KAPSARC
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King Abdullah Petroleum Studies and Research Center

Workshop Policy Brief

September 2014 KS-1406-WB04A

Policy Support for Energy Transitions: Where is Public Money Best Spent?

Summary for policy makers

Considerations for the effective allocation of public funding in support of energy transitions require an appreciation of the success and failure of policy instruments in achieving balanced energy transitions. Understanding the impact of structural changes in supply chains of both new and incumbent technologies on competitiveness of renewable technologies and resultant uptake levels is an often overlooked factor. KAPSARC's framework and model for evaluating transition policy and its effectiveness in balancing its multiple objectives begins to take these factors into account.

Recent renewable energy transition experiences highlight the inherent challenge of balancing the objectives of fast-paced penetration accompanied by local industry and service sector development. In some cases, market-pull renewable energy incentives, such as Feed-in-Tariffs (FITs), have tended to raise demand faster than the ability of local supply chains to respond. By contrast, supply-side push policy instruments, such as Local Content Requirements (LCRs) and access to cheap funding, may have helped accelerate cost reductions in new technology. As a result, direct policy support for local supply chains has intensified global competition and, more recently, raised legal disputes among renewable technology manufacturing nations.

It is not uncommon for participants in incumbent fuel and technology supply chains to continue to deliver large operational and cost improvements, leveraging decades-long experiences and efforts. It may be near impossible for policymakers to predict such scenarios along transition pathways. However, ignoring these possibilities may require more expensive, longer lived transition policy than anticipated. Furthermore, the increasing recourse to the World Trade Organization (WTO) and the pitfalls of poorly implemented local content requirements (LCRs), can impede cost effective transitions and damage the broader economic interests of a country's renewable sector. Transition policies face a multitude of challenges that will only be overcome with a greater understanding of the linkages between policy, markets and industry.

There is a risk in a "one-size-fits-all" approach to policy. FITs can be effective, even if not economically efficient. Production Tax Credits and other investment credits can induce volatile investment profiles if their validity and duration are not reliable. Transition objectives may be achieved with a more effective deployment of public funds through adoption of adaptive policymaking processes and consideration of hybrid solutions – in which new entrant technologies augment and leverage incumbent systems, rather than attacking them head on. However, the tools for supporting this adaptive approach are not yet understood or widely available.

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is an independent, non-profit research institution dedicated to researching energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal notice

Background to the workshop

In May 2014 KAPSARC hosted a workshop in London, United Kingdom, designed to address knowledge gaps in understanding linkages among industry sectors, decision makers and other actors including:

– Direct and indirect policy impacts on development of new technology supply chains spanning both the manufacturing and service sectors.

– The impacts of supply chain structure and scale on the cost competitiveness of new and incumbent technologies.

Renewable energy policy generally aspires to accelerate fuel and technology transitions while simultaneously supporting the development of local technology manufacturing and service sectors. Financial and non-financial policy instruments are normally designed with the stated aim of achieving transition objectives in a fast-paced, cost effective manner.

Recent experiences have illustrated that balancing the desired transition pace with supply chain development aspirations represents an enormous challenge for policy design. In many cases, the commonly used market-pull renewable energy incentives have raised demand for the new technology faster than the ability of local supply chains to respond. In other instances, supply-push policy instruments have caused renewable technology supply surpluses beyond the market's ability to absorb them. Experience also illustrates that incumbent fuel and technology supply chains are likely to capitalize on decades-long innovation and investment efforts to improve their competitiveness.

Policy aimed at stimulating transitions generates a number of complex new dynamics. Moreover, compliance efforts are faced with moving targets and unexpected interactions between different policies. These complexities and uncertainties can be different across countries and regions. KAPSARC's research intends to establish a framework to facilitate creative and effective policy design, incorporating the major dynamics that are likely to arise.

Policy incentives: what is the best 'FIT'?

Because of the high overall costs of renewable technologies relative to fossil-fueled technologies, a variety of incentives to promote penetration of renewable energy are being implemented around the world. Financial incentives ultimately involve reallocation of the costs of development among developers, consumers, and taxpayers. In liberalized markets, the need for a return on investment caps the amount investors will pay, leaving the balance to be divided between consumers and taxpayers. A common incentive policy is a feed-in-tariff (FIT). Recent experiences, including Germany's solar program, suggest that FITs and similar financial tools can be effective in meeting installation and generation targets rapidly. However, this fast compliance comes at a high cost with other potentially unfavorable side effects. Promoting renewables using FITs is generally considered effective due to the reduced investment risk for developers, but not necessarily economically efficient.

"A feed-in tariff is the fastest way to promote renewables and it is also the most expensive way."

However, a 'one-size fits all' approach to transition policy may not be a universal panacea for meeting renewable energy targets. The tapestry of state and federal regulatory regimes in the United States (US), for example, make implementing a federal FIT program extremely challenging. The interaction of

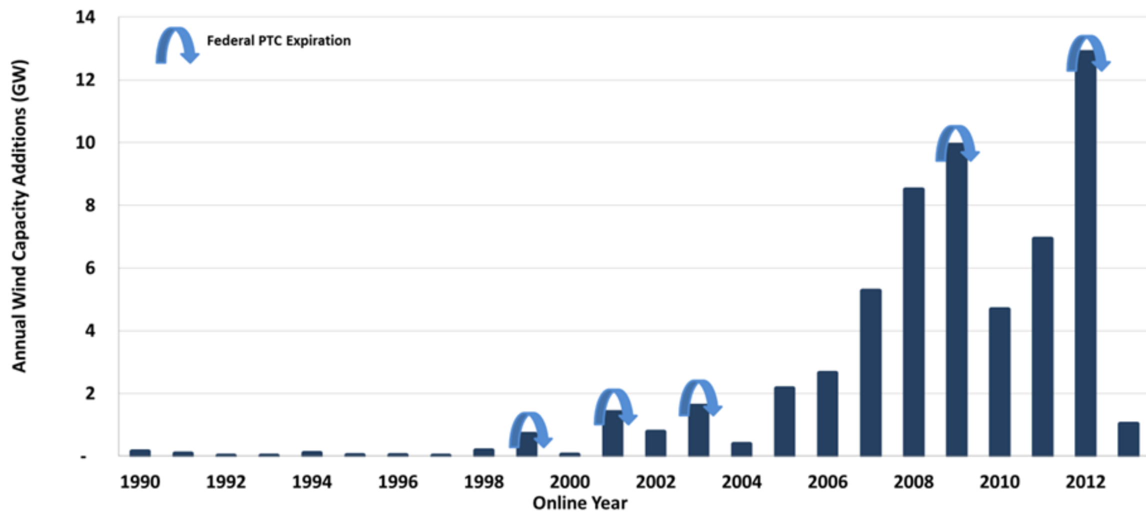

Figure 1: Wind installations in the US (Data sources: EIA Form - 860, Electric Power Monthly, and Electric Power Annual).

carbon trading, renewable generation mandates, the legacy of the Great Recession and FITs in Europe has delivered some perverse results including an increased use of coal. Elsewhere, investment tax credits may be inapplicable in some of the Middle East's major oil producing countries because no taxes are levied, and FITs would have a distorting effect against the backdrop of very low wholesale and retail power prices. Simply importing transition policies from Europe or the US may not be the answer.

Policymakers are inclined to believe that investment incentives for renewables are a short term undertaking; technology cost reductions will quickly overtake the need for continuing financial support. This leads to the '*cliff effect'* – the collapse in investment that occurs when one incentive program expires before policy makers realize there is a need for a successor scheme. Supply industries may suffer and possibly collapse as has been demonstrated by renewable energy investment cycles in the US over the past two decades. The expiration of the federal production tax credit (PTC) has typically been followed by sharp declines in wind capacity installations (Figure 1). A more careful planning of introduction, implementation, and expiration of investment support programs may smooth out the investment profile and reduce the risk that investors perceive in developing supply chains to support renewables deployment.

Incentives to "pick technology winners" are typically influenced by short-term political agendas rather than long-term sustainability and may interfere with market-driven technology evolution. Alternatively, it could be argued that picking a winning renewable technology for targeted support encourages innovation and development, facilitating technology scale-up. However, technology neutrality very seldom exists in reality, leading to a need for creative and adaptive transition incentive designs to identify and promote favored technology combinations. This is particularly important because implicit assumptions about the economic situation and renewable technology performance and costs may reflect the conditions prevailing at the time of legislation. Much has changed since the launch of the German FIT and the US PTC programs, some twenty years ago. Evolving market and regulatory dynamics impact mulitple variables beyond just electricity prices, creating a need to revisit transition policy regularly. For example, the

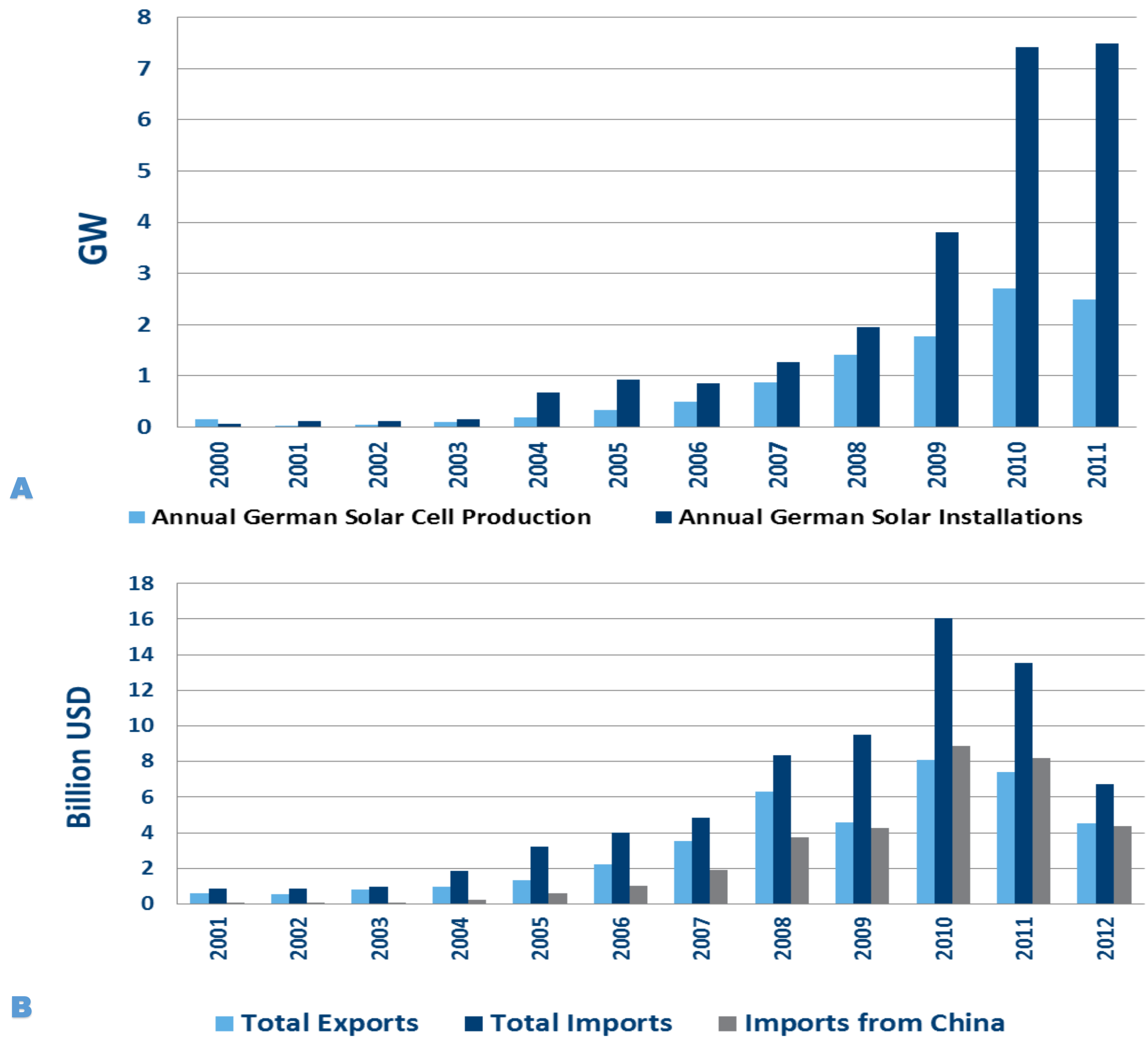

Figure 2. (a) Germany's annual solar cell production and installations; (b) Germany's imports and exports of photosensitive semiconductors, PV cells, and LEDs (Data sources: International Trade Center Data, Frondel et al. 2008, Hoppmann et al. 2014, and IEA 2013).

Contract for Difference FIT recently introduced by the UK Department of Energy and Climate Change allows sales of renewable energy to be made through the competitive dispatch mechanisms of the UK power market.

Competing forces: support for local supply chains vs world trade rules

Particularly in the wake of the Great Recession, governments promoted "green jobs" and development of indigenous supply chains for renewable energy technology industries to help their economies recover. In addition to achieving greater self-reliance for political reasons, they argued that a strong domestic base would provide a platform for exports in a globally growing industry. Direct policy support for supply chains has included capital grants, tax breaks and low interest loans for new technology manufacturers and installers. Indirect policy support has involved encouraging adoption by utilities and consumers via incentives including PTCs and FITs to build a strong domestic market.

Germany and China are often quoted examples of governmental policy implications on the development of the local supply chains and consumers market. Germany pioneered the penetration of the solar photovoltaic (PV) technology through the Renewable Energy Act (EEG), issued in 2000. Renewable policy reforms and the EEG amendments of 2009 and 2012 reduced the FIT level and renewable energy producers were incentivized to sell the power output directly, leveraging a market premium.

EEG implementation has led to a fast uptake of solar PV generating capacity with over 30 gigawatts (GW) installed within five years. The generous, particularly in hindsight, FIT scheme led to a massive demand on locally-produced PV modules. The local supply chains could not cope with the high demand – pulling in global supplies, mostly from China. By some measures, the German FIT was more beneficial to the Chinese PV supply chains, illustrating the transition policy quandary of balancing uptake pace and industry development objectives (Figure 2).

In China, supply-side measures resulted in very different outcomes. Governmental intervention in the PV industry over the last ten years went through three phases:

- 2004-2008: Policy motivated export-oriented growth in supply chains in response to the high demand from the West, particularly Germany. Local manufacturers received support in the form of R&D funding, export credits at preferential rates, export guarantees and insurance. As a result, the rapidly expanding local supply chains were able to leverage economies of scale and reduce costs.
- 2009-2011: Local PV supply chains assumed global leadership chiefly due to their sheer size and the resulting economies of scale. At the same time, the global financial crisis adversely affected the European markets' ability to import at previous levels. To prevent a sharp contraction in local supply chains, the government began to provide direct support for the local installations market. Multiple policy instruments were introduced to directly subsidize the cost of residential and grid-connected PV installations. The first FIT program was initiated in 2011, leading to a surge in local PV demand.
- 2012-present: More balanced policies have been put in place to provide greater support to the local market in the form of grants, FITs and other incentives.

"The massive overcapacity and price reduction in the solar PV industry have largely been driven by the (Chinese) government's over-zealous pursuit of industrial growth while neglecting to foster domestic PV demand."

The Chinese experience of export-driven policy that overlooks the role of domestic demand exposes local supply chains to the vagaries of global demand. The resulting volatility might endanger China's leading position deriving from its scale. On the other hand, indirect support for supply chains through market-driven policy can help develop a market for global suppliers faster than local industry can respond and there can be a temptation toward protectionism. However expedient this may seem in the short term, it carries longer term downsides.

Recourse to the WTO to resolve differences in the green energy sector is no longer an uncommon sight. The first case was brought forward in 2010 by Japan and the European Union (EU) against the Canadian Province of Ontario for the use of LCRs that were used in combination with a FIT mechanism to promote solar PV and wind technologies. The claim pointed to the inconsistent and less favorable treatment of imported renewable technology suppliers versus local suppliers. The WTO ruling was in favor of Japan and the EU, referring to the WTO's non-discrimination clause against treating imported and domestic goods differently. Many other renewable sector disputes have followed, including: US vs. China on wind power, US vs. India on solar panel exports to India, and China vs. EU on renewable technology

"Energy has reached the WTO and unfortunately there it is lawyers who take the decisions and not economists or regulators…Trade law in this area is getting more important."

"Dumping" or the provision of goods and services at less than their cost in order to secure market share and protect domestic jobs is another prohibited practice. Multiple large economies have implemented 'anti-dumping duties', penalizing low cost producers (in violation of WTO agreements), in order to protect their domestic suppliers while they establish their foothold within their own renewable technology industries. This practice puts smaller economies at a disadvantage. Anti-dumping approaches were used by both the US and the EU to protect their steel industries. Several cases of anti-dumping disputes in the renewable energy sector have reached the WTO, including: US, EU and India vs. China; US vs. India; US and India vs. Taiwan; and India vs. Malaysia.

Despite their questionable legality, LCRs are still viewed by many governments as a tool for instigating growth in domestic industries and attracting foreign direct investment. To achieve these goals, LCRs are integrated either directly (via minimum requirements for volume, weight, hours, etc.) or indirectly (via weighting systems) into larger incentive and policy schemes. Thus, LCRs can be utilized to shield an infant industry, but protectionism can result in offsetting negative consequences. For example, Brazil has implemented LCRs to support its wind turbine industry, requiring local sourcing of steel. This has limited the ability of domestic wind producers to access cheaper global steel markets, slowing their growth and reducing their competitive advantage. South Africa's renewable energy LCR proved to be unrealistic, requiring a 65%-80% local employee quota, but the lack of sufficient local skilled workers in renewable energy is impeding the development of the sector.

The judicious deployment of LCRs within a larger transition policy framework, taking into consideration the maturity of an industry and its sustainability beyond policy expiration can be helpful. But protectionism as the main tool for developing domestic green economies could eventually hinder their growth and the domestic economy at large.

Least resistance pathways towards a successful transition: the role of hybridization

It is widely understood that radical technological innovation initially develops in niches and, if successful, subsequently colonizes the existing socio-technical regime. A number of pathways leading from niche to regime have been identified based on empirical evidence. These range from direct competition between the new technology and the dominant socio-technical regime, where the former substitutes the latter, to processes where the new technology merges with the existing regime leading to its reconfiguration into a new hybrid regime. A key factor is that it is companies vested in a particular technology or regime, rather than the technologies and regimes themselves, that battle for dominance. Finding a route to long-term viability for companies vested in the incumbent regime through the transition may speed the progress of the transition without adding undue societal costs.

In the case of the transition towards renewable generation, it is apparent that transitioning away from conventional fuels and technologies via direct competition is difficult. Instead, reconfiguration may be potentially the least-resistant transition pathway that industry and governments could follow. Historical examples of reconfiguration pathways are offered by the cases of transition from sailing ships to steam ships and from carburetors to electronic fuel injection in internal combustion engines. More recently, examples of reconfiguration in road vehicles are offered by biofuels substituting petrol and diesel in internal combustion engine vehicles and by batteries complementing internal combustion engines in hybrid powertrains. In all of the above cases, the new technology was to a significant extent embraced by the regime actors. The incumbents in these cases accumulated competences and developed hybrid solutions, integrating new and existing knowledge into new products. This is the challenge facing the electric utilities around the world.

Thinking in terms of reconfiguration as opposed to direct competition offers both industry and governments a new perspective for developing future strategies. Actors seeking to innovate can target the creation of new markets for hybrid solutions, which governments can enable by removing barriers and offering support. Moreover, incumbent firms also play a crucial role in the outcome of transitions, by either hindering or aligning with policy driven transition pathways. Therefore, the development of hybrid solutions can be assisted by policy that encourages incumbent firms to follow reconfiguration pathways, as opposed to simply penalizing the incumbent technology. In general, policy effectiveness hinges on its ability to account for the potential interactions between the new and incumbent technologies and relevant firms.

The transformation of the utility industry – an opportunity for hybridization?

Is the transformation of the power utility industry both an outcome and an enabler of transitions? New forms of electric power generation would require new modes of grid operation. As a result, additional pressures emerge for electric utilities. The rapid penetration of renewable energy in several markets presents atypical financial and physical realities for power utilities, calling into question their role, traditional business models, and profit levels. Electric power grids are being reconfigured around a mix of utility-scale and distributed generation renewable technology applications. The installation costs of these new technologies and their integration into the power system could, in some circumstances, require additional investment and raise operational costs.

Integration costs are influenced by multiple variables including the power generation mix, overall system size and geography, market design, and renewable energy penetration levels. For example, it is argued that the German power system enjoyed sufficient flexibility to allow for a smooth transition to a 25% renewable energy share. In Saudi Arabia, solar energy profiles appear to be highly correlated with hourly demand shapes, raising hopes of low integration costs. On the other hand, the UK power system is an island with limited interconnections to other markets and the extent of its reliance on base-load nuclear power suggests more serious integration challenges.

The implications of utility-scale renewable technologies on grid operation given their geographic and operational characteristics is an active research area. When located very far from load centers, large wind and solar farms subject transmission grids to new energy flow patterns. Supporting the growing renewable energy output could call for expanding both transmission and distribution systems – in the latter case, to accommodate flows from distributed generation downstream of the transformers. Until storage technologies become economically viable, dispatching conventional generators in non-traditional ways, to account for the intermittency of renewables, introduces another layer of difficulty to utility system planning and operation.

New skills and functions would be required for managing the grid under much more stringent reliability standards. The relative dominance of utilities within the industry could be challenged with customers and independent retailers and distributors taking more active roles. In addition, consumer energy efficiency, demand response, and conservation efforts could have noticeable effects on transition trajectories. Consumers may also assume a more active role in producing energy and shaping their net demand, which will result in utilities taking a disproportionate hit unless either the socialization of the costs of reliability is ensured by regulators or utilities are relieved of the obligation to provide such services.

Conclusions

Unsurprisingly perhaps, the question "where is public money best spent?" remains unanswered, but the lack of a conclusive answer in itself is indicative of the complexities that arise when allocating public money to support policy-driven energy transitions. Supporting a local industry likely requires a combination of direct and indirect approaches tailored to a country's economic, regulatory, and industrial realites – there is no "one size fits all" approach that can be imported from abroad.

There is a danger in assuming a static back-cloth to a policy-driven transition pathway. For example, changes in incumbent technology and fuel economics, and overall economic and demand growth levels can dramatically alter the competitive landscape. If such changes happen to be unfavorable for the new technology, renewable technologies may then remain very dependent on incentives for a long period of time with periods of uncertainty and investment "cliffs" at the expiration of an incentive. On the other hand, shifts that are more advantageous to the supported technology could mean that static policy leads to overspending public money. Furthermore, transition policies and related initiatives can also dramatically transform their own landscapes – a factor that may not have been fully accounted for in transition policy design.

Given these changing dynamics, perhaps a new paradigm of working with rather than against the incumbent regime – reconfiguration rather than complete displacement – can potentially offer the least resistant pathway for industries and governments to follow.

Appendix: KAPSARC Energy Transitions Model

Energy transition policy analysis around the world confronts diverse issues that require a number of different methods in their study and resolution. Building on the tradition of science and technology studies, evolutionary economics and innovation theory, qualitative methods such as Frank Geels' multi-level perspective have generated significant insights into the dynamics of socio-technical transitions. However, these methods are process-oriented rather than goal-oriented. Therefore, they do not provide a formal tool for the ex-ante assessment of the ability of energy transition policy to meet its objectives in a given timeframe.

Well-established computer modelling tools such as computable general equilibrium and bottom-up energy systems models (e.g.: MARKAL) that are typically used in energy policy analysis have also been applied to the study of energy transitions. While they allow estimating monetary costs and benefits, the models are static, or recursive at best, and are typically driven by exogenous scenarios of technology uptake. Therefore, they also fail to provide tools for assessing the ability of policy to deliver a desired transition in a given timeframe.

To fill this gap, we are developing a dynamic simulation model. KAPSARC's model is based on a mixed System Dynamics/Agent Based approach. This novel approach has so far seen very limited application to our problem. In particular, the KAPSARC energy transitions model aims to formally represent the key dynamics involved in energy transitions, and particularly those concerning new supply chain development, in an endogenous fashion. This will allow testing the effect that different policy levers have on the rate at which the transition occurs, the cost of associated policy support measures and the extent to which national supply chains are able to develop as a result. Figure 3 below provides a simplified schematic of the model as it currently stands.

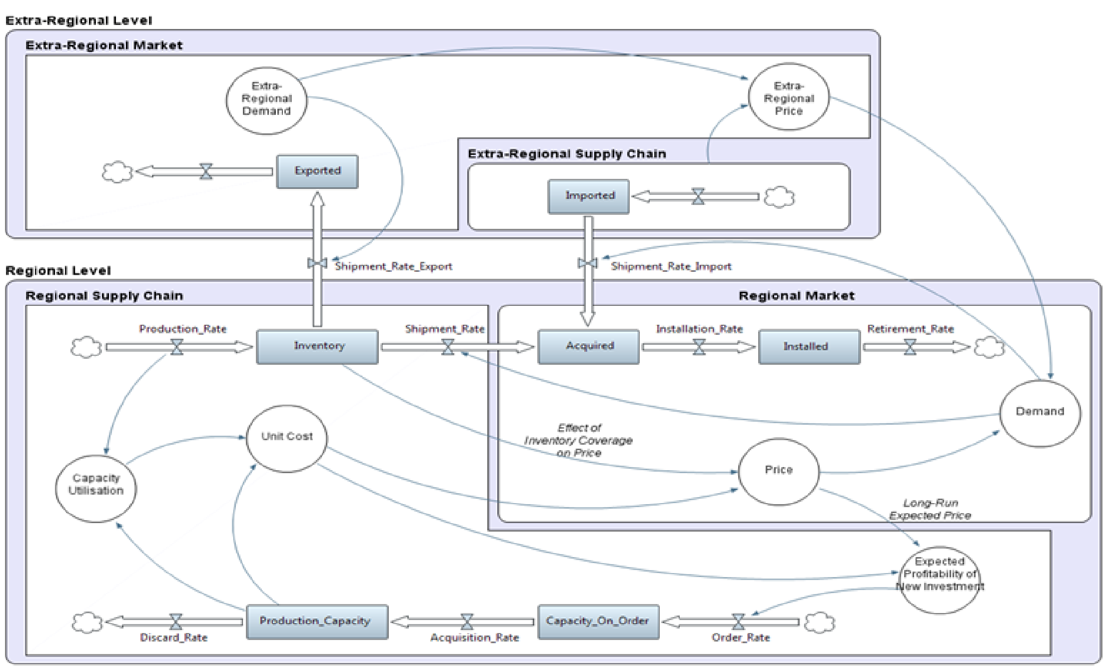

Figure 3. Schematic representation of the current state of development of KAPSARC's energy transitions model. The regional supply chain and market are modelled endogenously (Source: KAPSARC)

About the workshop

KAPSARC convened its second 'energy transitions' workshop in May 2014 with some 30 international experts to facilitate a dialogue on the progress of the framework we are developing at KAPSARC for understanding fuel and technology transitions. The workshop was held under Chatham House rules.

Participants included:

Osamah Al Sayegh – Director of Science & Technology, Kuwait Institute for Scientific Research (KISR)

Yasir Al Turki – Vice Dean of Academic Affairs, King Saud University (KSU)

Robert Ayres – Emeritus Professor of Economics and Political Science and Technology, INSEAD

Ibrahim Babelli – Chief Strategist, (K.A.CARE)

Raed Bkayrat – Vice President, Business Development, First Solar Middle East FZ-LLC

Jacqueline Boucher – SVP Economic Modeling and Studies, GDF-Suez

Marcello Contestabile – Research Fellow, KAPSARC

Amro Elshurafa – Senior Research Associate, KAPSARC

Hind Farag – Research Fellow, KAPSARC

Daniel Fuerstenwerth – Senior Associate Optimisation of the Overall System, Agora Energiewende

Frank Geels – Professor University of Manchester

Alan Goodrich – Director of Strategic Planning, SunEdison

Rob Gross – Senior Lecturer, Centre for Environmental Policy, Imperial College London

Yifan Guo – Researcher, Market Department, Research Institute of Economics and Technology, CNPC

Philip Heptonstall – Research Associate, Centre for Environmental Policy, Imperial College London

David Hobbs – Head of Research, KAPSARC

Abdallah S. Jum'ah – Former President & CEO, Saudi Aramco

Florian Kern – Senior Lecturer, Co-director, Sussex Energy Group

Johannes Kindler – Council, Bird & Bird LLP

Volkmar Lauber – Professor University of Salzburg

Deborah Mann – Director, European Gas and Power, IHS

Marwan Masri – President Emeritus, Canadian Energy Research Institute (CERI)

Will McDowall – Senior Research Associate, UCL Energy Institute

Laura Morris – Energy Policy Analyst, Energy Technologies Institute (ETI)

Rhiannon Mulherin – Business Development, Future Energy Technologies, Shell

Nora Nezamuddin – Research Analyst, KAPSARC

Peter Pearson – Professor, Cardiff University

Roland Roesch – Senior Programme Officer, Renewable Energy Markets and Technology, International Renewable Energy Agency (IRENA)

Muhammad Saggaf – President, KAPSARC

Amit Ronen – Director, GW Solar Institute

Keisuke Sadamori – Director, Directorate of Energy Markets and Security, International Energy Agency

Masakazu Toyoda – Chairman & CEO, Institute of Energy Economics, Japan (IEEJ)

Marie Wilke – Associate Lawyer, WTI Advisors Ltd.

Tom Williams – Laboratory Program Manager, Geothermal Technologies, National Renewable Energy Laboratory

Tamim Zamrik – Research Associate, KAPSARC

Sufan Zhang – Professor, North China Electric Power University

About the Energy Transitions Team

Jorge Blazquez, is a Research Fellow specialising in energy and economics. He has a PhD in macroeconomics from Universidad Complutense de Madrid.

Marcello Contestabile is a Research Fellow, Research Fellow specializing in technology transitions policy analysis. He has a PhD in energy policy and technology from Imperial College London .

Amro Elshurafa is a Senior Research Associate working on cost and technology assessments. Credited with 30 papers and 5 patents, he holds a PhD in electrical engineering.

Nora Nezamuddin is a Research Analyst focusing on transition policy and technology supply chain. She holds a BA degree from the American University, Washington, DC.

Tamim Zamrik is a Research Associate developing a modeling framework for energy transitions and supply chains. He holds a PhD in quantitative finance from Imperial College London.