

Johnson, Oliver

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Exploring the effectiveness of local content requirements in promoting solar PV manufacturing in India

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Exploring the Effectiveness of Local Content Requirements in Promoting Solar PV Manufacturing in India

Oliver Johnson

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Dr. Oliver Johnson is a researcher at the German Development Institute in the Department for Competitiveness and Social Development. He formerly worked at the United Nations Conference on Trade and Development (UNCTAD) and has a PhD in Science and Technology Policy Studies from SPRU (Science and Technology Policy Research) at the University of Sussex. He specializes in low-carbon innovation, energy policy reform and energy access.

E-Mail: oliver.johnson@die-gdi.de

Abstract

In a bid to make renewable energy technology deployment strategies politically acceptable, many countries are linking them to socio-economic goals, such as job creation, economic development and building competitiveness. A controversial industrial policy tool that is becoming increasingly popular is the use of local content requirements (LCRs). These regulate the extent to which certain projects must use local products and are often justified on the basis of supporting local employment and private sector development. The debate has centred around the rights and wrongs of protecting infant industry, with little progress being made to find a common ground. This paper seeks to move beyond this stalemate to understand under which conditions LCRs might be a legitimate and effective tool for promoting local manufacturing. To do so, it applies an effectiveness framework to LCRs for solar photovoltaics in India's National Solar Mission. The paper finds that for LCRs to be effective, they must be (a) limited in duration and incorporate planned evaluation phases, (b) focused on technologies and components for which technical expertise is available and global market entry barriers are manageable, (c) linked to additional mechanisms, such as training and promotion of business linkages and measures to support other stages of the value chain and wider services that are integral to success of renewable energy industries.

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Abbreviations

a-Si	amorphous Silicon
ArrA	American Recovery and Reinvestment Act
BHEL	Bharat Heavy Electricals Limited
BEL	Bharat Electronics Limited
CEL	Central Electronics Limited
BoS	balance-of-systems
CdTe	cadmium telluride
CEEW	Centre for Energy, Environment and Water
NRDC	Natural Resources Defense Council
CERC	Central Electricity Regulatory Commission
CIGS	copper indium gallium
CSP	concentrated solar thermal power technology
CSE	Centre for Science and Environment
DOE	US Department of Energy
DSC	dye-sensitized solar cell
EPC	engineering, procurement and construction
EPIA	European Photovoltaic Industry Association
EU	European Union
FIT	feed-in tariff
GATT	General Agreement on Tariffs and Trade
GoI	Government of India
ICTSD	International Centre on Trade and Sustainable Development
ILO	International Labour Organization
ISA	Indian Semiconductor Association
IREDA	India Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
LCR	local content requirements
MNRE	Ministry of New and Renewable Energy
NSM	National Solar Mission
O&M	operation and maintenance
PV	photovoltaic
R&D	research and development
RE	renewable energy
REN21	Renewable Energy Policy Network for the 21st Century
RET	renewable energy technology
RPO	renewables portfolio obligation
SERC	state electricity regulatory commission
TRIMs	Trade Related Investment Measures
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
EXIM	Export-Import
WTO	World Trade Organization

1 Introduction

It is widely accepted that increased deployment of renewable energy technologies (RET) necessary to mitigate climate change requires government intervention (World Bank 2012). Without it, environmental costs of carbon emissions will not be internalised, perceived risks associated with new technologies will remain high and energy systems will continue along conventional fuel-based path-dependent trajectories. However, government intervention is not a simple process: designing and implementing policy involves negotiation and compromise between a range of actors, each seeking to frame debates in ways that promote their own goals (Birkland 2010, 259). As such, many countries are aiming to make their RET deployment strategies politically acceptable by linking them to other socio-economic goals, such as job creation, economic development and building competitiveness. This win-win rhetoric is commonly heard within discourse on green jobs and green economy (c.f. UNEP 2008).

One national industrial policy tool increasingly being made part of government support for RETs is the use of local content requirements (LCRs). The World Trade Organization (WTO) (2013a) defines an LCR as a “[r]equirement that the investor purchase a certain amount of local materials for incorporation in the investor’s product” In this sense, LCRs act as performance requirements that regulate the extent to which certain projects must use locally¹ manufactured products (Tomsik / Kubicek 2006, 1). They are usually tied to government concessions, such as preferential tariffs, tax exemptions low-interest loans, infrastructure support and land acquisition support. LCRs can be applied in different ways: to a certain percentage of project cost (e.g. wind power projects in Brazil and China) or to certain components (e.g. solar photovoltaic (PV) cells and modules in India). In all cases, the aim of LCRs is to ensure private and public investment benefits the local economy by protecting infant industry and incentivising foreign firms to open local manufacturing facilities or outsource manufacturing to domestic firms (Lewis / Wiser 2007; Tawney 2012). Holding the promise of job promotion, local economic development and export potential, LCRs can help to build support for RET deployment strategies amongst powerful interest groups.

There is considerable controversy over the use of LCRs, as they tend to restrict project developers from using the full range of technologies available in the international marketplace. If local technologies are not competitive, project developers may then be burdened with higher costs and lower performance, which they are likely to pass on to the consumer. The WTO considers LCRs as inconsistent with rules governing free and fair international trade; the Agreement on Trade Related Investment Measures (TRIMs) explicitly prohibits local content requirements and the Agreement on Subsidies and Countervailing Measures prohibits subsidies linked to the use of local rather than imported goods. Flexible interpretation and limited enforcement of these rules has meant that many WTO member states continue to use LCRs. However, the WTO recently ruled that LCRs for wind power in Ontario, Canada, were inconsistent with Canada’s obligations as a WTO member, thus setting a precedent that is likely to have significant ramifications for other countries who have established, or are thinking about establishing, LCRs.

1 By ‘local,’ I refer to the physical location of an activity, not the characteristics of the actor who undertakes that activity. As such, goods produced locally by foreign companies tend to qualify as local under LCRs. Others may use the term ‘domestic’ or ‘indigenous.’

This tension inherent in LCRs raises an important question for research and policy: under which conditions are LCRs an effective policy tool for building a competitive local manufacturing industry? In an effort to address this question, this article explores the case of LCRs in India's National Solar Mission, which aims to achieve grid parity by 2020 through increased deployment of solar energy technologies and strengthening of the nascent solar technology manufacturing industry. LCRs are a particularly contentious component of the National Solar Mission. This paper assesses the impact of using LCRs to encourage India's local solar PV manufacturing industry, discusses what explains their limited effectiveness and suggests some policy recommendations. In doing so, the paper adds to a small, but growing literature on the intersection/interface between green industrial policy and trade (see, for example, Tomsik / Kubicek 2006; Lewis / Wiser 2007; Kuntze / Moerenhout 2013).

The paper is structured as follows. Section 2 gives an overview of the opportunities and challenges associated with localising solar PV manufacturing. Section 3 explores the controversy over LCRs as a policy tool for localising solar PV manufacturing and develops a framework for analysing their effectiveness. Section 4 evaluates LCR policy for solar PV technology in India, a country that has aspirations to become a "*global leader in solar*" (GoI / MNRE 2009). Section 5 seeks to explain the impact of India's LCR policy using the effectiveness framework developed in Section 3. Section 6 concludes.

Empirical analysis relies upon five sources of data: conference presentations and discussions; semi-structured interviews conducted in April-May 2012 and September-October 2012 (see Annex); participant observation at regional events (e.g. India Solar Summit 2012 and World Renewable Energy Technologies Congress 2012); government policy documents (e.g. strategy documents, business plans, consultation responses to draft regional economic strategies); and industry news reports.

2 Opportunities and challenges for localising solar PV manufacturing

The opportunities for localising manufacturing are touted as a way for countries to take advantage of green economy and drive renewable energy. However, there are many challenges associated with achieving this. Indeed, it might not always be the most appropriate option for all countries. In order to understand the opportunities and challenges faced, this section offers a background. It begins by providing an overview of different elements of solar PV manufacturing. It then sets out the potential benefits of localising such manufacturing and the challenge of doing so in today's competitive global market.

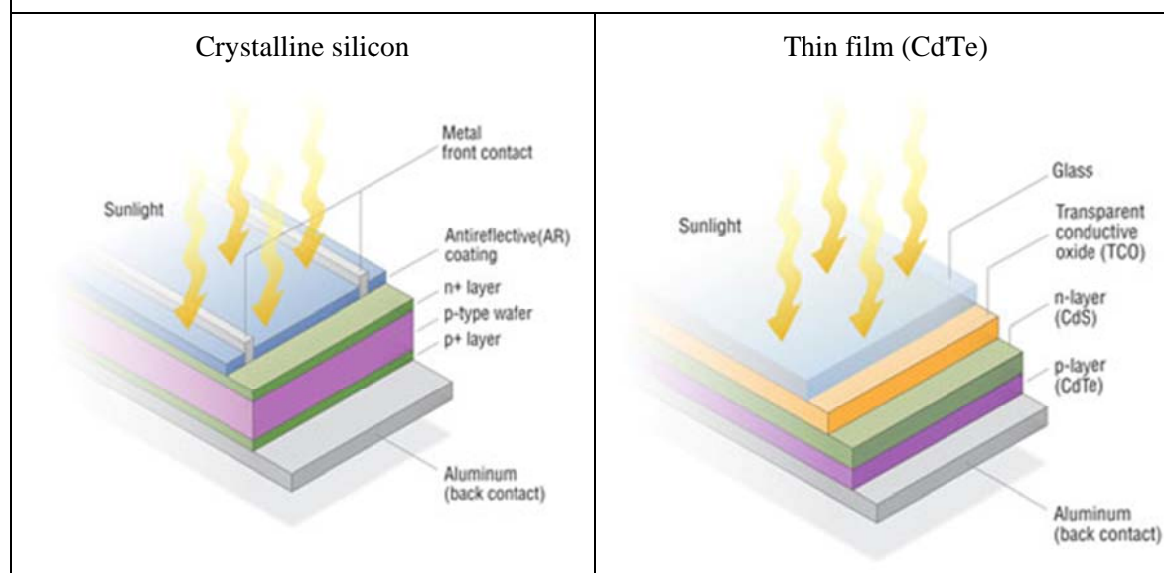
2.1 Different elements of solar PV manufacturing

Solar photovoltaic technology transforms sunlight directly into electricity. It relies on the property of semiconducting materials that enables them to conduct electricity when heated or combined with other substances. A complete PV system is made up of a number of components. The core component is the cell, of which there are two main types according to their composition and semiconducting material: crystalline silicon and 'thin film.' Figure 1 shows a cross-section of both cells types. For each cell technology, the manufactur-

ing process from raw materials to the finished cell comprises different elements. Fabrication of crystalline silicon cells involves four manufacturing stages:

- **Mining of silicon:** The mining process transforms quartz sand into metallurgical-grade silicon then further purifies it into solar-grade silicon feedstock.
- **Ingot growing:** The silicon feedstock is then grown into crystal ingots. The most common process for creating ingots is the Czochralski method: a 150mm seed crystal is mounted on a rod and dipped into a quartz crucible containing molten silicon; the rod is simultaneously rotated and pulled upward to form a single cylindrical ‘mono-crystalline’ ingot, with a perfectly-arrayed crystal composition. ‘Multi-crystalline’ ingots of multiple smaller crystals can be formed by casting molten silicon in a furnace and gradually cooling the resulting block-shaped ingot.
- **Wafer cutting:** Ingots are then cut with a wire or diamond saw into wafers roughly 150mm in diameter and 0.2mm thick. These are cleaned and polished prior to quality assurance inspection. Ingot growing and wafer cutting often take place within the same company.
- **Cell creation:** Finally, wafers are processed into cells in an energy- and chemical-intensive process. Through phosphorous diffusion, a semiconductor junction is created on the top surface of the wafer. Contacts are added to the front and rear of the wafer to make the cell a conductor. The contact on the front surface has a design pattern that makes it more conducive to maximum exposure to the sun’s rays, while reducing electrical loss (EPIA 2013; Green Rhino Ltd. 2013).

Figure 1: Cross-section of crystalline silicon and thin-film (CdTe) solar PV technology



Source: U.S. Department of Energy (DOE) (2012)

An alternative to the crystalline silicon cell is the thin film cell. Thin film technology was given a boost during supply shortages and subsequent price hikes in silicon during the

early 2000s. It is also believed to have higher levels of efficiency and higher resistance to heat, which can be an advantage in hot climates. Unlike the separate and complex phases of crystalline silicon cell manufacturing, the manufacturing of thin film cells is a simpler, wholly integrated process. The manufacture of thin film cells involves depositing one or more thin layers of semiconducting material onto a substrate made of glass, steel or a transparent film and coated with a layer of transparent conducting oxide. The thin film layers are approximately one hundred times thinner than the wafers used in crystalline cells. Thin film cells are usually categorized according to the semiconducting materials they use: cadmium telluride (CdTe); copper indium gallium selenide (CIGS) and amorphous Silicon (a-Si); dye-sensitized solar cell (DSC); and other organic solar cells (Platzer 2012; EnergyTrend 2013). Some thin film technology use hazardous materials, requiring careful handling during manufacturing and necessitating controlled disposal once the panel is no longer in use.

After the production of cells – be they crystalline silicon or thin film – the next step is to arrange and connect them together in an array to form a module. Module manufacturing is predominantly a production/assembly line activity. Among other activities, it involves connecting the cells to form an electric circuit, laminating the connected cells and fitting a frame to complete the module. The overall solar PV system, or plant, is formed by connecting the module to balance-of-systems (BoS) components. These include the inverter, battery, tracking and control system and will differ in scale depending on the system needs. The scale of PV systems ranges from small PV modules for charging a phone to household systems to large-scale grid-connected projects, where considerable civil and structural works are required to mount and connect many systems side-by-side. PV systems must also be designed according to their individual characteristics and to local standards.

Beyond the manufacturing of components and systems for solar PV, the project life-cycle includes project development, site preparation, plant installation and operation and maintenance (O&M). Investors, developers, lawyers, manufacturers and engineering, procurement and construction (EPC) contractors all play a role in these activities. Whilst one particular project may involve actors playing distinct roles, in other projects, actors may play multiple roles: a firm that has manufacturing and EPC divisions may be responsible for manufacturing, installing, operating and maintaining a system and its components.

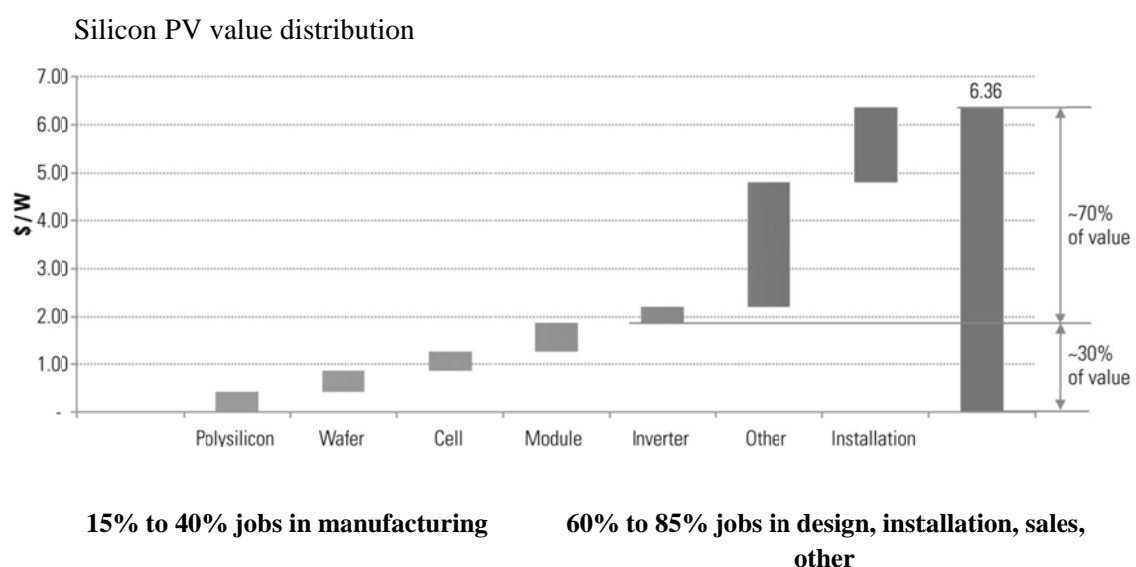
2.2 Potential benefits of local solar PV manufacturing

Governments and local industry may aspire to manufacture complete systems, manufacture certain components and import others, or just serve as an assembly base for components that are all imported. In their study of wind manufacturing around the world, Lewis and Wiser (2007, 1845–1846) highlight three important potential benefits of developing a local manufacturing industry: local job creation; export of domestic manufactured solar products to international markets and cost savings. To these, I also add the potential benefit of accumulating technological capabilities, which is widely acknowledged as vital to developing long-term competitiveness and adapting technology to local needs (Bell / Pavitt 1993; Fu et al. 2011). These factors are treated in more detail below.

The promise of job creation is one of the main driving forces behind developing a local solar manufacturing industry. Policymakers keen to generate jobs and economic growth in today's difficult economic climate will find it hard to ignore reports about the number of job opportunities created in renewable energy and 'green economy' more generally. A report by the International Renewable Energy Agency (IRENA) claims that between 2004 and 2010, global employment in the renewable energy sector grew from 1.3 to over 3.5 million jobs (IRENA 2011, 15). Official figures from the German government claim that renewable energy industry has created approximately 382,000 jobs in the country, with 111,000 of those located in the solar PV sector (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2012). It is widely reported that renewable energy provides more jobs per unit of energy delivered than fossil fuels (Kammen et al. 2004; IRENA 2011, 15).

However, these numbers do not explain where in the value chain these jobs lie. The European Photovoltaic Industry Association (EPIA) (2013) estimated that manufacturing held a 60 per cent share of jobs in the EU's PV industry in 2005, reducing to 45 per cent by 2020. IRENA estimates that by 2009 just under 40 per cent of global jobs in solar PV are in manufacturing. Data in Figure 2 suggest that, by 2012, the share of manufacturing jobs in the US PV industry was already in the range of 15-40 per cent (CEEW / NRDC 2012a, 18). There appears to be consensus that, with growing automation and consolidation in the global solar PV manufacturing industry, in the long term most jobs will be created in installation, system integration and operation and maintenance (O&M). By nature, these jobs are local. Indirect job creation will also be high, with predictions of around 39 per cent of total employment creation (EPIA 2013; CEEW / NRDC 2012a). Of course, these figures do not account for jobs in conventional energy industries lost as a result of growth in cleaner energy industries.

Figure 2: Jobs and value creation in solar PV industry



Source: CEEW / NRDC (2012a)

Another reason for developing a local manufacturing industry may be the creation of an export product, which can be very lucrative as countries around the world seek to increase deployment of RETs. Export-promotion may be the main aim of a local manufacturing policy, but in many cases it will be an additional, long-term goal. In China, nearly all manufacturing of solar PV has been geared towards exports for German, Spanish and US markets, and in 2007 it replaced Japan as the market leader in terms of production/manufacturing (Becker / Fischer 2012, 7; Byrne et al. 2010, 15). The promise of export competitiveness has clearly been the rationale behind initial development of China's solar PV manufacturing industry. In India, most solar manufacturers focused on exporting to Europe and the US; providing for the local market on a large-scale is a new phenomenon. However, recent fall in demand from traditional export markets, such as the US and Europe, means many countries need to look towards promising local markets.

A further argument for investing in local manufacturing is the potential cost advantages it can offer. Countries like China and India can reduce costs through lower wages compared to Europe and the US. Locally produced raw materials may also be cheaper, especially after transportation costs and supply security risks are factored in. Different elements of the value chain might hold greater potential for cost advantages than others. For example, for a country like India, local manufacture of cells and modules is unlikely to reduce costs below those achieved through economies of scale (c.f. China) and innovation (c.f. Europe and US). Meanwhile, local manufacturing of BoS components could be an important source of cost reductions. Recent decreases in cell and module costs have resulted in relatively higher BoS costs in solar PV systems (of up to 68 per cent of project costs) and there is considerable opportunity for innovation to reduce the costs of BoS components (GTM Research 2013; Rocky Mountain Institute 2013).

Finally, local manufacturing skills and associated spin-offs can be instrumental in building the technological capabilities necessary to maintain, repair and adapt technology. For instance, the local PV manufacturing industry can assist in the design and installation of components and systems optimized for local solar irradiation patterns, landscape and maintenance requirements, which differ depending on the specific atmosphere (i.e. levels of dust, sand and humidity). As experience and product feedback grows, firms and individuals can develop skills and capabilities for research and development and innovation. This way, benefits can be sustained over the long-term and the local manufacturing industry will not be left behind as technological frontiers shift.

2.3 Competing in the global solar PV manufacturing industry

Whilst the potential benefits of developing a local PV manufacturing industry are myriad and enticing, they are not guaranteed. The global solar industry has developed significantly over the past few years; it is now relatively mature and this generates significant barriers to entry for countries with limited solar manufacturing capabilities. The feasibility of entering a specific part of the value chain depends upon three issues: technical barriers, financial barriers and global market competition. These barriers for different parts of the PV value chain are summarised in Table 1.

The solar PV industry requires specialists across a broad spectrum of skills and knowledge, from experience with chemical materials to production line management skills to mechanical and engineering capabilities. Within the manufacturing stages of the solar

Table 1: Market entry barriers to localising PV manufacturing

Component	Technical barriers	Financial barriers	Global market competition
Crystalline silicon cells			
<i>Polysilicon feedstock</i>	High technical skills necessary. Complex production line	High capital costs (\$500m-\$1bn per plant), long lead times to add capacity, energy intensive	Industry dominated by 7 companies supplying around 90 per cent of the total polysilicon market
<i>Ingots and wafers</i>	As above	High capital costs but standard production facilities can be bought off the shelf	Dominated by 5 companies sharing over 90 per cent of the market
<i>Cells</i>	As above	High capital costs for the manufacturing line, economies of scale needed	Many players. Top 10 producers in 2008 produced just over 50 per cent of the total.
Thin film cells	Complex manufacturing line, intensive training of workforce required	Small-scale equipment can be bought off the shelf, but capital costs increase with plant size	Very dynamic, many start-ups.
Modules	Low technical skills required	Capital and energy requirements much lower than other processes	Large no. of module manufacturers. Many of leading module manufacturers are also cell manufacturers. Main differentiating factor is efficiency.
Glass	High technical skills required	Capital and energy intensive	Very large demand required, only specialised glass can be used for PV applications
Balance of systems			
<i>Inverters</i>	Highly skilled professionals needed for R&D and quality management	High investment cost in manufacturing equipment and quality inspection site	Large demand required to build a production line. Market dominated by a few global players
<i>Batteries</i>	Medium-skill electronic assembly and quality control	Med-low investment cost	Existing battery manufacturers can also supply appropriate batteries for the PV industry.
<i>Transformers</i>	Medium skill electrical training	Investment costs are fairly low	Mature and competitive industry, but with room for growth.
<i>Steel structures and cables</i>	Low technical skills required	Low investment cost	Existing industry could integrate another product
Sources: Green Rhino Ltd. (2013); Fraunhofer ISE (2012, 11-12); IRENA (2011, 7-8)			

PV value chain, most technical, engineering and research staff are likely to require at least undergraduate-level education in their respective field of specialisation. Skilled labourers will be personnel such as technicians or electricians who have undertaken an apprenticeship during their education. Research and development (R&D) staff supporting the production process will include experienced scientists and engineers with a high level of specialisation in solar PV. And BoS integration activities require technicians for the integration of roof top mounted systems and engineers for the integration of ground mounted systems. In addition, highly skilled staff are required to provide services such as management, contracting, design and marketing issues. Installation requires qualified technicians

and operation and maintenance needs no significant academic or scientific background (IRENA 2011, 7–8; Green Rhino Ltd. 2013; Fraunhofer ISE 2012, 11–12).

Financial barriers vary according to capital and energy costs. In the silicon mining sector, whilst silicon is widely available in the form of sand, transforming and purifying it is a costly and energy-intensive process, making up about 25 per cent of the cell cost and 35 per cent of the energy input. At a range of \$500m–\$1bn per plant, capital requirements are high. Adding new capacity takes considerable time and newcomers face barriers of existing long-term contracts. Ingot growing and wafering stages of the solar cell manufacturing process are similarly capital and energy intensive, creating significant barriers to entry. As noted in Section 2.2, BoS costs are now more than half the system cost for PV. However, business process costs for BoS vary substantially by project size, location, ownership and project phase (Rocky Mountain Institute 2013).

Market competition in solar PV manufacturing is fierce and set to continue. In their analysis of 300 solar PV cell and module manufacturers, GTM Research (2012) forecasts that 180 of them are likely to go out of business or be bought by 2015. In general, technological capabilities are concentrated in the hands of a few global players; many companies have decades of experience in solar technology R&D and the leading manufacturers are becoming larger and increasing their global market share through mergers and acquisitions (REN21 2012; UNEP/Bloomberg New Energy Finance 2011, 49). For example, the polysilicon mining industry is dominated by seven companies² supplying around 90 per cent of the total silicon market (Green Rhino Energy Ltd. 2013). Five companies dominate the ingot and wafer processing industry, with over a 90 per cent market share. However, standard production facilities can be bought off the shelf and many silicon mining and cell creation companies are looking to backward and forward integrate into these stages. There is more space in cell manufacturing: the top 10 cell manufacturers in 2008 produced over 50 per cent of global production (Green Rhino Energy Ltd. 2013). However, in the wake of falling cell and module prices, it is generally assumed that China will maintain leadership in cell manufacturing due to its large economies of scale (Byrne et al. 2010).

New entrants will need to compete with these large, well-established companies. Limited local capabilities and industrial experience can make the complex quality control processes associated with maximising cell efficiency a significant challenge for newcomer firms (Babelli 2012). Therefore, it might make much more sense to focus on localising other parts of the manufacturing process, such as module assembly and BoS systems and integration. BoS manufacturing and integration, in particular, are viewed as potential revenue opportunity, with plenty of room for innovation and efficiency improvements, so there are many companies looking to get involved (IMS Research 2012; GTM Research 2012).

Governments and firms have to consider these various barriers to entry when thinking about entering or supporting development of a certain technology and process. For example, when considering the issue of localising manufacture of wind turbines and solar thermal technology, the South African government's Department of Trade and Industry split sections of the manufacturing industry into four categories: shallow, intermediate, advanced and globally leading. Using these categories, they focused on achieving local manufacturing in all but the globally leading component parts, which were high-tech and

2 Hemlock, Wacker Chemie, REC, MEMC, Tokuyama, LDK Solar and OCI Company

required capabilities for frontier innovation that they did not have (Government of the Republic of South Africa / Department of Trade and Industry 2011). A long term plan may involve starting small in terms of manufacturing – perhaps at the shallow end – and having a targeted strategy of building up capabilities to expand the degree of local manufacturing. And beyond manufacturing, installation, operation and maintenance of solar PV systems are naturally more local, so it is important to focus on training and support to build up capabilities in these areas (Renner 2013).

3 Promoting local manufacturing through local content requirements

Localised manufacturing can be an important element of a move to a renewable energy system that is not dependent on foreign imports. Energy security and the promise of green jobs are strong political motivations for building up local manufacturing capabilities. This section explores the current fashion for local content requirements (LCRs) as a tool to promote local manufacturing and highlights the corresponding international pressure to eliminate LCRs. It then presents a framework to analyse the legitimacy and effectiveness of LCRs.

Table 2: Policy options to promote local manufacturing		
Policy tool	Goal	Example
Local content requirements	Infant industry protection	India, Brazil, Canada, etc.
Financial and tax incentives	Incentivise investors to use local technology by offering low interest loans or tax credits tied to use of local products	Denmark and Germany, the government provided soft loans below market rate for wind projects which had significant local content.
Favourable customs duties	Support local assembly/production line activity	Germany and Denmark also put in place customs duties which favoured the import of components over fully assembled wind turbines
Export credit assistance	Support for manufacturers to reach export quality standards	
Quality certification and supplier development programmes		
Research and development (R&D) support	Grants for R&D activities that help local manufacturers adapt and improve technology and processes.	
Source: Lewis / Wiser (2007, 1852–1853); Sustainable Prosperity (2012, 4)		

3.1 The current fashion for local content requirements

There is a range of policy tools that governments can use to promote local manufacturing (see Table 2). In this paper, I focus on the policy instrument of local content requirements for two reasons. They are becoming an increasingly popular tool for promoting local manufacturing, yet there is relatively little knowledge about how effective they are. Growing controversy over use of this policy tool within international trade debates highlights the need for better understanding the conditions under which they might be a relevant policy option.

As noted earlier, according to the WTO (2013a), an LCR is a “[r]equirement that the investor purchase a certain amount of local materials for incorporation in the investor’s product.” By mandating the use of local products in specific projects, LCRs aim to guarantee sales for local infant industries whilst they build up the capabilities necessary to compete with international competitors, both domestically, and eventually internationally (Khan / Blankenburg 2008, 342–343). LCRs are typically favoured because they are essentially a way to pursue the benefits noted in Section 2.2 without placing a direct burden on the government budget. For LCRs to have an impact, they should be slightly more ambitious than what the local share would be under liberalised conditions and they should increase as local firms increase their capabilities. The protective space LCRs provide is generally assumed to be of a temporary nature; hence they should be phased out once the protected infant industry has become competitive. Of course, this is not always the case in practice, particularly if manufacturers successfully lobby to retain the privileges they have received.

Support for infant industry is not new: Cimoli et al. (2006, 8) note that, since the 19th century, countries which have caught up with the most economically developed have always involved some government support in the form of protection and direct and indirect subsidy. Examples include the US in late 18th century, Germany in mid-19th century, Continental Europe, Japan, Korea and Taiwan in the second half of the 20th century. The automobile manufacturing sector is a good example. A 1986 UNIDO study found that in 1980, 27 countries around the world had LCRs in their automotive industries to shield domestic manufacturers from international competition; these ranged from 15–20 per cent in Nigeria and Malaysia to nearly 100 per cent in India and Brazil (UNIDO 1986).

Table 3: Countries with local content requirements for renewable energy technologies			
Region	Period	Industry	Local content requirement
China	1996–2008	Wind	Wind turbines under China’s NDRC were required to source at least 70 per cent content from local manufacturers; bids with larger amounts of local content are scored higher
Brazil	2005–2009	Wind	At least 60 to 90 per cent local content for wind development
India <i>Central gov’t</i>	2009–	Solar	National Solar Mission-approved solar PV projects must use locally manufactured cells and modules. Solar thermal projects must have 30 per cent local content.
Canada <i>Quebec</i>	2006–	Wind	At least 60 per cent local content for wind development; bids with larger amounts of foreign content are scored higher
<i>Ontario</i>	2009–2012	Wind	At least 50 per cent local content for wind development; at least 60 per cent local content for solar development under feed in tariff.
US	2009–	All manufacturing industries	All public projects backed by ArrA funds must use ArrA-compliant products. If the local content of a product is over 50 per cent and manufactured within the U.S., it can be considered ArrA compliant.
Source: Rivers / Wigle (2011); CEEW / NRDC (2012a, 22); Hao et al. (2010); UNEP / Bloomberg New Energy Finance (2011, 29).			

In the renewable energy sector, particularly wind, many countries have used LCRs as part of the renewable energy support schemes (see Table 3). For example, In Brazil, LCRs have been attached to concessional loans from the national development bank, Banco Nacional de Desenvolvimento Economico e Social. From 2008, firms accessing these loans had to ensure that at least 60 per cent of the total cost of wind energy projects was sourced from Brazil. The LCR was increased from 60 per cent to 84 per cent in 2012. Whilst this has been criticised by many foreign wind companies, it has helped Brazil to build up considerable capabilities throughout the wind supply chain, with the potential to be a regional hub for wind power manufacturing (Bloomberg 2012a; 2012b; UNEP / Bloomberg New Energy Finance 2011; IRENA / GWEC 2012).

3.2 International pressure to eliminate local content requirements

Despite the promise of LCRs as a mechanism to promote local value creation/local manufacturing, their increased use is matched by growing vocal concern over trade protectionism.³ LCRs are generally seen as inconsistent with the WTO's international trade rules. Article III:4 of the General Agreement on Tariffs and Trade (GATT) states that:

“The products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution or use.” (WTO 2013b)

This is reinforced by the WTO's (1994a) Agreement on Trade Related Investment Measures (TRIMs), which explicitly prohibits local content requirements because they are inconsistent with this provision of GATT and Agreement on Subsidies and Countervailing Measures, which prohibits “subsidies contingent ... upon the use of domestic over imported goods” (WTO 1994b). The general philosophy behind this position is that LCRs are considered to be ineffective in promoting overall welfare because they force countries to invest resources inefficiently in sectors where they don't have a competitive advantage as they will artificially improve the competitiveness of local products *vis-à-vis* foreign products. This is assumed to bring the danger that LCRs may also be pushed by interest groups who seek monopoly rents in the supply of equipment and services for renewable projects. Restricted competition allows local producers to extract monopoly rents and reduces both the number of actors in the sector and competitive pressures on them.

Until recently, enforcement of WTO rules on LCRs has been limited. The most notable exception is a landmark case in 1984 in which Canada's LCRs for foreign investment projects were ruled as inconsistent with the national treatment obligation of Article III:4 of the GATT (WTO 2013c). Despite fairly clear written statements prohibiting LCRs, there was plenty of room for interpretation and there are a number of loopholes, such as government procurement (ICTSD 2008). In addition, for many years there was no clear strategy on how to apply trade regulations to environmental goods (Cosbey 2011).

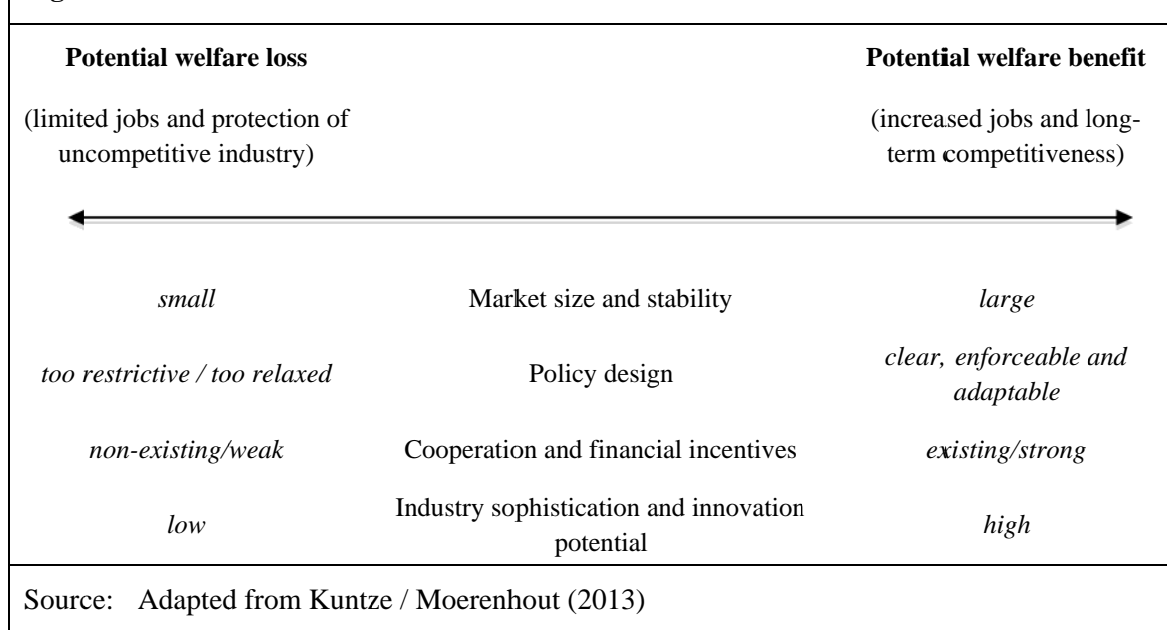
3 This concern is often hypocritical, as countries who complain about LCRs often have their own protection measures in place.

This is all changing. The issue of LCRs for RETs has been climbing the agenda WTO for a number of years (Ali-Oettinger 2012; ICTSD 2012). The most famous is the recent case brought about by Japan against Ontario, which is likely to have far-reaching consequences. In September 2010, Japan began consultations with Canada regarding LCRs in the province of Ontario's feed-in tariff for wind and solar. By mid-2011, the case remained unresolved so Japan, with support from the EU, requested the WTO Dispute Settlement Body to establish a panel to review the case. The panel presented its findings in December 2012, ruling that the LCRs were inconsistent with Canada's obligations under the TRIMs Agreement and the GATT. Importantly, the panel found that Ontario's LCR did not meet the exception criteria associated with government procurement as the electricity purchased by the government under the FIT programme was for commercial resale (WTO 2013d). This ruling sets a clear precedent that will have important ramifications for other countries with, or seeking to establish, LCRs; particularly those like India who have previously viewed their LCR policies as permitted under WTO rules because they are associated with publicly procured electricity.

Another critique of LCRs, unrelated to WTO concerns, is that on their own they are unlikely to help local firms fully develop the technological capabilities needed to be globally competitive in the long-term. LCRs overemphasise manufacturing, neglecting other equally important, and potentially more value-added, parts of the value chain. For example, Tawney (2012, 12) notes that half the value in the US solar PV value chain comes from services, such as engineering, logistics and labour. In addition, LCRs do little to address systemic barriers to the development of local technological capabilities that local manufacturing firms might face. Of course, LCRs might create a space for learning-by-doing necessary to adapt the technology to local conditions and ensure effective operation and maintenance in the field. However, development of more advanced technological capabilities needed for research, development and innovation closer to the technological frontier require more active support (Bell / Pavitt 1993; Bell 2009). Without developing these capabilities, countries will just be consumers of new technology and remain dependent on imports. In order to build the expertise necessary to become low carbon producers and innovators in their own right, LCRs need to be linked with other policies that support and catalyse learning (Yin 1992, 26; Wei 1995; Ockwell et al. 2009, 6).

3.3 Analysing legitimacy and effectiveness of local content requirements

The LCR debate appears to have reached a stale-mate. If the practice of LCRs is discontinued, there is a risk that political buy-in to RET deployment policies might be difficult to achieve. On the other hand, there is no guarantee that LCRs will help build the requisite local capabilities necessary for real competitive upgrading. The debate needs to move beyond whether LCRs are right or wrong policy, but understanding under which conditions LCRs might be a legitimate and effective tool for promoting local manufacturing (Cosbey 2011). A far more relevant research question, and the one that lies at the heart of this paper, is: under which conditions are LCRs an effective policy tool for building a competitive local manufacturing industry?

Figure 3: Evaluation framework for LCR effectiveness

In order to understanding the conditions under which the potential benefits of LCRs are realised, I adapt the effectiveness framework developed by Kuntze and Moerenhout (2013). The adapted framework focuses upon four determinants of LCR effectiveness (summarised in Figure 3):

- Market size and stability:** One of the most commonly cited factors determining the effectiveness of LCRs is the size and stability of the local market (Lewis / Wiser 2007; Deloitte 2012, 8). Manufacturing within small or unstable markets is unlikely to reach the economies of scale necessary for cost effective production (Hao et al. 2010, 6-7). In order to increase and stabilise the market, LCRs are often implemented in tandem with policies geared towards catalysing market demand, such as feed-in tariffs.
- Policy design:** It is imperative that LCRs are designed appropriately. If they are too high, they may discourage project developers and investors who find it too difficult or expensive to source locally. If they are too low, they may create bureaucratic hurdles without doing anything to increase local content. If they are too vague, they may be impossible to enforce. One of the key challenges in determining how to administer LCRs and withdraw them if necessary is having enough information about whether they are working. There is a need to continuously reflect upon and adapt policies as previous rounds of the policy cycle reveal areas for improvement, new scientific evidence emerges, stakeholder alliances change, or financial scope shifts.
- Cooperation and financial incentives:** Supply chains are complex and LCRs are only one of many support mechanisms that may be in place. If LCRs are to catalyse local manufacturing, they must be aligned with other financial support mechanisms, such as duty exemptions, tax breaks, special economic zones. Engaging with a wide variety of stakeholders, such as project developers, local manufacturers, foreign manufacturer, engineering, procurement and construction contractures, utilities and government ministries, can help to identify and iron out potential conflicting policies.

- **Industry sophistication and innovation potential:** LCRs might be a short-term political objective geared towards appeasing certain interest groups, but they will only catalyse long-term competitiveness if there is potential for innovation and learning-by-doing. Without the technological capabilities needed to learn and improve, LCRs will merely help firms to sustain their activities but not help them develop any competitive edge. Whether these capabilities are sufficient will also depend greatly on the sophistication of respective industry and specific area of the value chain targeted by LCRs. If they focus on globally competitive parts with high barriers to entry then there may be little opportunity for innovation within new or uncompetitive firms (Lewis / Wiser 2007; Tomsik / Kubicek 2006).

4 Local content requirements in India's National Solar Mission

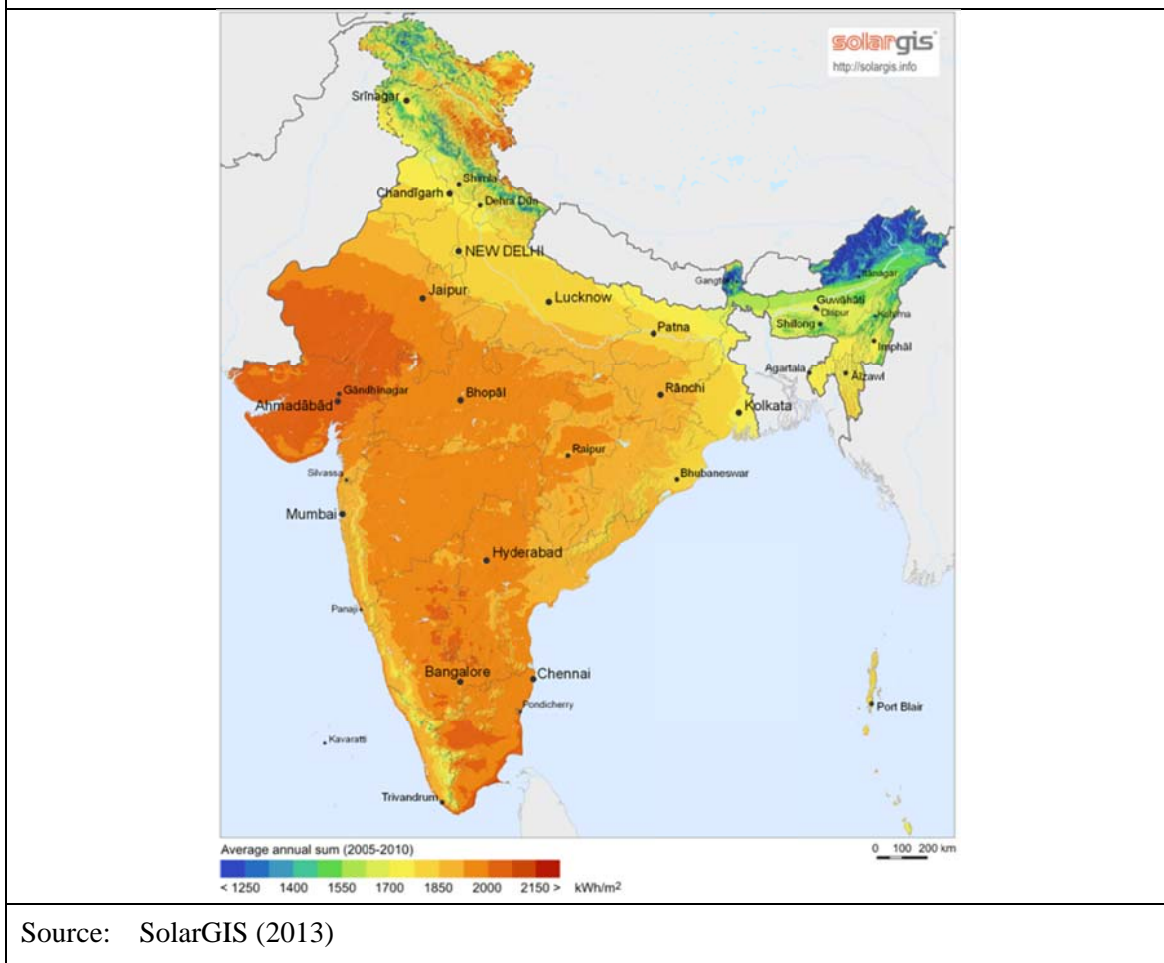
As part of a concerted effort to promote solar energy in India, the Government of India (GoI) has made local manufacturing a strong priority. In particular, the GoI has chosen to establish LCRs as means to build up the country's local solar manufacturing industry. This section sets out India's solar energy potential and associated policy mechanisms. It then examines the government's LCR policy aimed at promoting local solar manufacturing and evaluates their impact.

4.1 The solar landscape in India

The Indian economy faces significant challenges in meeting its energy needs. In 2009, the power deficit was 11 per cent, roughly 40 per cent of the population had no access to electricity, and the per capita consumption of 639kWh was one of the lowest in the world (Sargsyan et al. 2010, 6). The 2006 Integrated Energy Policy Report estimated that India needed a five- or six-fold increase in electricity generation to meet lifeline per capita consumption and sustain an 8 per cent growth rate (GoI / Planning Commission 2006, xiii). It is clear that India needs to bring on new generation capacity to achieve this. Increasing generation capacity using fossil fuels brings serious issues. Firstly, 75 per cent of oil consumption depends on imports and, by 2017, 30 per cent of coal consumption is expected to rely on imports (KPMG 2011, 11). As the cost of these resources continues to increase, satisfying an increasing energy demand will be a huge burden and will impact energy security. Secondly, there is considerable pressure from the international community to meet the rise in generation demand in an environmentally sustainable way.

Solar energy is viewed as a particularly promising source that can help the country meet demand in a way that enhances energy security, reduces imports, mitigates fuel volatility, increases access and reduces emissions. Solar irradiation in India is strong: the average solar radiation intensity is 200 MW/km² and, with 250–300 days of sunshine per year, a cumulative total of roughly 5000 trillion kWh/yr is generated (Sharma et al. 2012, 935; Kumar et al. 2010, 2438-2439). Solar energy intensity varies geographically, with the western states of Rajasthan and Gujarat receiving the highest annual radiation and north-eastern states receiving the least (see Figure 4). Parts of Ladakh, Andhra Pradesh, Maharashtra and Madhya Pradesh also receive high levels of radiation (Sharma et al 2012, 935). All in all, this is a considerably higher intensity than those of European countries with the highest installations today (KPMG 2011, 23).

Figure 4: India's solar irradiation



4.2 Policy support for solar PV

Solar power and other renewable energy sources have been promoted in India for many decades. In response to the oil crises in the 1970s, in 1981 the GoI created a Commission for Additional Sources of Energy within the Department of Science and Technology. In 1992, this evolved into the Ministry of Non-Conventional Energy Sources, the first ministry in the world dedicated to renewable energy. In 2006, it was renamed the Ministry of New and Renewable Energy (MNRE), as it is known today.

Under the current structure, policy support comes from central and state governments (see Table 4). At the central government level, the Ministry of New and Renewable Energy (MNRE) is responsible for the development of national renewable energy laws, setting up technical standards for renewable energy, conducting resource assessments, supporting research and development in renewable energy technologies and managing data on renewable energy use. Any fiscal incentives for promoting renewable energy are developed in tandem with the Ministry of Power and Ministry of Finance, both of whom are jointly responsible for designing national electricity tariff policies. The Central Electricity Regulatory Commission (CERC) is then responsible for setting guidelines for feed-in tariffs for different renewable energy technologies and regulating regional electricity cooperation and large-scale third-party sales.

These roles are mirrored at the state level: the state government develops state-specific renewable energy policy and fiscal incentive mechanisms; the state nodal agency undertakes resource assessments, allocates renewable energy projects and monitors progress; and the state electricity regulatory commission (SERC) develops feed-in tariff mechanisms, determines and enforces renewable energy obligations on distribution companies and regulates interstate electricity trade and local third party sales.

The 2003 Electricity Act paved the way for significant increases in renewable energy production in India. Section 86 (1) (e) mandated SERCs to

“promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution license.”

Table 4: Roles of state and central government agencies in policy development, regulation, and promotion of renewable energy			
	Central government (Ministry of Power / Ministry of Finance)	Ministry of New and Renewable Energy (MNRE)	Central Electricity Regulatory Commission (CERC)
Central	<ul style="list-style-type: none"> Develops national electricity tariff policies, which also cover RE Provides fiscal incentives for promoting RE 	<ul style="list-style-type: none"> Develops national RE laws Sets technical standards for RE Conducts resource assessments for RE; supports R&D in RE technologies Promotes effective use of information technology for RE, manages database Reviews RE programs to understand their effectiveness and efficiency 	<ul style="list-style-type: none"> Sets guidelines for feed-in tariff design for different RE technologies Regulates the regional electricity cooperation mechanism Regulates interstate open access, and third-party sales
	State government	State Nodal Agency	State electricity regulatory commissions (SERCs)
State	<ul style="list-style-type: none"> Develops state-level RE policy Provides fiscal incentives for promoting RE sources 	<ul style="list-style-type: none"> Conducts resource assessments for various RE sources Allocates RE projects and monitors progress Provides facilitation services to project developers - IREDA personnel escort project developers to various government departments with the objective of facilitating and streamlining clearances Facilitates clearances and land acquisition Creates awareness and educates the masses about adoption of RE Maintains database on RE source 	<ul style="list-style-type: none"> Develops feed-in tariff methodologies for different RE technologies Determines RPOs and enforcement mechanism Sets regulations on intrastate wheeling, open access, and third-party sale
Source: World Bank (2010a, 37–38)			

The National Electricity Policy in 2005 and National Tariff Policy in 2006 solidified India's commitment to renewable energy by requiring licensed utilities and captive electricity producers to purchase certain amounts of renewable energy under a renewables portfolio obligation (RPO) scheme. In addition, they allowed for SERCs to determine feed-in tariffs to promote these technologies (Sharma et al. 2012, 938; Goyal / Jha 2009, 1396-1397). In response, a number of specific federal and state-level incentive schemes were created, which promoted rooftop solar PV installations and large-scale solar power plants. The National Rural Electrification Policy, enacted in 2006, also offered a range of incentives for renewable energy projects, and a generation-based incentive scheme for solar PV was introduced in 2008 (Sharma et al. 2012; Kumar et al. 2010, 2441).

Between 2003 and 2009, India's renewable energy generation capacity grew from 2.5GW to about 15GW, making up around 10 per cent of total electricity generation capacity (World Bank 2010a, 17). Most of this was in hydropower and wind, the latter having developed due to "early and aggressive incentives ... [leading] to the development of world-class players in the sector" (World Bank 2010a, 16). The contribution of solar energy to the total energy generation capacity, however, was negligible. Given the perceived potential for growth in solar, the GoI launched the Jawaharlal Nehru National Solar Mission (hereafter NSM) in November 2009.

One of eight missions in India's National Action Plan on Climate Change, the NSM sets out India's pathway towards achieving grid parity for solar energy technologies by 2022 through fostering 20GW of solar installations and positioning India as a global leader in solar manufacturing. The NSM has the following targets:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up capacity of grid-connected solar power generation to 1000 MW by 2013 and an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff.
- To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million m² solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022 (GoI / MNRE 2009).

Whilst it was positioned within a set of climate change-oriented missions, the NSM has a number of drivers other than concern over climate change. It is clear that the GoI sees the NSM as an opportunity to reap a range of benefits from a transition to renewable energies. As part of the rhetoric associated with the NSM, Prime Minister Singh stated in his speech launching the Mission:

"We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people. Our success in this endeavour will

change the face of India. It would also enable India to help change the destinies of people around the world.” (GoI / MNRE 2010a)

Nearly all interviewees agreed that the NSM had multiple aims, ranging from developing technological capabilities, ensuring energy security to sustain economic growth, developing technology export and leadership capacity and pursuing energy access through off-grid opportunities.

The NSM was planned in three phases. Phase 1 was planned as a pilot phase that would guide the country to 1000MW of installations. For PV, Phase 1 was split into two batches with developers in each batch being given 1 year to commission their plant after the contract had been awarded. The first batch was commissioned in January 2012 and the second is to be commissioned in January 2013. For concentrated solar thermal power technology (CSP), Phase 1 consisted of only one batch, with developers being given 2 years to commission their plant after contract approval. Phase 2 was planned to consolidate the achievements of Phase 1 by directly supporting a further 3000MW and leveraging another 6000MW. Phase 3 would then involve a process of scaling up to install another 10,000MW over 5 years. By phasing the NSM in this way, the GoI hoped to use the end of each phase as an opportunity to evaluate and review progress and refocus the feed-in tariff as necessary. This was also considered vital in order to learn from developments outside of the NSM and outside of the country. The evaluation of Phase 1 and planning of Phase 2 are currently underway.

Meanwhile, parallel to the federal solar policies but ostensibly part of India’s solar ambitions, a number of states have embarked on RET deployment initiatives. Gujarat has been particularly active: the state government created a fixed feed-in tariff in 2010 and established a solar park within which project developers could establish their projects. Inaugurated in April 2012, the solar park has been instrumental in reducing risks associated with land and power evacuation, greatly increasing developer confidence and interest.

4.3 Taking a global leadership role in solar PV manufacturing

A key goal of the NSM was *“to take a global leadership role in solar manufacturing (across the value chain) of leading edge solar technologies and target a 4-5 GW equivalent of installed capacity by 2020”* (GoI / MNRE 2009, 9). In cells and modules, private companies, such as Tata BP Solar, and state-owned enterprises, such as BHEL, BEL, and CEL, developed solar PV manufacturing capabilities for small-scale off-grid solutions in the 1980s and early 1990s. After the turn of the century, the industry began to grow to meet export demand: about 70 per cent of cells and 80 per cent of locally manufactured modules were sent to Europe, the United States, Japan, and Australia, where deployment policies had catalysed market demand (Millennium Post 2012). By the time the NSM was announced, India had about 15 players in cell manufacturing, over 20 players in modules and more than 50 in solar PV assembly (ISA 2010). Manufacturing capacity was roughly 700MW, with 280MW in cells and 350MW in modules (Bhargava 2012). Local silicon production was non-existent but projects to develop these facilities were approved in principle under the 2007 Semiconductor Policy (ISA 2010, 15).

By supporting a 6-fold increase in manufacturing capabilities, the NSM was expected to catalyse innovation, expansion and dissemination of solar technologies, from silicon material to BoS components; all with a view to generating jobs, becoming a dominant player with export power, achieving grid parity with fossil fuel-based technologies quicker and creating greater flexibility for energy security (GoI / MNRE 2009. 5; CEEW / NRDC 2012a, 17).

After the government announced the NSM, a committee was established and given the task of “*identifying the critical elements/components which lend themselves to indigenous manufacture and recommend the minimum indigenous content for solar power projects*” (GoI / MNRE 2010b). The resultant policy option chosen to promote local manufacturing was local content requirements (LCRs) attached to the feed-in tariff for solar PV and CSP plants. Some interviewees believed that the choice of LCRs as a mechanism to promote local manufacturing was due to pressure from manufacturers to use this policy tool. Interviewees from MNRE agreed that manufacturers had lobbied for support, but claimed that the policy was chosen on the basis of experiences in other countries.

For solar PV, the NSM’s LCR guidelines stated that

*“... in the case of Solar PV Projects to be selected in first batch during FY 2010-11, it will be mandatory for Projects based on **crystalline silicon technology to use the modules manufactured in India**. For Solar PV Projects to be selected in second batch during FY 2011-12, it will be mandatory for **all the Projects to use cells and modules manufactured in India**. PV Modules made from **thin film technologies or concentrator PV cells may be sourced from any country**, provided the technical qualification criterion is fully met.”* (GoI / MNRE 2010a, 7, emphasis added).

In the first batch, the LCR for solar PV only applied to manufacturing of crystalline silicon modules, thereby promoting module assembly. In the second batch, the LCR also included manufacturing of crystalline silicon cells, suggesting that the government hoped a year would be sufficient to develop greater cell manufacturing capabilities from experience in module assembly. Thin film manufacturing capacity in India was limited to one company (Moser Baer). Interviewees from MNRE stated that they were concerned LCRs for thin film would give this company a monopoly, so projects using that technology were exempt from LCRs. Meanwhile, the LCR for solar thermal plants under the NSM demanded project developers to ensure 30 per cent of local content in all plants/installations under solar thermal technology, excluding land (GoI/MNRE 2010a).

At the time, there was considerable concern over the LCRs for solar PV. A World Bank report in 2010 on barriers to solar power development claimed that 75 per cent of PV players interviewed felt domestic content would be a major barrier to development of solar plants in the country. The remaining 25 per cent who were ready to adhere to the LCRs were local manufacturers or had tie-ups with local manufacturers (World Bank 2010b, 14). The report concluded that the Mission’s pilot phase should focus on ensuring high quality installations at competitive rates; LCRs could be integrated into Phase 2 after developers had gained knowledge and experience (World Bank 2010b, 13). Yet despite such concerns, a report by SEMI, the global industry association for electronics

manufacturers, estimated that leading local manufacturing companies had committed US\$ 700 million of investment in capacity expansion (SEMI 2010), and several of the manufacturers interviewed stated that they were preparing to expand their capacity.

4.4 Evaluating the impact of local content requirements

In early 2013, the solar PV element of Phase 1 of the NSM was completed: the first batch of projects was commissioned in early 2012; and the second batch of projects was commissioned in early 2013. In order to learn from the pilot phase of the NSM and take forward lessons into the design of Phase 2, the GoI funded a review of the NSM in mid-2012. The review concluded that, rather than supporting the local crystalline silicon manufacturing industry, LCRs resulted in a bias towards foreign thin film PV manufacturers, whose products were exempt from the LCR (CEEW / NRDC 2012a, 20–21). Although, Sahoo and Shrimali (2012) argue that there was already an existing trend towards preference for foreign thin film PV technology, so LCRs may have amplified this trend. On a global level, 14 per cent of PV installations use thin film technology and 86 per cent use crystalline silicon technology. The global preference for crystalline silicon technology was not replicated in India. In the first batch of Phase 1, where the LCR related to crystalline silicon modules, 50 per cent of the installed systems used thin film technology and 50 per cent used crystalline silicon. In the second batch of Phase 1, where any projects using crystalline silicon technology had to source cells and modules locally, the figures departed from the global norm even further: 59 per cent used thin film technology and 41 per cent used crystalline silicon (CEEW / NRDC 2012a, 21).

In addition to growing interest in foreign thin film technology, the solar PV manufacturing industry witnessed massive upheaval during the two years of Phase 1. Oversupply in a crowded and competitive manufacturing market led to price reductions which outpaced reductions in cost. Many companies failed to survive, let alone make profits (REN21 2012, 49).

The impact of the bias towards foreign thin film technology and falling exports of locally manufactured crystalline silicon technology was considerable. Receiving few local orders and hit by falling exports to EU and US, which had previously been their main markets and the reason for their establishment, local manufacturers, such as Tata BP Solar, Indosolar and Moser Baer suffered heavy losses. PV manufacturers interviewed suggested that total local industry production between 2011 and 2012 was around 10–15 per cent of operating capacity in modules and practically zero per cent in cells. Indeed, in 2011, Indosolar stopped manufacturing completely and defaulted on bank loans, Moser Baer went into corporate debt restructuring and Tata BP Solar decided to close their manufacturing arm. Although no formal analysis has been done on the job effects, some of the PV manufacturers interviewed said that almost 50 per cent of their workforce had been laid off because of closed production. Under these conditions, interviewees noted that R&D investments in Indian manufacturing firms was non-existent. As the industry has consolidated and as protectionism has risen, tie-ups with foreign firms, which previously were often the basis for R&D, have diminished. The result of this, Sahoo and Shrimali (2012) claim, is that the Indian solar PV industry has become less competitive over time.

Based upon these impacts, the LCR is widely considered to have failed in economic terms. As one interviewee from MNRE succinctly put it, *“the purpose for which local content was imposed has been defeated.”* Yet according to interviewees at MNRE and within the PV industry, by 2012, local manufacturing capacity had increased, although there was no consensus on the figures. As one cell manufacturer noted, *“everyone studies and comes up with their own projections; it’s Pandora’s Box at the end of the year.”*⁴ Most interviewees put the total manufacturing figure for cells and modules at 1.8-2GW, which corroborates with recent MNRE figures (GoI / MNRE 2013). Some manufacturers interviewed quoted figures of over 500MW for cell capacity and over 1GW for modules. Furthermore, the NSM’s LCRs appear to have given a strong political signal that the government is committed to supporting and protecting the manufacturing sector. Most manufacturers interviewed were optimistic that local industry would be reinvigorated by continued investment in local manufacturing.

In comparison to PV, CSP technology may have offered a more promising opportunity for developing local manufacturing and innovative capabilities (CEEW / NRDC 2012b). Through the 30 per cent LCR, project developers would have been able to use local manufacturers that could provide all but the most advanced and globally-leading components of CSP plant technology. However, planned projects are facing significant delays and many may never be completed, so these gains will, at best, be delayed and, at worst, fail to materialize. Problems of land acquisition, lack of high quality irradiance data, increasing equipment costs due to rupee depreciation and limited availability of some components have caused set-backs in all projects. These issues are expected to continue if not adequately addressed by policy changes (CEEW / NRDC 2012b).

Based upon its evaluation of the LCR, the MNRE has been engaged in revising its strategy for promoting local manufacturing. A task force was set up to manage inputs from all industry players and develop recommendations. Interviewees from MNRE were well aware of the plight of local manufacturers and this seems to have translated into caution regarding whether or not to continue with LCRs. It also appears that the recent WTO ruling over Ontario’s LCR will influence the redesign more than previously imagined. Initially, MNRE officials seemed unconcerned by the global debate. Prior to this ruling, the GoI had appeared before the WTO to address concerns brought up by some foreign manufacturers, but GoI’s defended its LCR on the grounds that it related to government procured electricity, and no further action was taken. However, since the Ontario ruling these concerns have resurfaced. In February 2013, the US notified the WTO Secretariat of a request for consultations with India regarding LCRs in the NSM (Seth / Jai 2013; Creed / Kordvani 2013), even though US firms benefited significantly from sales of US thin film technology. The launch of Phase 2 of the NSM is likely to be delayed until completion of consultations which are scheduled to begin in March 2013. It seems unlikely that a decision on the role of LCRs in the new phase will be made before that time (SeeNews Renewables 2013).

4 Arguably, there is still ample room for foreign manufacturers to access state-level policy. In some states, there does seem to be some movement towards setting up manufacturing policies and support for domestic content, either explicitly or implicitly.

5 Explaining limited effectiveness of local content requirements in India's National Solar Mission

We have seen in the previous section that LCRs resulted in neither increased job opportunities nor improved competitiveness, both of which were major goals of the NSM. Understanding why LCRs failed is imperative, both so adaptation of the LCR is appropriate and so other countries can learn. To this end, this section uses the effectiveness framework developed in Section 3.3 to explain the limited effectiveness of LCRs in India's NSM. The framework investigates four determinants of effectiveness (see Table 5).

Table 5: Explanatory factors for limited effectiveness of LCRs in India		
Element	Level	Analysis
<i>Market size and stability</i>	large	<ul style="list-style-type: none"> • Old market shrinking and business models had not changed • New potential market was large, but competitive as no ring-fencing for local products • Global market going through restructuring – price cuts passed on to manufacturers
<i>Policy design</i>	loopholes	<ul style="list-style-type: none"> • Omission of thin film LCR meant it was obvious choice for project developers looking for lowest cost, particularly given low tariff due to auctions • US-EXIM bank finance exacerbated this choice • Conflicting incentives
<i>Cooperation and financial incentives</i>	existing	<ul style="list-style-type: none"> • Good understanding within government of plight of manufacturers and project developers • But, many conflicting policies regarding promoting of local manufacturing
<i>Innovation potential</i>	low	<ul style="list-style-type: none"> • Innovative potential decreasing as capacity utilization remains low • In general, manufacturers were geared towards low-cost assembly
Source: Author's own		

5.1 Market size and stability

Market size and stability is seen as a decisive effectiveness factor of LCRs. This element relates to the opportunities/demand for product and competition. If market size and stability are high, then the conditions will allow for economies of scale, helping manufacturers to develop, grow and build competencies. Stable demand was always considered a weakness of India's energy system (ISA 2010). But the NSM's feed-in tariff has certainly increased the size and stability of the solar PV market by catalysing demand. At the same time, a number of state-level feed-in tariffs have helped to increase market demand; although, with the exception of Gujarat, there are still concerns over the ability of the state to fulfil guarantees for these state-level schemes. Demand is expected to continue as experience with solar PV technology increases, costs decrease and India continues to expand its energy supply.

At first glance, the large market opportunity made LCRs favourable because there is demand for products, leading to sales and learning by doing. However, the increase in market size has also brought with it a diversification of the market. The traditional focus of Indian manufacturing industry was the export markets in the EU and US. Local manufacturers often had tie-ups to larger manufacturers and project developers in these regions, where high feed-in tariffs helped to maintain a fairly stable downstream demand. This foreign market stability was rocked by the huge structural changes in the global PV industry in 2010/2011. As feed-in tariffs were reduced, demand for products fell and competition in manufacturing significantly increased.

Arguably, LCRs did nothing to help local manufacturers adapt their traditional business model. The local market that filled the vacuum left by falling export demand comprised grid-based, rooftop, off-grid and device-specific (such as solar lanterns or torches) solar applications. Readjusting to this new large market from an export focus has been tricky for some players, and it is no surprise that such readjustment has left some firms behind. Many interviewees from manufacturing firms attributed their survival to cross-subsidisation from other business activities. Some smaller manufacturers claimed to have coped because they focused on small-scale PV applications where they had a competitive advantage due to good understanding of the diverse needs of the local market.

5.2 Policy design

Policy design is considered an important determinant of LCRs: too high and they may be unachievable; too low and they may have no impact. Despite demand for solar PV being there, the design of the policy was such that developers could bypass the LCR associated with crystalline silicon PV technology in favour of the alternative thin film PV technology. Two reasons made this loophole an increasingly preferred option.

First, thin film was already more popular in India than elsewhere. Interestingly, Sahoo and Shrimali (2012, 14) find evidence that this trend towards foreign thin-film technology was replicated in solar PV projects that were not part of the NSM. Although experience of how thin film technology performs over life time of a plant was limited, it was often considered more appropriate for India because it could use a wider range of materials, was considered more durable and could be a potential entry point for developing countries that have glass manufacturing capabilities. Because they are less efficient than crystalline silicon modules, thin film modules require more land to achieve comparable output, but this land issue was not considered a problem in India. Meanwhile, future disposal of toxic materials used in thin film technology was noted as a concern (CEEW / NRDC 2012a).

Secondly, thin film technology is generally slightly cheaper than either imported or local crystalline silicon technology, although cost differentials are decreasing (REN21 2012; Koshy 2012). Given the low bids in the feed-in tariffs reverse auctions, project developers were desperate to find lowest cost options to make their projects financially viable. An additional and unforeseen driver of cost viability was US-EXIM financing. Offering concessional finance at 4–5 per cent interest, compared to 14–15 per cent interest rates from Indian bank, the US Export-Import (EXIM) Bank made lending conditional on the use of US-manufactured thin film modules (CEEW / NRDC 2012a, 20–21). This was regarded by nearly all interviewees as a key factor in making thin film PV attractive. India's Centre

for Science and Environment (CSE) claimed this was an example of US protectionism “*distort[ing] the market completely in favor of U.S. companies*” (Kaften 2012).

Overall, the design of LCRs appears to have had some effect on project developers’ choices when planning and designing their projects and their ability to get lowest costs on international markets. In essence, the profit margin they could squeeze out of extra funds generated through the feed-in tariff was limited by technology choice, particularly as there was very little leeway to reduce BoS costs. Given that the auctioning process for feed-in tariffs led to extremely low tariffs (see Altenburg / Engelmeier 2012), dependence on the generally higher cost crystalline PV systems compromised the feasibility of the project even further.

5.3 Cooperation and financial incentives

For LCRs to have a positive impact, they should not be applied in isolation to appease manufacturers in the short term, but be consistent with other policy mechanisms so that they help to build the whole ecosystem necessary to support local manufacturing in the long term. LCRs in the NSM were one of myriad other incentive programmes that the GoI and states offered: feed-in tariffs; generation-based incentives; renewable portfolio obligations; capital subsidies; accelerated depreciation; and tax incentives (World Bank 2010a, 39). According to a World Bank (2010a, 39) report at the time, there were significant overlaps and lack of coordination between policy mechanisms leading to limited transparency and fiscal discipline, convoluted processes for claiming subsidies and weakened impact.

One case is particularly striking: locally manufactured solar PV products faced much higher taxes than imported intermediate and final solar PV goods. 12.8 per cent import duty was levied on imported inputs for manufacturing solar PV and sales tax of the subsequent manufactured cell or module was 5 per cent. In comparison, imported modules faced no import duty, adding an additional cost barrier to the ability of local manufacturers to compete. This specific discrepancy was well known. The GoI’s attempted to rectify it in its 2007 Semiconductor Policy, levelling the playing field, where there will be no duty on solar component manufacturing equipment in-line with the Singapore guidelines. However, by 2013 it had still not been approved by the Ministry of Finance (Sahoo / Shimali 2012, 5; Interviews with MNRE and manufacturers).

Rectifying these policy overlaps and inconsistencies is not an easy issue. Policy implementation faces significant barriers. The 2007 Semiconductor Policy has still not been approved and anti-dumping legislation against Chinese solar PV projects, which was requested by local manufacturers in January 2012, was still under review a year later.

5.4 Industry sophistication and innovation potential

For LCRs to have a positive long-term impact on all domestic economic actors – manufacturers, project developers, ancillary industry, electricity utilities and consumers – the manufacturing sector must eventually become globally competitive. If the potential for innovation is non-existent or compromised in some way, then LCRs may merely protect an inefficient industry.

At the time the NSM began, the innovation ecosystem in India was fairly weak (ISA 2010; Ali et al. 2012, 630). Solar PV research was of an exploratory nature and leading Indian solar PV cell and module manufacturers rarely collaborated on scientific publications with academic researchers (Sinha / Joshi 2012). Those manufacturers with a long history, such as BHEL, BEL and CEL, were ostensibly public laboratories, receiving heavy government subsidies. Although once innovative and at the forefront of solar PV research according to some interviewees, their competitive edge had waned over time. In their analysis of LCRs in the NSM, Sahoo and Shrimali (2012) argue that the Indian solar PV industry has become less competitive over time, leaving innovation potential sorely lacking. Despite increases in manufacturing capacity, utilisation of that capacity has dwindled, leaving no opportunity for dynamic learning effects, which are the cornerstone of building competitiveness. Interviewees in the manufacturing industry lamented that R&D budgets were non-existent and any innovations that did happen were simply tweaks in factory floor processes.

In addition, the LCR's focus on manufacturing of cells and modules did not take into account other important elements of the value chain, such as balance of systems components, installation, operation and maintenance and training (CEEW / NRDC 2012a, 20). Many consider that the focus on cells and modules, rather than raw silicon at one end and balance of systems components at the other, is misguided. Some feel PV should have no LCR; others feel that it should be broadened and more targeted to where India can really become competitive (CEEW / NRDC 2012a). It is widely appreciated that PV technologies need to be adapted and fine-tuned for the Indian environment: these may include modifying PV system design, adjusting installation plans and adapting maintenance procedures to specific atmospheres, such as the dusty environment in Rajasthan and the sandy environment in Gujarat. Many interviewees highlighted the importance of experience in this area and its role in ensuring long-standing reliability of the sector. Training is an important part of maintaining standards. Whilst the government claimed to be setting up a few training schemes, most interviewees felt that they were a minor element of the plan to transform India into a solar hub.

6 Conclusions and recommendations

This paper has sought to identify the conditions under which LCRs are an effective policy tool for building a competitive local manufacturing industry, using case of India's experience applying LCRs to promote local solar PV manufacturing. It did so through an effectiveness framework, which demonstrated the role weak policy design, lack of policy coordination and limited innovative capabilities played in limiting the effectiveness of LCRs.

India's NSM, launched in 2009, had a clear industrial policy aim: building up manufacturing capabilities that would allow India to be a 'global solar hub.' The policy tool chosen to achieve this was the use of LCRs linked to auctioned feed-in tariffs. It is clear that LCRs as they were designed in Phase 1 of the NSM were not effective. They may have helped Indian manufacturers weather some of the storm that has hit the global solar manufacturing industry in the past few years. But there have been significant reductions in employment and development of the full range of technological capabilities needed to make India a solar leader has not taken place. The high percentage of thin film technology within

NSM projects, as compared to the global norm, points to some of the unforeseen impacts that LCRs can have, although this was arguably an existing trend.

The analysis in the paper explored four potential factors behind the limited effectiveness of LCRs in India. India's market size and stability was greatly increased by the NSM's feed-in tariff and similar state-level schemes. As such, this was not considered to be a factor affecting the poor performance of LCRs, although local manufacturers may have had trouble adjusting to business models geared towards the diversity of local market demand rather than exports. The design of LCRs in the NSM had some significant drawbacks, which were not detected at first. The focus on crystalline silicon technology and the omission of thin film technology incentivised those project developers looking for lowest prices in the international market to use foreign thin film technology. Foreign thin film technology was already widely favoured in India, largely because it was cheaper. The bias towards this technology was then amplified by the availability of cheap finance from the US EXIM bank in return for the use in projects of US thin film technology – in essence a US-made content requirement. Not only was the LCR policy flawed, but it clashed with a range of other solar PV deployment incentives. For instance, locally manufactured solar PV cells and modules had to pay duties on imported inputs and final products, whereas there was no duty on imported modules. This potentially negated the effect of protection provided by LCRs, although from their design it is not clear whether LCRs ever managed to really protect local manufacturers. Finally, the limited innovation capabilities of Indian solar PV manufacturers were severely limited by their lack of productivity. As such, they were not able to take advantage of LCRs to build up competitiveness in the long-term. Rather, it appears that their competitiveness may have declined during Phase 1, although this is unsurprising and unavoidable given the idle capacity.

This analysis has a number of implications for other countries looking to use LCRs to develop local solar PV and other renewable energy manufacturing industries. Of course, there can always be unintended side effects or unexpected external impacts. However, the effectiveness framework offers a heuristic tool for assessing whether or not LCRs can help build a competitive local manufacturing industry. Four lessons can be drawn from using the framework.

Firstly, experience from the Indian case shows that LCR policy must be of limited duration and incorporate planned evaluation phases. It is important that local manufacturers see infant industry protection as a temporary shelter under which they can have the protective space to build competitiveness. Regularly assessing the extent to which LCRs are helping firms to do this, and adapting policy as necessary, is vital to achieving the policy objective of building a viable local manufacturing industry.

Secondly, countries looking to use LCRs to develop local solar PV and other renewable energy manufacturing industries must consider their design very carefully in order to have maximum impact. Some technologies may have more potential to be locally manufactured than others. For example, it may be worth focusing on technologies and components for which technical expertise is available and global market entry barriers are manageable. For whichever technologies and components are included, the LCR must be set at an appropriate level: too high and they may be unachievable; too low and they may be trivial. Whilst LCRs may have been ineffective in Phase 1 of India's NSM, deployment targets were still met. In addition, they showed political commitment to building a local solar PV

manufacturing industry and there is now a better understanding of what needs to be in place to develop it. The current evaluation of Phase 1 of the NSM allows lessons to be learned and changes to be made.

Thirdly, what can also be taken from the Indian case is the need for additional mechanisms to support development of long-term capabilities. Doing so requires focusing on all stages of the value chain and putting in place measures to support the wider services that are integral to success of the solar industry, such as balance of systems, installation, maintenance and training activities. LCRs on their own are unlikely to help local firms fully develop the technological capabilities needed to be globally competitive in the long-term: additional mechanisms, such as training and promotion of business linkages, are necessary to support development of long-term capabilities. In addition, building competitiveness in RETs requires focusing on all stages of the value chain and putting in place measures to support the wider services that are integral to success of renewable energy industries.

It remains to be seen how current WTO negotiations will impact the use of LCRs in India and elsewhere. The tension between international discourses on trade and climate change needs to be resolved in order to move forward in the effort to deploy renewable energy technologies and transition to more sustainable energy systems.

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Annex

In-depth, semi-structured interviews conducted as part of the research

Organisational position of the interviewee	Number interviewed
<i>Central government level</i>	
Ministry of New and Renewable Energy (MNRE)	4
India Renewable Energy Development Agency (IREDA)	1
NTP Vidyut Vyapar Nigam Limited (NVVN)	1
<i>Private sector</i>	
Solar PV manufacturers and project developers	12
<i>Other</i>	
Donor community	3
World Trade Organization	1
Research institutions	10
Independent energy consultant	2
Evidence from the interviews was augmented through participant observation in a number of national events and discussions with participants	

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