even lower cost locations.

Global Demand and its Growth

Global demand for medical devices is being driven by increasing expenditures and greater attention to provision of health care services in developing markets, construction of hospitals and clinics, and establishment of public health insurance. In addition, global demand should continue to grow due to aging populations in major OECD markets, new and significant emerging markets and rising global income levels in developing countries. Further, global harmonization of standards and regulatory requirements should help facilitate overall market growth.

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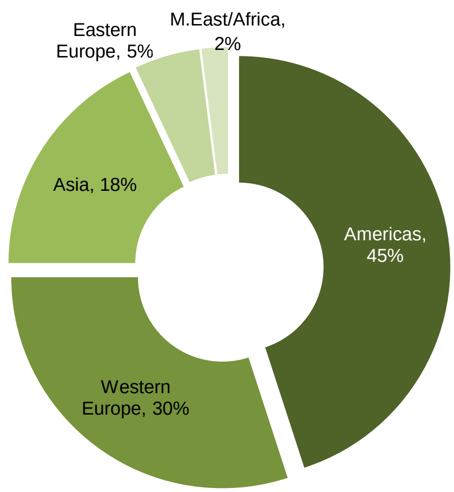
[14] "*Medical Devices Industry Assessment*," http://www.ita.doc.gov/td/health/Medical percent20Device percent20Industry percent20Assessment percent20FINAL percent20II percent203-24-10.pdf

The US, EU, Japan and Canada are extremely large and lucrative medical device markets; however, they are mature markets with stable but relatively low (3-5 percent) annual growth rates. In order to facilitate expansion, medical device companies recognize that they must look increasingly at developing countries to drive future growth. For example, demand for medical devices in China and India is growing at double digit growth rates compared to developed countries, albeit from a much lower base.

Global Market Share for Medical Devices



Source: Associate for Malaysian Medical Industries, 2010.

Key Export Policies

The opportunities for expansion of medical device exports will come from certain strategically important ongoing policy initiatives and activities. With respect to accessing foreign country markets, the contributions of Global Harmonization Task Force (GHTF), Latin American Harmonization Working Party (LAHWP) and Asian Harmonization Working Party (AHWP) could play a significant role in the international harmonization of regulatory requirements. This could lead to opportunities for greater market penetration by Malaysian firms as well as by competitors. In addition, continued focus on reducing or eliminating tariffs in key markets, and higher insurance reimbursement rates will also significantly influence growth and expansion prospects. Further, assisting SMEs in export opportunities through market information, trade missions, and other trade promotion activities has been successful in increasing exports for this industry in several Western European nations and could also be useful in the Malaysian context.

In the United States, the MDI needs and expects the United States Government to remain involved in several areas that will establish and improve trade conditions. The same could be said for Malaysia. In particular, following the United States and European priorities for action, some of the issues enumerated below could be beneficial to the MDIs in Malaysia. For example:

- Negotiate to reduce or eliminate import tariffs on Malaysian medical devices;

- Address foreign governments' regulatory policies that are inconsistent with international harmonization efforts and that may cause unfair discrimination against the Malaysian medical device industry; and

- Educate the industry on how to comply with foreign regulatory requirements and provide similar export assistance opportunities that foreign governments do for their industries.

Export Barriers

As noted above, there are a myriad of trade issues for medical devices, which vary from country to country and which need to be either harmonized or reduced. Certain countries, including India, some Latin American countries, and parts of Asia, still maintain high tariffs on some medical products that reduce the net sale price of medical devices. MDI firms in Malaysia and elsewhere also face increasing competition globally, especially from those foreign firms that can successfully compete on the basis of price. The following highlight some of the key challenges:

- *International Regulatory Environments*: An increasingly common practice among some developing countries is the establishment of national regulatory requirements that are inconsistent with regulatory systems in Western economies. Specifically, these systems tend to require information in dossiers that may be unnecessary or burdensome in determining product quality, safety and effectiveness. Device firms are devoting tremendous amounts of time and money to determine the requirements, conduct additional clinical trials, and pay additional user fees;

- *International Reimbursement Payment Environments*: Reimbursement or payment practices in certain countries may have a negative impact on MDI sales prospects even though they are designed to assist patients and should end up in increasing sales. Many countries around the world are facing skyrocketing costs of health care and are addressing costs by reducing reimbursement rates, establishing price caps, requiring mandatory price reductions, using diagnostic related groups (DRGs), limiting funds available for medical devices, and/or requiring inappropriate information or pricing from the manufacturer. Many high tech medical devices have a life-cycle of 18-24 months, which makes reimbursement key for continued product innovation, including incremental improvements;

- *Harmonization Efforts:* Harmonization of medical device regulations across the world is one way to reduce the industry's burden and ensure maximum accessibility of safe, effective medical devices by patients. Ideally, products 'approved once, should be accepted everywhere.' ITA is encouraging governments all over the world to make use of guidance documents produced by international bodies, most notably GHTF, to promote international regulatory harmonization, and to eliminate or reduce redundant regulatory procedures; and

- *Intellectual Property Right (IPR):* Although IPRs and counterfeiting have not yet become significant problems for medical device firms (as compared to pharmaceutical firms), the sector is beginning to face increased revenue losses due to these activities. IPR violations include using medical device firms' patented technology to manufacture a competing medical device. IPR violations occur in markets that may not fully respect or enforce patent protection. There is limited data on counterfeit medical devices, but based on industry feedback, the most frequent incidences to date are in IVD reagents and solutions, contact lenses, medical test kits, combination products, and component parts, such as semiconductors used in imaging equipment.

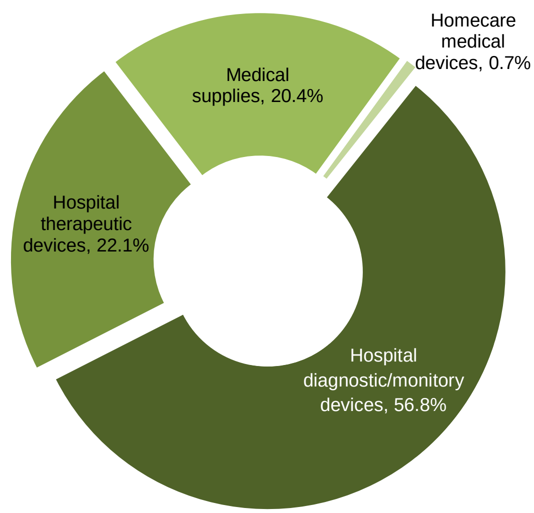
The Regional Setting

Taiwan (POC)

In Taiwan (POC), there are over 500 manufacturers whose scope of business is related to medical devices, and most of them are merely small and medium traders with a registered capital of less than USD 1 million. Although they are not large enterprises, their operations cover a wide variety of medical devices and focus on the 'engineer to order' models.

Structure of Taiwanese Medical Device Industries

Taiwanese medical device industry revenues (USD 1.75 billion)



Note: Homecare medical devices include wheel chairs, electric cars, blood pressure meters, thermometers and blood glucose meters. Hospital diagnostic/monitory devices are X-ray, electrocardiogram (ECG), ultrasonic scanning apparatus, magnetic resonance imaging (MRI) apparatus, and devices for checking physiological parameters. Hospital therapeutic devices include dental, ophtalmological and orthopedic apparatus and appliances, surgical machinery, and orthopedic and dental prostheses. Medical supplies cover gloves, syringes and catheters, first-aid kits, bandaging and dressing.

Source: ITIS Program, IEK/ITRI (2009/04).

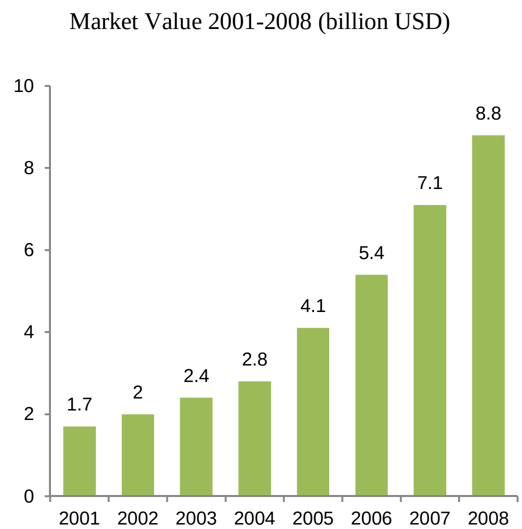
In terms of the international position of Taiwan's MDI, Espicom's statistics show that Taiwan's medical device market was ranked as twenty-sixth in the world in 2009. In terms of the structure of Taiwan's MDI, while hospital medical devices are the focus of the global MDI, commanding over 50 percent of the total, Taiwan's MDI focuses on homecare medical devices, and the output of blood pressure meters, electric vehicles and electronic thermometers is in a leading position in the world. As a whole, the output value of Taiwan's MDI commands less than 1 percent of the global market, and homecare medical devices and medical supplies are the focus, commanding 77.2 percent of the total output value, with a comparatively lower percentage of diagnostic and therapeutic medical devices for hospital uses which are the main focus of the global market.

The value of Taiwan's medical device output in 2009 was around USD1.77 billion, an increase of 13.8 percent on 2008. Major exports include electric vehicles (with the world's highest output), thermometers and blood pressure meters (with the world's second largest output), contact lenses, blood glucose meters and blood glucose testers, and medical supplies such as rubber gloves and catheters. As a whole, most Taiwanese medical devices are middle to low end products, and most high-end products, such as diagnostic imaging, IVD products and implants involving high technologies and high risk, are imports.[15]

China

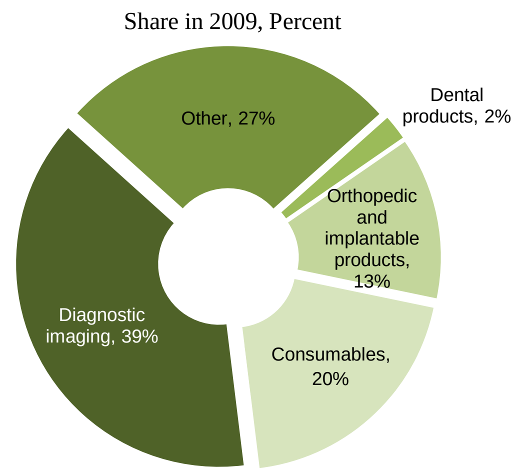
According to the Australian Trade Commission, the Chinese market for medical devices in 2010 was estimated at between USD14-16 billion. China is not only Asia's second largest medical device market; it is also one of the fastest growing medical device markets in the world. In fact, for 2010, Espicom estimated China's medical device market growth to be in the region of 13.6 percent.

China's medical device market has grown rapidly



Source: Goldman Sachs, UBS, L.E.K. analysis

China's medical device market by product segmentation



Note: Diagnostic imaging such as X-ray machines and MRI; consumables such as catheters and syringes; orthopedic and implantable products such as pacemakers and stents; dental products such as dental implants; and other such as cardiovascular (ECG and heart lung machines) and pulmonary (incubators and ventilators).
Source: Espicom Business Intelligence, DeviceLink.com

The diagnostic imaging segment remains the largest, with strong growth coming from implantable devices.

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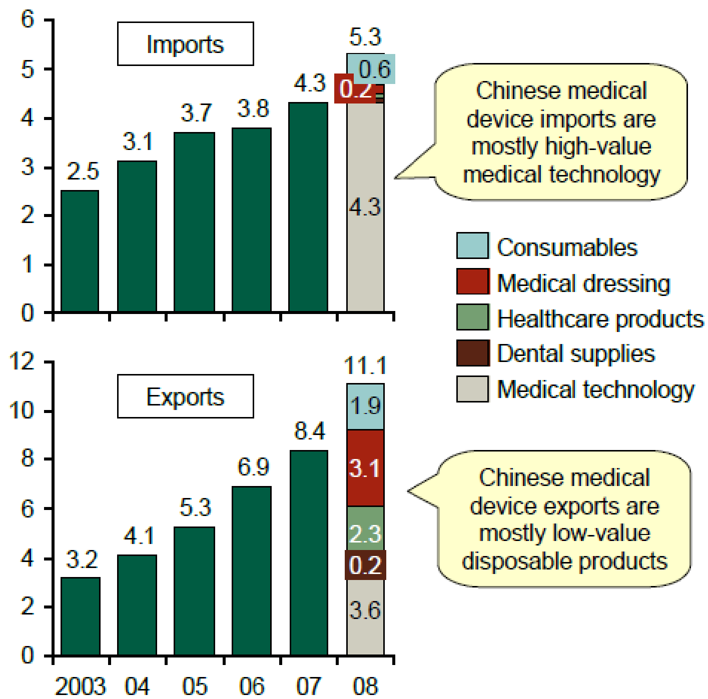
[15] Taiwan, Ministry of Economic Affairs, Industry & Technology Intelligence Services (2009). *Industry Insights: Medical Device Industry.* P. 332-333.
http://www.itis.org.tw/itisdata/English/2010/201000216.pdf

China Medical Devices Trade, 2003-2008

Billions of USD



According to Espicom Business Intelligence, in 2010, the Singapore medical device market was valued at USD235 million, similar in aggregate terms to Pakistan and Peru. In per capita terms, at a total of USD46, the market is similar to Poland and Saudi Arabia.

Indonesia and Vietnam

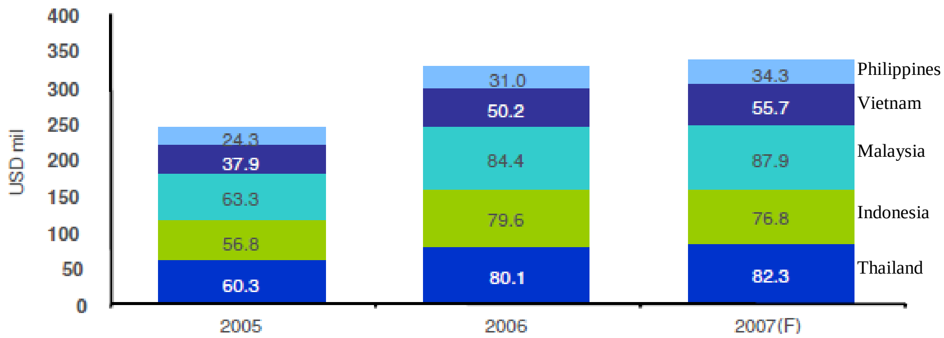
Also according to Espicom Business Intelligence, the Indonesian market for medical equipment and supplies was valued at USD430 million in 2010, equal to just USD2 per capita. In terms of overall market size, it is similar to Hong Kong. In per capita terms the total is more akin to the Philippines. The bulk of the Indonesian medical device market is supplied by imports, which reached USD421.3 million in 2008, more than doubling over the previous year. Imports have grown at a compound annual growth rate (CAGR) of 43.0 percent in 2004-2008.

Vietnam — "In 2010, the Vietnamese market for medical equipment and supplies is estimated at USD515 million, or USD6 per capita. It is expected that the device market will continue to expand strongly at 15.3 percent per annum. This will take the Vietnamese market to over USD1 billion in 2015, although the per capita rate will remain low."[16]

[16] http://www.webptc.com/download/PTC_JULY10.pdf

“Essentially, while this market is small, it also growing quite fast.[17] However, of note is the fact that the local production of the medical device market is extremely limited and accounts for only 5 percent of the market. The local manufacturers are producing low-end products of decent quality.”[18] “The value of exports is low, at USD185.5 million in 2008, with 29.6 percent of medical products exported to Japan.”[19]

Market Size of the Imaging and Monitoring Medical Devices



Source: http://www.solidiance.com/Admin/pdf/Vietnam_Medical_Device_Industry.pdf
Note: The chart above compares the market size of the imaging and monitoring medical devices. Imaging devices include: MRIs, computed tomography (CT) scanners, nuclear medicine devices, all x-ray devices and ultrasounds.

Singapore

Singapore is assembling the building blocks to become a known location for ‘world-class’ med tech manufacturing. It has 35 manufacturing plants, 26 R&D centers and 29 regional headquarters for local, regional and international companies, with over 10,000 people employed in the industry. Companies such as Baxter, Medtronic, Alcon, Res Med, Ciba and others are producing ophthalmic devices, cardiovascular implants and interventional products for spine and cardiology, among other. In addition, other firms, such as MDS Sciex, Illumina, Affimetrix, Biorad, Perkin Elmer and others are producing parts and final products for mass spectrometers, micro array and gene chips, high pressure liquid and gas chromatography apparati and thermocyclers.

Singapore is also striving to become a ‘living lab’ to test health care solutions for private firms in conjunction with the local government and arrive at regional solutions that take into consideration the market needs of South East Asia in the medical devices arena. Such a development will require resources being funneled towards additional funding for R&D and training of Singaporean scientists and university graduates via scholarships and strategic partnerships with industry in the US, Europe and Japan. These are solutions that are available to Malaysia also and that should be considered in a plan for the Malaysian MDI.

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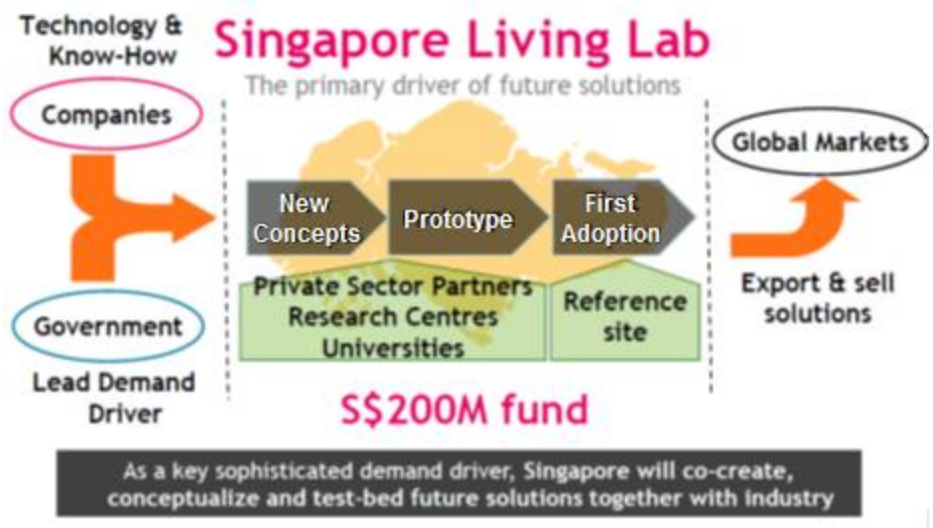
[17]http://www.solidiance.com/Admin/pdf/Asiapac percent20Biotech percent20Interview percent20with percent20Damien percent20Duhamel percent20- percent20Vietnam percent20Healthcare percent20- percent20The percent20Next percent20Growth percent20Frontier.pdf
[18] http://www.delvnm.ec.europa.eu/eu_vn_relations/trade_economic/Greenbook_09.pdf
[19] http://www.webptc.com/download/PTC_JULY10.pdf

Singapore as a Living Lab to Test-Bed Asian Healthcare Solutions



Source: Economic Development Board of Singapore

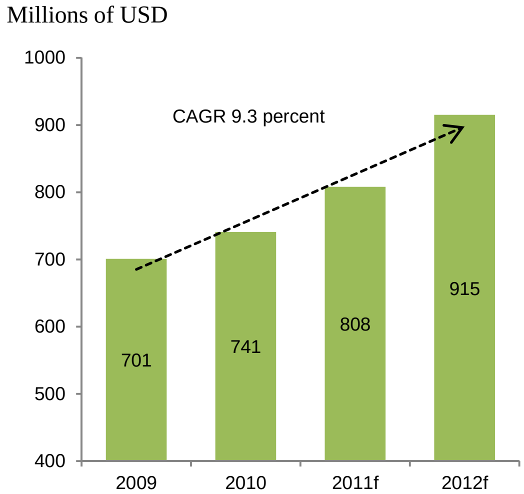
Malaysia's Position in the Global Industry Structure

At present, the MDIs located in Malaysia extend from manufacturers of relatively simple products such as rubber gloves, to more complex machined and electronic components and to the assembly of extremely complex devices such as defibrillators. The latter are mostly mounting, assembly and finishing operations for MNCs. The former include both large, home-grown MNCs — rubber gloves manufacturers, for example — and smaller faster-growing producers of moderately intricate products such as precisely machined orthopedic devices and electronic components for X-ray or other devices. One of the interesting aspects of the medical device group of industries is that they require close linkages with other industries and are thus very likely to succeed in areas where clusters of upstream and downstream firms are present. And it is exactly this aspect of the MDIs that, combined with the professionalism and expertise of many of the mid-tier companies, will allow them to move up the value chain and along the value chain in other industries, such as aeronautics, photography, precision machinery and electronics.

The importance and size of Malaysian exports in this sector are driven by three main factors:

- The size and growth of the rubber gloves and plastic product (tubing, valves and etc.) industry;
- The emergence of Malaysia as a component importer, specialized assembly, and export center; and most importantly,
- The growth of mid-sized Malaysian companies that are manufacturing increasingly complex equipment that is used to produce sophisticated medical devices or products, such as, for example, optics components and 'finished' orthopedic devices.

Malaysia — Medical Devices Market



Source: Frost & Sullivan, 2010.

AMMI identifies 'ancillary' industries to the MDI:

- *Rubber* — gloves, catheters, condoms;
- *Steel* — hypodermic needles, surgical instruments implants;
- *Plastic* — Intravenous (IV) sets, syringes;
- *Electronic* — pacemakers, electrocardiogram (ECG) machines;
- *Textile* — surgical gowns, drapes, covers;
- *Packaging* — procedural kits; and
- *Food* — sutures.

These industries are quite diverse and provide the MDIs with the possibility of creating clusters. However, most of the products that feed from the industries above into the MDIs, are rather low-technology, such as raw latex for the rubber gloves and catheter producers, not particularly high grade steel for surgical instruments, and basic textiles for surgical gowns or covers. If Malaysian MDI firms are going to move up the value chain, they will need increasingly sophisticated inputs. Helping firms in these ancillary activities design, produce, and deliver these sophisticated products must be an important component of Malaysia's supplier development strategy for moving up the value chain in medical devices — and other sectors as well.

For example, in order to produce orthopedic implants, one Malaysian firm imports the specialized titanium alloy. Recently, they developed more advanced products by cooperating with the local electronics, machining and engineering industries, including the aeronautical industry, to make machines that were able to cut specific orthopedic devices with a very high degree of accuracy and precision. These kinds of development are discussed in more details below, but are illustrative of the opportunities that exist today in Malaysia to move up the MDI value chain.

Malaysia's MDIs can be situated within three generic clusters:

- *Group 1:* Mature companies producing relatively simple products, such as latex and rubber gloves or rubber tubes that are utilized in blood transfusion or dialysis equipment;

- *Group 2:* Companies that produce relatively complex orthopedic equipment or other devices and surgical instruments utilizing locally developed high precision machinery; and

- *Group 3:* MNCs that import many, if not most, of the components necessary to assemble a complex device, which is subsequently exported.

The first category consists of firms producing such items as disposable hospital kits, including haemo-dialysis, gynecology and blood transfusion tubing and other rubber and plastic extrusion products. Among the local disposable medical device manufacturers, several firms achieved compliance with internationally accepted quality system management in Malaysia.

In Malaysia there are also firms producing innovative kits for blood collection, which design and manufacture innovative medical devices and procedure packs for global healthcare markets. These products are sold in more than 35 countries and, initially focusing on infection control, they now are prominent in safety and innovation.

The second group consists of companies that are leading medical surgical instruments suppliers, specializing in the design and assembly of a wide range of custom-made fully and semi-automated machines, equipment and fixtures for the semi-conductor, audio, medical devices, pharmaceutical and automotive industries.

There are also firms providing low-cost manufacturing of precision electromechanical and machined components with downstream integration into subassemblies, intermediate modules or final products for the global electronic manufacturing services (EMS) providers or original equipment manufacturers (OEMs). Such firms provide services which include the design of machined components and tooling, manufacturing, procurement of assembly components, process engineering, assembly and testing, logistics management and distribution. Their principal activities are in precision computer numerical control (CNC) turning, machining, electromechanical assembly and contract manufacturing. They undertake to develop and fabricate the complete process, tooling and equipment for making precision engineering components, electromechanical assemblies and modules.

Malaysia also has companies that specialize in sterilization of medical equipment primarily with gamma rays and ethylene oxide. These firms provide an ancillary but essential product in the health care industry and are a separate category.

Interestingly, in Malaysia there are companies that are leading providers of implants, instruments and cases to orthopedic device manufacturers. They design, develop and produce these products for companies in the arthroscopy, dental, endoscopy, laparoscopy, osteobiologic, spinal and other segments of the medical device market. They also provide limited specialized products to non-healthcare markets, such as the aerospace market. Products include implants, including forged, cast and machined products for the global orthopedic device market; instruments used in the placement and removal of orthopedic implants and in other surgical procedures; cases, including plastic, metal and hybrid cases used to organize, secure and transport medical devices for orthopedic, endoscopy, dental and other surgical procedures, and other specialized products for the aerospace market.

The last group includes international MNCs that import unfinished parts of highly complex equipment and assemble them in Malaysia, to produce such products as defibrillators.

Considering the rich diversity of Malaysian MDI companies, the following points can be noted:

- While several MDI companies are relatively low-value added producers of rubber and plastic products, many have managed to exploit the competitive advantage of Malaysia in the latex industry to become the premier rubber and latex glove manufacturers in the world;

- Several companies are now a step above simple production of rubber, latex and plastic equipment, producing disposal medical packs, most of them sterile, which are becoming more and more important in the health care world and for which there will be a rapidly growing "single-use" market;

- There are several examples of companies that have moved up the value chain and would be able to move further up the value should R&D spending be boosted. Some have already started doing this in a spectacularly successful way and may be the example that should be closely analyzed and perhaps emulated across Malaysia; and

- There are many examples of foreign MNCs that have found a suitable assembly operation in Malaysia. These MNCs provide a platform for export revenue and employment opportunity at varying skill levels. They also constitute a training ground for entrepreneurs. Many of the Malaysian entrepreneurs now running their own firms gained experience and know-how from MNCs in both the medical device and electronics industries. This is more than an interesting fact. It is a benefit that Malaysia could exploit further. There are many experienced workers and skill development programs which can be put to use in the process of moving up the value chain.

Other opportunities exist as well. One of them is to develop the manufacture of IVD kits for diabetes, drug abuse and especially malaria and other tropical diseases. In principle, the opportunity could be relatively small but would provide high growth potential, given the need for such tests internationally. Malaysia has quite a considerable base of expertise in tropical diseases and could utilize it to develop additional innovative tests, which could be an initiative to market a Malaysian 'all-in brand' for certain tests. The government could provide WC loans to companies in this field and encourage the development of R&D through grants and perhaps scholarships at universities and research centers that are already investigating such tropical and other diseases.

Expanding further on the position in the global value chain, Malaysian medical device companies appear to be situated in three sections of the value chain: at the very beginning (rubber gloves, basic tubing), in the middle where high precision instruments are being both used and, more importantly, developed, modified and innovated, to finish some products such as orthopedic prosthesis or at the end where extremely complex instruments are assembled for MNC. One of the issues that needs to be addressed is how to increase the value added in assembling even very complex equipment and instruments by MNCs that are then being sold abroad, primarily. Another very important development is how to ensure that talented Malaysian scientists and entrepreneurs are trained and enabled to perform additional R&D, as this will be a key element in moving up the value chain.

Only the first group of companies has substantial revenues coming from the sale of their products to the Malaysian health care market, including hospitals and end users. They are very profitable and have still growing at a frantic pace, making some minor innovations that initially bring substantial margins. These companies have found a niche in Malaysia because of latex rubber plantations, a highly skilled workforce and a favorable business environment. This is a case of adding value to natural resources and moving up the value chain in the latex/rubber sector. It is a step forward for one sector and a first step for medical devices.

The second group of companies is arguably the most interesting, for two reasons. First, they have developed highly complex machinery and have trained a highly skilled workforce to produce relatively simple products that need to be upgraded and produced in large quantities as a 'single use' culture continues to spread. Second, they have been able to develop a competitive advantage given the other industries in Malaysia and the availability of skilled labor. And third, because even though now much of the 'raw materials' are imported, these companies have a good possibility of 'moving up' the value chain and take advantage of other growing industries in Malaysia.

The third group may not yet be significant in the value chain yet, since most of the equipment and inputs are imported and most of the final products are exported. But skilled labor in these industries will undoubtedly feed in the other two groups and contribute to the increase in skill and technological level of the workforce and products manufactured in Malaysia. Some of this is already happening.

Key Opportunities

Total revenues for the MDIs in Malaysia, including exports, amounted to approximately USD3.5 billion during 2009, which is not an insignificant figure. What is especially interesting is that the growth rate for the MDIs is higher than for health care in general, projected to be close to 10 percent until 2013 at least, according to the Association of Malaysian Medical Industries (AMMI). This illustrates the positive effects of developing the MDIs in particular as opposed to pharmaceuticals or health care in general. And, should Malaysia be successful in moving up the value chain, growth could prove to be even higher.

What is particularly interesting is that China and South East Asia are becoming more and more important in this sector due to both their size and extremely fast growth, according to analysts from various international investment banks who are starting to take notice of the MDI in this part of the world. Malaysia is well poised to take an important role in this development.

Although, healthcare has not been viewed historically as a way to invest in Asian expansion, the situation appears to be changing radically. Up until now, healthcare accounted for a very small proportion of the Asian stock markets (less than 2 percent of market capitalization of an Asia ex-Japan, Morgan Stanley index). Emerging markets generally have accounted for a low proportion of the sector's revenues as a result of younger populations compared to Europe, the United States and Japan and low per-capita spending on healthcare. However, the market opportunity for both medical device and drug companies is expanding rapidly and Asian markets in particular are set to become a material top-line revenue driver for European medtech companies. The potential for increased demand is underlined by China where Morgan Stanley estimates the Chinese medtech market to be worth USD17.5 billion in 2010 growing at a 30 percent yearly pace since 2008, compared to a global medical equipment and diagnostics market of about USD370 billion growing at around 5 percent per annum.

Many of the Group 1 companies in Malaysia are already advanced companies in their own sector and several are multinationals in their own right. There is little that can be done in the short term to assist them in moving up the value chain. In the long run, they could benefit from additional R&D to remain at the vanguard of latex and rubber developments.

Group 2 companies are those that should be the target of Malaysia's focus in trying to move up the value chain. Facilitating the private sector development of these companies will result in several advantages not only for the Malaysian MDIs, but also for Malaysian manufacturing in general. Eventually at least some of these firms may evolve into companies that have the capacity to develop their own medical devices 'in full' from basic research to commercialization of 'Malaysian brand products'. In other words, they will have moved up both ends of the smile curve. Entrepreneurs will improve their output further and further to produce more and more sophisticated products in their companies. Eventually such processes will result in discovery and innovation, like, for example, a 'better' orthopedic device or a new listening device.

Group 3 companies are part of the value chain of international MNCs and are simply taking advantage of the Malaysian low cost, highly skilled workforce and engineering capabilities. There is little that can be done in addition to what is already being provided by the government except that care should be taken to ensure that the competitive advantages that are present in Malaysia in this sector are not eroded by countries like China or, eventually, Vietnam. One significant advantage of having MNCs in Malaysia carrying out this kind of manufacturing/assembly is that they provide a fertile training ground for entrepreneurs that could branch off and start their own companies. As in the PV industry, in Malaysia, foreign PV manufacturers have come in with both beginning in the end of the smile curve handled in-house by the same manufacturer, leaving very little room for appropriating additional value add to the Malaysian subsidiaries which end up being complex assembly shops.

In addition, clusters of companies will become more and more important, developing symbiotic supply chain and supplier relationships with core firms in the MDI sector. Building up the capacity of firms in these ancillary sectors will be an essential ingredient in Malaysia's strategy to move up the value chain and capture additional value added opportunities.

Given the structure of the Malaysian MDIs and their positioning in the value chain of medical devices, which stretches from rubber gloves and tubing to highly intrusive cardiovascular, dialysis and radiotherapy devices, a differentiated approach should be taken for companies in the three groups in order to build a model for a movement towards higher value added products. Naturally, on one end of the scale, we have rubber and latex manufacturers that are already at the leading edge of their industry, indeed they are multinationals in their own right. They already have differentiated and 'state of the art' products, which, however, have a relatively low unit sales value and intrinsic value added. On the other end of the scale, we have operations that are owned and managed by foreign multinationals.

Analysis of the Group 2 companies visited in the context of this study, on the other hand, demonstrated that a movement 'up the value chain' is not only eminently possible, but that it has already started in Malaysia. There are two particular examples of companies that have very successfully emerged as manufacturers of 'more highly value added' products and have done so not only in the medical devices value chain, but are expanding their expertise to other industries.

The first manufactures products for other, larger firms, such as Kodak, Fuji and AGFA. They started with producing X-Ray cassettes to replace analog photos of X-Rays. They moved on to different industries and are now supplying companies from the automotive to the aeronautical sectors. Their integrated approach to product development now spans the whole gamut of development, from design to customer service by way of manufacturing and assembly.

Another company in Malaysia has developed its own cluster which spans medical tubing manufacturing to sterilization services and manufacturing and assembly of trays ready for the operating room. They then sell their products to companies located around their production hub.

As they produce according to certain standards reliably and in a timely fashion, they undoubtedly obtain more and more orders of a more and more complex nature. They also are learning to work with their customers and provide to them solutions to their problems utilizing higher and higher skill solutions. They probably have already provided some 'innovative' solutions to their customers, solutions that their customers would not have been able to devise on their own or could have only devised with higher R&D spend.

At the same time they have been able to apply their solutions to other industries thus creating more and more interesting synergies as well as contributing to the development of machining 'clusters' in the MDIs.

Key Bottlenecks

The total domestic sales of the Malaysian MDIs are projected to reach USD740 million by the end of 2010. This is less than one third of their total exports of around USD3 billion for the year that recently ended, according to the AMMI. The current size of the internal market may be a bottleneck to movements up the value chain for Malaysian MDIs as R&D usually accompanies the fulfilling of initial domestic demand, a topic that will be covered below. However, Malaysia can take steps to expand greatly the size of the domestic market and, by so doing, help Malaysian firms gain a foothold in moving up the value chain.

In his seminal work on "The Competitive Advantage of Nations", Michael Porter identifies the composition of home demand and its internationalization as the root of competitive advantage. This cuts two ways in Malaysia. On the one hand, Group 2 firms would improve their export prospects if they had better access to the domestic Malaysian market. Domestic sales help local firms gain experience as well as a reputation for reliability and quality. Targeted public procurement programs would go a long way towards helping these firms gain a foothold in Malaysia and, shortly afterwards, in the rapidly growing, dynamic East Asia and African markets. On the other hand, the relatively limited size of the internal Malaysian MDI market makes exporting an absolute imperative. This is thus undoubtedly one of the most important bottlenecks to the development of domestically developed, innovative high value added products such as, for example, a new type of defibrillator or a more efficient dialysis machine.

It would be difficult to assure a movement up the value chain in the MDI if we were to try to implement a 'classical' movement toward the discovery of complex devices through innovation. For example, it is unlikely, in the short term, that a domestic Malaysian company would be able to 'invent' a new hearing device or a new type of stent to unclog arteries. This can only be achieved through massive amounts of R&D both from the private and the public sectors. This observation should not, however, lead to the conclusion that Malaysia would not be able to move up the value chain in some medical devices. And this is already taking place in, for example, orthopedics.

What is extremely interesting about the MDI in Malaysia is the fact that sub sectors of the industry are highly technologically intensive and prone to innovation. For example, the orthopedic industry and the other company that was developing machines not only for x-rays but also for photographic equipment.

The table below shows various types of bottlenecks now present in Malaysia, both from a global perspective and in terms of long term versus short term hurdles to development.

These include short term, Malaysian specific bottlenecks that could and should be addressed by the government in order to mitigate their impact. Tax, approvals and currency/export related issues need to be investigated and streamlined. Government could facilitate the import of certain products, such as titanium for prosthetic implants, for example, in order to improve productivity of companies in the sector. Also in the short term, approval times for the commercialization of certain products are not optimal.

Financing has also undoubtedly slowed growth and dampened innovation. Financial institutions in many markets are reluctant to lend medium to long term and for pure R&D, as loans or investments are perceived too risky. A centralized approach to WC financing and VC would help as well as encouragement of the private equity industry.

The human capital factor is of paramount importance in industries with a high technological content and a strong demand for skilled labor. Several industry players believe that there may be a gap in the skill level needed by firms in the industry and recent university graduates entering the labor force. Others have expressed the need for a centralized government agency to approve and monitor grants as this would alleviate some of the difficulties encountered by firms and entrepreneurs in the sector.

Key Bottlenecks Specific to the Medical Device Industry

	Short-term ←		**→ Long-term**
↑ Local	Value Added Tax (VAT) issue where imports are exempt.	Tax incentives.	Insufficiency of R&D spending.
	Lack of uniformity in compliance with international standards.		Lack of sufficient university graduates with specific industry skills.
	Need to streamline approval process for research grants.		Lack of sufficient reimbursement rates.
	Lack of sufficient working capital (WC) and other bank financing.	Lack of sufficient venture capital (VC) financing.	
	Lack of sufficiently large domestic market for medical devices.		Need for stringent regulation approval of medical instruments to establish global credibility for products developed in Malaysia.
Global ↓	Currency undervaluation in key competitor countries.		MNCs' unwillingness to share IP or at least perform higher-level research in Malaysia.

Supplier development programs can help local Malaysian firms producing ancillary goods and services meet the stringent quality requirements of both local Malaysian MDI enterprises and MNCs operating in Malaysia. Building up a local supply base and cluster will help anchor these firms in Malaysia and make them less susceptible to move elsewhere in search of lower wages or modestly lower production costs. Global experience in both low tech and high tech industries also suggests that the presence of dynamic firms in ancillary industries helps other firms become more innovative and move up their value chain.

These supplier development programs should be complemented by dynamic workforce development programs. These should span the gamut from short term technical training programs for craftsmen to longer term advanced training for engineers and product designers. Malaysia is already one of the pioneers in this area; additional steps, however, should be targeted to the MDI sector as well as to any other sector where Malaysia may have an emerging competitive advantage.

In the long run, Malaysia authorities must also ensure that local regulation ensures stringent approval of medical instruments to establish global credibility for Malaysian developed products. As noted above, this should be coupled by public efforts to ensure standards harmonization and the removal of other tariff and non-tariff barriers inhibiting Malaysian firms' access to rapidly growing target markets. Finally trade missions and export promotion efforts should target non-traditional, but potentially rapidly growing markets such as Asia and Africa. Malaysian firms have not yet begun to explore these markets. Chinese firms are beginning to make inroads. It would be wise for Malaysian firms not to cede this territory to its competitors.

Policy Recommendations

The recommendations are made in the context of upstream and downstream in the value chain to differentiate the three Groups of companies in the MDIs. Within each of these three Groups, the recommendations are further split into market and smile curve recommendations.

Upstream Market Recommendations

Policymakers could accelerate efforts to facilitate the growth of Group 2 companies with tax incentives and increase the incentive for the creation of domestic clusters. This could be achieved, for example, by granting tax breaks to companies established in specific areas. Often, biotechnology and medical device companies, especially those that are trying to develop innovative products, have little or no revenue during their early years. More generous tax breaks for these specific companies, coupled with easier financial packages and VC investment, could encourage such innovation.

Additional international enterprises could be identified, who could help in the development of local firms in Group 2, initially as suppliers and then as innovators. This is being done in Singapore, for example, where specific teams are sent at the government's expense to the United States and Europe for training and development in experiencing the entire 'R&D to commercialization' product cycle.

Policymakers could also consider exempting Malaysian manufacturers from Value Added Tax (VAT) so as to even the playing field vis-à-vis international companies that pay no VAT on imported parts which are subsequently assembled in Malaysia. Certain import restrictions could be relaxed or modified, such as the policy of approving every titanium alloy import, which results in some firms being unable to keep up with demand for their orthopedic products.

The stringent enforcement of adherence to international standards and requirements is an absolute necessity. This will not only result in better products made more efficiently, but also attract foreign companies to bring the manufacture and even the development of more high value added products in Malaysia, including those with a high IP content.

For the Malaysian MDI to fully realize its potential in developing markets, standards and criteria for regulatory approval, risk management, and quality must be improved and most importantly harmonized to meet global international best practices based upon GHTF guidance documents.[20]

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[20] To that end, the Global Harmonization Task Force (GHTF), a voluntary organization comprised of regulators and industry with five Founding Members (US, Canada, Japan, EU and Australia) has its core objective of streamlining and harmonizing regulatory practices through five study groups. Emerging market countries like India, China, Malaysia, Indonesia, Thailand, Vietnam, Mexico, Chile, South Africa and Brazil now participate in GHTF through their regional organizations, the Asian Harmonization Working Party (AHWP), and the Latin America Harmonization Working Party (LAHWP), respectively. The participation of the developing countries in these forums, coupled with guidance documents issued by GHTF will be critical in establishing regulatory regimes for medical devices that are distinct from traditional pharmaceuticals. Upon further development in this area, the medical device industry will continue to evolve as a global industry.

Additional support may be provided to facilitate the collection of market intelligence, allowing firms to cross-fertilize their developments.

Upstream Smile Curve Recommendations

To move up the value chain, it is essential that firms conduct more R&D. This suggestion cuts across other industries as well and will require a revamp of the national innovation ecosystem. This will in turn involve macro-level efforts to boost human capital development, creativity and entrepreneurship, strengthen technological diffusion, improve access to finance, and, perhaps most importantly, strengthen the driving force of innovation, which is internal competition. [21]

The MDIs in Malaysia would specifically benefit from greater cooperation with international medical device companies and universities in the US, Japan, Europe and elsewhere. Offering scholarships in the sector and providing for internships would help the top Malaysian students, scientists, managers and experts improve their capabilities. Many Malaysian managers have recently very successfully started their companies after several years' experience in operations with international MNCs operating in Malaysia. Learning from MNCs has allowed these entrepreneurs to adapt their acquired knowledge to the Malaysian milieu and invent new business models.

Many steps have already been taken in this direction and have been eminently successful. But much more needs to be done along the same lines in order to increase the number and the size of such efforts. The government could encourage such entrepreneurship, for example, by assisting in the creation of 'medical devices' specific scholarships that would allow entrepreneurs to be hone their skills. The creation of additional 'incubators' where synergies between companies can be exploited also could be encouraged.

Malaysia could also enhance the transfer of MDI-specific technologies from US, EU, and Japanese companies by identifying firms that are developing innovative products and help them establish themselves in Malaysia to create a 'hub' for South East Asia.

In addition to boosting R&D, additional efforts could be developed to promote branding — which lies at the opposite end of the smile curve. These efforts could be targeted to promising Group 1 and 2 companies, with the objective of establishing a well-recognizable Malaysian brand that exudes value, quality and trustworthiness. This can only be done in applying resources in marketing and commercializing products directly to end buyers and not relying on international health care companies with their own brand names. For example, although many latex and rubber products are produced in Malaysia, they are often commercialized abroad by international companies. The creation of Malaysian 'brands', perhaps with the assistance of tax incentives, could be achieved by the development of Malaysian products sold by Malaysian companies in the South Asian Market, for example.

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[21] For more information see World Bank (2010). *Malaysia Economic Monitor — Growth through Innovation*. Washington, D.C.: The World Bank.

Downstream Market Recommendations

The MDI would benefit tremendously from efforts that help increase domestic demand, particularly for higher-end medical devices. This is unlikely to yield immediate results, but the development of high-tech hospitals will undoubtedly create a symbiotic relationship with industry and international MNCs and help innovation.

Government could also further promote the growth of a domestic VC industry. There are already several funds that assist in the financing of SMEs and these will undoubtedly spur growth. However, MDI companies need specific assistance and investment requires specialized knowledge. As more R&D is required in this industry than in many other manufacturing industries, there is a specific need for specialized risk assessment, which in turn requires knowledge of complex scientific and mechanical principles. To assist MDI companies develop their own medical devices would require encouraging public/private partnerships that finance start-ups and other companies that are trying to develop new products which may not have substantial revenues in the near term. Financing such endeavors is a specialized activity in itself. In many countries, governments have created specific credit institutions and even investment vehicles that are assisting firms in financing medium to long term investments and development of further research to discover new technologies. Malaysia should intensify its efforts in this arena to deepen the downstream market, as only through what is undoubtedly 'riskier' behavior on the part of firms will result in advances in the MDI and the 'innovation' of new products.

In the biotech sector, Malaysia has established a Malaysian Life Sciences Capital Fund (MLSCF) in conjunction with a US-based VC fund. A similar initiative could be considered for medical devices. The size of such a fund must be carefully considered and increased readily as more investment needs are discovered.

The expansion of access to finance for Group 2 companies will be crucial in ensuring their growth. Many of these firms were established relatively recently and are in desperate need of growth capital. Commercial banks and other financial institutions are often reluctant to provide WC to such enterprises. The government may want to consider back to back facilities for banks to be on lent to Malaysian medical device companies so as to provide such short term WC loans essential for growth.

Policymakers could also help establish clusters through development of further infrastructure to support the smaller enterprises. Such centers are crucial in developing synergies between the various firms. R&D 'discoveries' are often made in the context of cooperation between firms. 'Incubators' such as those that already exist in Malaysia in health care, could be encouraged further and funded so as to allow them to grow in size and numbers. The government could provide for the construction and establishment of these centers which could then be 'rented out' to various nascent firms at variable rates or even by allowing for the firms to pay 'only when able' or offer equity ownership to the entity managing the center. This would lower the financing needs for the companies and provide the centers with some upside potential, however risky.

Finally, the government may want to consider allowing subsidized loans to small enterprises engaged in basic research for new technologies (or even export based products). Such loans could take the form of convertible participations in the upside, should an outright ‘subsidy’ not be economically feasible.

Downstream Smile Curve Recommendations

Government could foster the development of training programs and specialized courses in Malaysian universities to ensure that sufficient skilled graduates are available to meet demand growth.

Help Group 2 companies in producing increasingly complex ‘packaged’ products focused on export to emerging economies. This development would also be essential in developing Malaysian brands. For example, some Malaysian companies are already producing ‘ready kits’ for emergency and operating rooms in hospitals. Doctors are increasingly willing to utilize ‘one use only’ equipment, given the high incidence of infections, worldwide. (Such infections often still cause more fatalities in many hospitals than the injuries or diseases themselves). Malaysia is well poised, given its competitive advantages in latex and rubber manufacturing, in developing specific-use products that can be branded as ‘Malaysian’.

The overall value of advanced technologies must be taken into greater consideration when establishing their reimbursement rates. For example, the higher the domestic technological development, the higher the reimbursement rate, so that demand is encouraged for locally developed solutions.

A central entity for industry support may be considered, in order to reduce the wasting of resources and provide firms in the industry with a more efficient service in terms of help in obtaining funding or assistance in ensuring that certain products are approved for commercialization. The same entity could set some kind of milestones linked scheme in order to push compliance with internationally recognized standards for production of certain products. This particular scheme could be tied to enabling legislation linked to the Medical Devices Act.

In addition, by bridging the gap between university graduates and industry requirements, increasing the ability of firms hiring international talent and firming up the compliance of all Malaysian firms to international standards, Malaysia could attract MNCs that will either actually perform R&D in the country and/or manufacture or assemble higher value added products.

GLOSSARY OF ACRONYMS

AdvaMed	Advanced Medical Technology Association
AHWP	Asian Harmonization Working Party
AMMI	Association of Malaysian Medical Industries
ASP	average selling price
BOS	balance of system
CAGR	compound annual growth rate
CdTe	cadmium telluride
CIGS	copper-indium-gallium-selenide
CNC	computer numerical control
COCIR	European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry
COMTRADE	Commodity Trade Statistics Database
c-Si	crystalline silicon
CT	computed tomography
DRG	diagnostic related group
DTA	Dental Trade Alliance
E&E	electrical and electronics
ECG	electrocardiogram
EDB	Economic Development Board
EDMA	European Diagnostic Manufacturers Association
EHIMA	European Hearing Instrument Manufacturers Association
EMS	electronic manufacturing services
ETP	Economic Transformation Program
EU	European Union
EUCOMED	European Medical Technology Trade Association
EUROM VI	European Industrial Federation Committee on Medical Technology
EUROMCONTACT	European Federation of National Associations and International Companies of Contact Lens Manufacturers
EVA	ethylene vinyl acetate
FDA	Food and Drug Administration
FDI	foreign direct investment
FIDE	Federation of the European Dental Industry
FIT	Feed-in Tariff
GDP	gross domestic product
GHTF	Global Harmonization Task Force
GTM	GreenTech Media
GW	gigawatt
IAMERS	International Association of Medical Equipment Remarketers and Servicers
IMP3	Third Industrial Master Plan
IP	intellectual property
IPR	intellectual property right
IV	intravenous

IVD	in-vitro diagnostic
JETRO	Japan External Trade Organization
JFMDA	Japan Federation of Medical Devices Associations
JIRA	Japan Industries Association of Radiological Systems
JMED	Japan Medical Devices Manufacturers Association
kWh	kilowatt hour
LAHWP	Latin American Harmonization Working Party
MBIPV	Malaysia Building Integrated Photovoltaic
MDI	medical device industry
MDMA	Medical Device Manufacturers Association
MITA	Medical Imaging Technology Association
MLSCF	Malaysian Life Sciences Capital Fund
MNC	multinational corporation
MRI	magnetic resonance imaging
MW	megawatt
MW-dc	megawatt - direct current
NAICS	North America Industry Classification System
NEM	New Economic Model
NKEA	National Key Economic Area
NREL	National Renewable Energy Laboratory
OECD	Organization of Economic Co-operation and Development
OEM	original equipment manufacturer
POC	Province of China
PRC	People's Republic of China
PV	photovoltaic
R&D	research and development
RM	Ringgit Malaysia
ROW	Rest of World
SAR	Special Administrative Region
SERI	Solar Energy Research Institute
Si	silicon
SME	small and medium enterprise
TFP	total factor productivity
US	United States
USD	United States Dollar
VAT	Value Added Tax
VC	venture capital
VOS	value of shipment
WC	working capital

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