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Non-recourse project financing for concentrated solar thermal power

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ABSTRACT

Non-recourse project financing can play a significant role in scaling up total investment in concentrated solar thermal power (CSP). Non-recourse project financing is designed to identify, allocate, and mitigate risks through project structuring and contracting. These techniques can be utilised to address risks specific to CSP projects. Complementary de-risking techniques, such as debt guarantees, can facilitate non-recourse project financings at bankable levels of return in higher risk contexts. Technological advances and learning through global industry scale-up have delivered major reductions in CSP plant development costs. Ambitious CSP targets in China and other jurisdictions underpin future CSP market development. Hybrid off-take models in current utility-scale CSP projects are utilising thermal storage technology to sell rapid response dispatchable power into electricity wholesale markets at peak periods, enabling lower long-term PPA prices at other times. These developments underpin CSP as cost-competitive with solar PV with battery storage and other forms of low emissions technology. Based on an analysis of selected CSP non-recourse project financings, an emerging contractual model of non-recourse project financing risk mitigation and complementary de-risking measures is identified. While the key features of this model are applicable to large-scale projects in developing countries, it is adaptable to meet the requirements of a wide range of projects. In this way, non-recourse project financing can play a pivotal role in the feasibility of large-scale projects in a potentially critical technology for low-carbon energy development that may otherwise be difficult to finance.

1. Introduction

This research suggests that non-recourse project financing can play a significant role in scaling up investment in concentrating solar thermal power (CSP) plants. (Unless otherwise indicated, in this paper scaling-up refers to increasing total CSP capacity as opposed to increasing plant size.) Non-recourse project financing is designed to identify, allocate and mitigate risks through project structuring and contracting. These techniques can be utilised to address risks specific to CSP projects. Complementary de-risking techniques, such as debt guarantees, can facilitate non-recourse project financings at bankable levels of return in higher risk contexts. Technology advances and learning through global industry scale-up have delivered major reductions in CSP plant development costs. Ambitious CSP targets in China and other jurisdictions underpin future CSP market development. Hybrid off-take models in current CSP utility-scale projects are utilising thermal storage technology to sell rapid response dispatchable power into electricity wholesale markets at peak periods, enabling lower long-term PPA prices at other times. These developments underpin CSP as cost-competitive with solar PV with battery storage and other forms of low emissions technology. Based on an analysis of selected CSP non-recourse project financings for which data is available, an emerging contractual model of non-recourse project financing risk mitigation and complementary de-risking measures is identified. While the key features of this model are applicable to a wide variety of project types, the core concepts are adaptable to meet the requirements of a wide range of projects. In this way, non-recourse project financing can play a pivotal role in the feasibility of large-scale projects in a potentially critical technology for low-carbon energy development that may otherwise be difficult to finance.

We begin by reviewing the diverse literature regarding CSP deployment, cost, contractual risk mitigation, and complementary de-risking techniques. Section 2 summarises current global CSP deployment. Section 3 considers present and projected CSP cost reductions, focusing on the comparison of CSP to thermal energy storage (TES) and solar PV with battery energy storage (BESS). Section 4 examines how non-recourse project financing is designed to reduce financing costs by identifying, allocating, and mitigating project risks. Section 5 considers complementary means of de-risking CSP projects such as debt guarantees and concessional finance, through the involvement of stakeholders including States, international financial institutions, and insurers. Section 6 examines the policy context of CSP deployment in China. We conclude that non-resource project financing, with complementary de-risking measures, is useful and adaptable to the requirements of a wide range of projects.

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2. Global deployment OF CSP

The earliest utility-scale CSP plants operated in California in the 1980s.[1] Following termination of supportive taxation policy,[2] no additional CSP plants were commissioned until 2006. Feed in tariffs in Spain and tax incentives in the US then facilitated a 'second wave' of CSP development.[3] Global CSP capacity grew tenfold between 2006 and 2016 to approximately 5 GW, with over 3 GW under construction. In 2016 Spain had 2.3 GW installed CSP and the United States around 1.7 GW, constituting over 80% of the global total.[4] All new installations in 2015 and 2016 incorporated thermal energy storage (TES), which 'continues to be viewed as central to the competitiveness of CSP by providing the flexibility of dispatchability'.[5] The storage capacity of Spanish CSP plants has demonstrated the ability of CSP to add dispatchability, with a decade of consistently reliable performance documented by transmission system operator (TSO) documents.[6]

Since 2015, CSP activity has been growing quickly in developing countries, including Morocco, Saudi Arabia, the UAE, Chile, South Africa, India and particularly China.[7] China's first CSP demonstration project was a 70 kW solar tower plant near Jiangning in Jiangsu in 2006. China's initial 2020 CSP target of 10 GW in its 13th Five-year plan[8] was subsequently amended down to 5 GW.[9] Wang et al. indicate that: ' … to reach this goal, investments into CSP will annually be supported by 100 Billion yuan (1 Chinese yuan = approximately 0.15 US $).'[10] China is trialling a variety of technology types throughout the country, particularly in the arid NW where solar resources are optimal. The National Energy Administration (NEA) commenced a series of 20 demonstration plants in September 2016 (9 tower, 7 trough, and 4 Fresnel projects). This will involve construction of 'four solar-thermal power generation demonstration bases in Qinghai, Gansu, Inner Mongolia, and Xinjiang with a total capacity of hundreds of megawatts'.[11] Wang et al. note that the successful expansion of CSP in China will require ongoing cost reductions through scale effects of larger plants. They refer to industry estimates that in the 1000 MW scale, a power generation cost of 0.7–0.8 yuan per kWh should be possible, equating to 20 billion yuan investment per 1000 MW, observing that this is too high for many Chinese enterprises to finance, particularly given the undeveloped state of the CSP industry in China.[12]

Plants with a cumulative capacity of 300 MW were planned for completion by the end of 2018,[13] with 200 MW installation achieved. This included two power towers with molten salt storage. Six plants totaling 350 MW are planned for completion in 2019. One project has been abandoned, with the remaining ten projects (totaling 749 MW) under development but experiencing 'little progress, mainly because of financial or internally political obstacles'.[14] Some industry commentators expect only 1 GW installed by 2020.[15] Reasons include bank perceptions of CSP risk as an early stage technology, and in relation to grid integration of renewables.[16]

Despite China's success in meeting its 2020 solar PV targets in 2018,[17] Wang et al. and other commentators are sceptical of China's ability to meet its 2020 CSP targets. Nonetheless, media reports indicate very large Chinese CSP investments are in the planning stage. The largest of these appears to be the proposal of the Northwest Electric Power Design Institute (NWEPDI) engineering group to build a 7.4 GW CSP park in Akesai County, in Xinjiang in northwest China. NWEPDI has already completed a 50 MW parabolic trough plant in Akesai (near Tianjin) as part of China's 20 state-sponsored CSP pilots. These projects were required to be completed by the end of 2018 to be eligible for the Feed-in-Tariff (FiT) of 1.15 yuan/kWh ($170/MWh).[18] NWEPDI has designated a 40-mile site where it plans to develop 2.1 GW of capacity by 2025, with a further 5.3 GW in a second development phase.[19] While a large number of project proponents are reported to bidding almost 15 GW of capacity into the second round of CSP pilot projects,[20] the

[1] Gilbert Cohen et al. 'Solar Thermal Parabolic Trough Electric Power Plants for Electric Utilities in California' (report for the California Electricity Commission CEC-500-2005-175, November 2005), 17. www.energy.ca.gov/2005publications/CEC-500-2005-175/CEC-500-2005-175.PDF.

[2] María Méndez, Tom Downes and James Blatchford 'The Future of Solar Energy: Power Plant Scale CSP' (research paper for Energy and Policy program, University of Chicago, December 2008), 7. file:///C:/Users/sgeroe/Downloads/team2(1).pdf.

[3] Andrei Ilas, Pablo Ralon, Asis Rodriguez and Michael Taylor 'Renewable Power Generation Costs in 2017' (report for the International Renewable Energy Agency, 2018), 77. file:///C:/Users/sgeroe/Documents/JUIP%20reasearch/IRENA_2017_Power_Costs_2018.pdf See also Jim Hinkley et al. 'Concentrating solar power – drivers and opportunities for cost competitive electricity' (report for Commonwealth Scientific and Industrial research Organisation, Australia, March 2011), 4. http://www.garnautreview.org.au/update-2011/commissioned-work/concentrating-solar-power-drivers-opportunities-cost-competitive-electricity.pdf.

[4] REN21 'Renewables 2017 Global Status Report', 72–73.www.ren21.net/wp-content/…/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf.

[5] REN21 'Renewables 2017 Global Status Report', 72–73.www.ren21.net/wp-content/…/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf.

[6] Susan Kraemer 'How has Spain's Concentrated Solar Thermal Power Performed?' SolarPACES/International Energy Agency Technology Collaboration Network web site, 30 November 2017 http://www.solarpaces.org/spains-concentrated-solar-thermal-power-performed/.

[7] REN21 'Renewables (2018) Global Status Report', 100.www.ren21.net/wp-content/…/2018/06/17-8652_GSR2018_FullReport_web_final_.pdf.

[8] Jun Wang, Song Yang, Chuan Niang, Yaoming Zhang and Peter D Lund 'Status and Future Strategies for Concentrating Solar Power in China' (2017) 5(2) *Energy Science and Engineering* 104 http://onlinelibrary.wiley.com/doi/10.1002/ese3.154/full.

[9] 2016年12月26日,国家发展改革委、国家能源局《能源发展"十三五"规划》(发改能源(2016)2744号National Development and Reform Commission and National Energy Agency 'Thirteenth Five-year Plan for Energy'. http://www.xinhuanet.com/power/2018-01/08/c_1122227306.htm.

[10] 国家能源局《关于组织太阳能热发电示范项目建设的通知》(国能新能 [2015] 355号)、《关于建设太阳能热发电示范项目的通知》(国能新能 [2016] 223号) 2015, 2016. National Energy Agency 'Notice Regarding Organising Construction of Solar Thermal Energy Demonstration Projects', number 355, 2015 and number 223, 2016. [author trans] http://www.xinhuanet.com/power/2018-01/08/c_1122227306.htm.

[11] 国家能源局《关于组织太阳能热发电示范项目建设的通知》(国能新能 [2015] 355号)、《关于建设太阳能热发电示范项目的通知》(国能新能 [2016] 223号) 2015, 2016. National Energy Agency 'Notice Regarding Organising Construction of Solar Thermal Energy Demonstration Projects, number 355, 2015 and number 223, 2016. [author trans] http://www.xinhuanet.com/power/2018-01/08/c_1122227306.htm.

[12] Wang et al. above n. 14, 100.

[13] REN 21 2018 report above n. 7, 100.

[14] 'China concentrated solar power pilot projects' development' http://helioscsp.com/china-concentrated-solar-power-pilot-projects-development/.

[15] Wang et al. above n. 14, 100.

[16] *New Energy* Update 'Financing is Key to China's Ambitious CSP goals' 11 December 2017 http://analysis.newenergyupdate.com/csp-today/financing-key-chinas-ambitious-csp-goals.

[17] International Energy Agency 'Renewables 2017: Analysis and Forecasts to 2022', Executive Summary, 3. https://www.iea.org/Textbase/npsum/renew2017MRSsum.pdf.

[18] 关于太阳能热发电标杆上网电价政策的通知(发改价格[2016]1881号) National Development and Reform Commission 'Notice on solar thermal power generation benchmark tariff policy' NDRC Price [2016] No. 1881 https://chinaenergyportal.org/en/notice-solar-thermal-power-generation-benchmark-tariff-policy/.

[19] 'Northwest Electric Power Design Institute Eyes 7 GW Concentrated Solar Power in Xinjiang' http://helioscsp.com/northwest-electric-power-design-institute-eyes-7-gw-concentrated-solar-power-in-xinjiang/.

[20] For a list of projects under planning and development as of early 2018 see '15 GW Concentrated Solar Thermal Power Projects to Compete for China 2nd Batch Pilot Projects'. http://helioscsp.com/15-gw-concentrated-solar-power-projects-to-compete-for-china-2nd-batch-pilot-projects/.

actual extent of development will be constrained by CSP target levels and financial support provided on that basis. The operation of the first three of the demonstration projects completed in 2018 will be a significant factor regarding decisions with respect to a proposed second batch of demonstration projects.[21] Given that China plans to move from a demonstration phase from 2015 to 2020 to a large-scale development phase from 2020 to 2030, it may play a role in CSP cost reductions comparable to that seen in solar PV manufacturing and deployment.[22] The International Energy Agency forecasts are well below China's target level for deployment. It forecasts that China will install 1.9 GW by 2023, along with I GW in Morocco and South Africa, 1 GW in the Middle East, and 300 MW each in Australia and Chile (with multilateral development bank support). This would amount to an 87% increase in global capacity over the period.[23] Hence, China's CSP expansion is occurring the context of large-scale deployment globally, with associated implications for scale economies and learning-by-doing, High upfront costs and the perceptions of risk arising from the relatively unproven nature of CSP, particularly power tower and heliostat technology, increase the difficulty of CSP project financing. Risk management approaches integrated into non-recourse financing of CSP projects, and complementary de-risking strategies could serve to ameliorate these concerns, contributing to the viability of Chinese and other countries' CSP targets.

3. Global CSP cost reductions

This section considers CSP plant costs, particularly compared to solar PV with BESS. High upfront installation costs have historically been a barrier to CSP investments. Levelised costs of electricity (LCOE) for solar PV are currently around US$0.10 per kWh on average globally.[24] Global average LCOE for CSP in 2017 was US$0.22.[25] Plant scale, financing, and supply-chain factors have contributed to recent CSP cost reductions. For example, tender bidding processes have facilitated plant-level economies of scale, with auction cycles leading to a 30% reduction over two bid cycles in Chile in 2015 and a 43% reduction over five bid cycles between 2011 and 2015 in South Africa.[26] Total installed costs of newly commissioned CSP projects fell 27% in 2010–2017, with a 33% LCOE reduction overall.[27] Learning rates (the cost decrease with every doubling of cumulative capacity) in 2010–2020, based on project and auction data, have been estimated at 30% for CSP. This was driven by around 90% of cumulative capacity being installed over that period.[28]

The 30% learning curve rate of the International Renewable Energy Agency is higher than previous estimates, as it factors in record low CSP costs in the South Australian Aurora plant and the Dubai DEWA IV plant.[29] At the Aurora plant, SolarReserve signed a 20-year PPA with the South Australian government to supply up to 125 MW power from the 150 MW tower station at a maximum price of USD 0.06 per kWh (AUD 0.078 per kWh). In Dubai, a consortium of ACWA (Saudi Arabia) and Shanghai Power (China) successfully bid for the 700 MW combined tower and trough station DEWA IV, at a PPA price of USD 0.073 per kWh.[30] These bids were both approximately half the previous lowest LCOE for CSP.[31]

Lilliestam and Pitz-Paal suggest a combination of factors to explain the achievement of such low prices, in neither case explicable by above average solar irradiation or output for CSP plants. First, the hybrid long-term PPA and merchant off-take adopted at Aurora allows the plant to sell up to 25% of its 150 MW capacity onto wholesale electricity markets at high to very high prices in peak periods. Its 8 h plus thermal storage capacity plant can take advantage of the pronounced 'duck curve" arising from high levels of rooftop PV generating during the day, and the concomitant need for dispatchable power after sunset. Thus, the plant can combine guaranteed revenue for 75% of its generation under its PPA with the South Australian government, with high earnings from power sales in peak periods. Additionally, SolarReserve has a $A 110 million concessional loan from the South Australian government, covering one-sixth of its total investment.[32] Lilliestam and Pitz-Paal conclude that the 35-year PPA at the DEWA IV plant significantly reduces LCOE over its life (compared to standard 20-year PPA). Combined with very low financing cost, possibly due to state-related Chinese, Saudi Arabian and Dubai project participants, this enables project viability at such a low bid price.[33] These developments indicate that non-recourse project financing combined with the de-risking elements of long a PPA and concessional financing, plus the market advantage of rapid-start dispatchable power based on 8 h of storage is driving dramatic reductions in LCOE.

Falling technology costs have also driven CSP cost reductions. Specifically, the technology cost of towers similar to Aurora has decreased by 40% in the last three years, and 60% over five years. Lilliestam and Pitz-Paal note that: 'Three similarly configured Chinese solar towers under construction fit almost perfectly in this trend as well.'[34] Similarly, the IRENA report notes technological improvements in solar field elements, such as collectors and mirrors, have reduced costs in installation and engineering.[35] Combined with the fact that low bid prices of Aurora and DEWA IV were not due to above average DNI for CSP plants, or low labour or input costs, they should be replicable in other locations.

Falling technology costs have been used as the basis for projections of parabolic trough CSP deployment scale-up in India. India's deployment of CSP began with the Jawaharlal Nehru National Solar Mission (JNNSM), launched in 2010. India has 225 MW operational CSP capacity, and 292 MW under construction.[36] CSP cost is lower in India than in the United States or Spain, but is still higher than the cost of other renewables.[37] Sharma et al. calculate CSP cost reduction

[21] 'China concentrated solar power pilot projects' development' above n. 14.

[22] Shuxia Yang, Xianguo Zhu and Weishang Guo 'Cost-Benefit Analysis for the Concentrated Solar Power in China' [2018] *Journal of Electrical and Computer Engineering,* 1. https://www.researchgate.net/publication/325151778_Cost-Benefit_Analysis_for_the_Concentrated_Solar_Power_in_China.

[23] International Energy Agency 'Renewables (2018): Market analysis and forecast from 2018 to 2023: Power' https://www.iea.org/renewables2018/power/.

[24] Andrei Ilas et al. 'Renewable Power Generation Costs in 2017' (report for the International Renewable Energy Association, 2018), 69. http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017.

[25] Andrei Ilas et al. 'Renewable Power Generation Costs in 2017' (report for the International Renewable Energy Association, 2018), 69. http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017, 85.

[26] Andrei Ilas et al. 'Renewable Power Generation Costs in 2017' (report for the International Renewable Energy Association, 2018), 69. http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017, 74.

[27] IRENA report above n. 24 Executive Summary, 11. See also Figure 4.10 final report, 17.

[28] IRENA Report 2017 Notes CSP's "Spectacular" Cost Reductions, 17. January 20, 2018 https://www.solarpaces.org/irena-report-2017-notes-spectacular-cost-reductions-csp/.

[29] IRENA final, 83.

[30] Johan Lilliestam and Robert Pitz-Paal 'Concentrating Solar Power for Less than USD 0.07 per kWh: Finally the Breakthrough?' (2018) 26 *Renewable Energy Focus*, 17.

[31] IRENA above n. 28.17.

[32] Lilliestam and Pitz-Paal above n. 30, 17–18.

[33] Lilliestam and Pitz-Paal above n. 30, 19–20.

[34] Lilliestam and Pitz-Paal above n. 30, 18.

[35] IRENA report above n. 24, 83.

[36] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 122.

[37] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 122.

potential based on local manufacture of key components at 14% reduction in LCOE of parabolic troughs over 20 years, with a further 8% achievable by the use of local logistics.[38] These cost reductions are projected to facilitate deployment of 500 MW of CSP by 2020; 1 GW by 2025; 5 GW by 2030; 10 GW by 2040; and 20 GW by 2050. These projections take into account JNNSM targets, but are mainly based on an S-diffusion curve derived in part from an expected reduction in LCOE and resultant investment.[39] Based on these deployment assumptions, the researchers calculate a cost reduction in parabolic trough LCOE reduce of 40% by 2030 and 50% by 2050.[40] Thus, deployment and cost reduction projections are interrelated. The report also provides an estimate of cost reduction based on projections of global CSP scale-up and learning curve rate of 49% by 2050.[41] While subject to uncertainty, these projections indicate the potential development of CSP and cost reductions in the Indian market. The 'bottom-up' analysis of specific CSP components in the study is consistent with the 2012 Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) report on CSP costs, which contends that this methodology is more accurate than learning curve analysis based on insufficient data points for early-stage technologies.[42] This report also predicts that technology development will be a major cost driver, which is consistent with the dramatic reductions in power tower costs referenced above. Indeed, such cost reductions are not limited to CSP development, and are consistent with those achieved in relation to parabolic troughs without storage in 2011–2014.[43]

Cost reductions are rendering CSP cost competitive with solar PV. As one of the main advantages of CSP is its ability to combine with molten salt thermal storage (TES) to achieve reliable dispatchable power, it is germane to compare the cost of CSP with TES to solar PV with battery storage systems (BESS). A 2018 comparative study by Payaro et al. surveyed the literature and concluded there had been no comparative study of potential cost reduction of CSP with TES and state of the art utility-scale PV with BESS.[44] That report concluded that CSP with TES is cost competitive with PV + BESS at 85% plant capacity factor (CF) at least until 2027, as molten salt storage is less costly than BESS.[45] At 50% CF, PV and BESS are less costly than CSP with TES by 2020 on some scenarios, as the TES comparative cost advantage over BESS is less significant.[46] While these results are likely to be less reliable for longer-term projections, for example in relation to BESS cost reductions driven by technology development, they do indicate that CSP with TES will be cost-competitive for higher CF plants for some time. This is particularly relevant for plants such as Aurora in South Australia, that are selling into electricity wholesale markets at peak periods through the utilisation of storage capacity. For these reasons, it is concluded that CSP with TES has achieved, and is likely to continue to achieve, cost reductions that render it a commercially viable technology for large-scale deployment.

4. The role of non-recourse project financing in CSP risk mitigation

Financing alternatives can address risk in CSP projects, thus affecting risk premiums. Risk management can enhance the viability of power plants that might not otherwise be able to obtain financing. This section explains how non-recourse project financing operates as a mechanism to identify, allocate, and mitigate projects risks. We then discuss risks in relation to CSP projects, and provide a summary overview of some of the most common contractual means by which they can be addressed. We also discuss complementary de-risking approaches for CSP projects.

Non-recourse project financing refers to financial and contractual arrangements in which the revenue of a project provides the sole or predominant source of loan repayment and operating expenditure and project assets constitute the sole collateral or debt security.[47] The principal contracting parties in project financings include investors or sponsors, lenders or financiers, and a specific purpose vehicle (SPV) that holds the project assets and contracts with others. Non-recourse project financing is also known as off-balance sheet financing, as project assets owned by the SPV are typically not directly entered on the sponsor's balance sheet.

Risk identification and allocation are fundamental to the structuring, contractual documentation, and mode of non-recourse project financing. Sponsor borrowers will seek off-balance sheet financing with as little recourse as possible to sponsor assets (as distinct from project assets). This serves to isolate the sponsor or investor from the risk of failure of large-scale capital-intensive projects. Lenders naturally seek sufficient security in the form of potential repayment from project assets. This tension underlies the basic trade-off in project finance negotiations in which parties seek to arrive at a minimum of recourse to the sponsor in combination with sufficient credit support for lenders, for example, by means of guarantees or undertaking by the sponsors or third parties. Parties thus seek to structure financing in which no one party assumes all credit risk, and the total guarantees or undertakings represent a 'bankable credit'.[48] Risks are generally appropriately allocated contractually to the parties best able to mitigate those risks.[49] This facilitates financing in circumstances where exposure to large potential losses may otherwise place projects beyond the financial capacity of the sponsors. Risks in large-scale project financings are also diffused through the agglomeration of equity investors in a SPV, and a pooling of resources of financiers through syndicated loans. This approach was first applied in the early development of the oil industry in the South Western United States. Its use

[38] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 123, plus Table 6 p 125 and Table 7 p 127.

[39] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 123, plus Table 6 p 125 and Table 7 p 127, Tables 11, 24-125.

[40] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 123, plus Table 6 p 125 and Table 7, 125.

[41] Chandan Sharma et al. 'Cost Reduction Potential of Parabolic Trough Based Concentrating Solar Power Plants in India' (2018) 42 Energy *for Sustainable Development* 121–128, 123, plus Table 6 p 125 and Table 7, 124.

[42] CSIRO report above n. 4, 2.

[43] Lilliestam and Pitz-Paal above n. 30, 8.

[44] Albert Payaro, Ankit Anurag Naik, Rafael Guedez, and Björn Laumert 'Identification of Required Cost Reductions for CSP to Retain its Competitive Advantage as Most Economically Viable Solar-dispatchable Technology' (AIP Conference Proceedings 2033, 040028, 8 November 2018), 2. https://aip.scitation.org/doi/pdf/10.1063/1.5067064.

[45] Albert Payaro, Ankit Anurag Naik, Rafael Guedez, and Björn Laumert 'Identification of Required Cost Reductions for CSP to Retain its Competitive Advantage as Most Economically Viable Solar-dispatchable Technology' (AIP Conference Proceedings 2033, 040028, 8 November 2018), 2. https://aip.scitation.org/doi/pdf/10.1063/1.5067064 7, Figure 6 and 7.

[46] Albert Payaro, Ankit Anurag Naik, Rafael Guedez, and Björn Laumert 'Identification of Required Cost Reductions for CSP to Retain its Competitive Advantage as Most Economically Viable Solar-dispatchable Technology' (AIP Conference Proceedings 2033, 040028, 8 November 2018), 2. https://aip.scitation.org/doi/pdf/10.1063/1.5067064, 7 Figure 6.

(*footnote continued*)

[47] Gerald Pollio 'Project Finance and International Energy Development' (1998) 26 (9) *Energy Policy*, 688.

[48] Stefano Caselli and Alessandro Steffanoni 'Project Finance' in *The Oxford Handbook of Entrepreneurial Finance* (Oxford University press, 2012, 7.

[49] McConnell Scott, 'Project Financing in the Energy Industry and its Impact on Completion Risk' (2001) 20 *Australian Mining and Petroleum Law Journal*, 159.

remains predominant in the power generation, oil and gas and large-scale transport infrastructure.[50]

Regulatory, market, and technological risks have been identified as the primary categories of risk in RE investment.[51] Technological and operating risks are manifold but include the non-optimal choice of location in terms of solar irradiation, insufficient experience with less mature technologies (such as towers as opposed to trough collectors), and dependence on suppliers of key components.[52] Regulatory risk primarily relates to incentives and stability for investment and cost recovery. Lack of a supportive policy framework for renewable energy (re), especially CSP, has been identified as the primary risk, and a key determinant in the selection of countries for investment.[53] Market or commercial risks are also diverse. They include exposure to fossil fuel prices in hybrid plants, non-guaranteed power purchase or financial weakness of a power off-taker or other key contractor, liability of turnkey contractors and solar suppliers with respect to issues of plant performance, issues of risk pricing, and intellectual property right issues where it is necessary to share knowledge with other stakeholders.[54]

From the project developer's perspective, an obvious and effective means to address risks is to add a risk premium to the risk-free cost of capital. O&M is not financed but paid out of revenues From the lender's perspective, there is no 'upward potential' to counterbalance risk, as lenders (in contrast to equity investors) will not participate in enhanced return on investment (equity) in the event of project profitability.[55] Thus, debt financiers are characteristically more risk-averse than equity investors, who anticipate the possibility of higher returns. The Debt Service Cover Ratio (DSCR) is a primary means of determining the financial viability of RE projects from a bank's perspective, with a higher DSCR required for riskier projects. Banks may also require higher equity contributions to project financing, thereby reducing leverage, thus increasing the total cost of capital given the higher internal rate of return (IRR) required by equity investors. Banks may also require some degree of on-balance sheet financing, and higher cost of capital to cover technology risk.[56] Careful project and technology selection, a higher ROI requirement, contracts with guarantees are other common means to address RE project risks.[57]

The structuring of a project involves the way these entities are connected by contracts to achieve overall objectives. CSP plants share common elements with conventional power plants in terms of financing structure. The SPV is the central entity and the principal contractor with all other project parties. The CSP plant will be the fuel supplier, and equipment manufacturers, turnkey builders, and operation and maintenance (O&M) contactors will require highly specialized skills. Accordingly, risk mitigation in relation to these contracts is considered in the context of project financing. Financiers, of course, have an interest in contractually based risk mitigation, and will generally seek to ensure that 'contracts with suppliers, EPC and off-takers build in warranties for the project and keep risks to acceptable limits.'[58]

Some of the most common contractual risk mitigation approaches for investors and financiers involve long-term power purchase agreements (PPAs, often with municipal and state governments in the United States) or take-or-pay contracts, for security in relation to the cash flow of the project. Technology performance guarantees for specified periods can be negotiated with suppliers or the project developers. For example in closed-end wind funds in Germany technical and force-majeure risks are reduced by plant supplier warranties and insurance contracts.[59] In the US, many CSP plants have been pre-financed by developers, suppliers, or builders and received non-recourse project financing after a successful start-up. Contracts and associated performance guarantees generally exist between project companies and suppliers, rather than directly between a supplier and a financier (particularly given complex financial backing of typical non-recourse financings). Banks can also insist on adequate insurance for such unconventional risks resulting from design flaws.[60] Technology insurance may be difficult to obtain for unproven technologies[61]; hence performance guarantees may be the only viable strategy. Nonetheless ' … contracts and warranties are not sufficient to guarantee a bankable project. In general, it is better to mitigate potential risk, such as a supplier risk, than to secure them through contracts. This is an important factor in obtaining bankable contracts.'[62] For example, while in Spain until 2009 all CSP projects received non-recourse financing for construction, extensive due diligence preceded financial closure, with only prime engineering procurement construction (EPC) contractors accepted for contracts. Financial closure requirements were used as a risk mitigation strategy with regard to risks of early-stage technology. In addition, long-term performance guarantees were accompanied by high failure penalties.[63] A more structured approach to due diligence and selection of

[50] Steffen, B. 'The Importance of Project Finance for Renewable Energy Projects' (2018) 69 Energy *Economics* 280–294, 281.

[51] Cleijne, Hans and Ruijgrok, Walter 'Modelling Risks of Renewable Energy Investments' Report of the project 'Deriving Optimal Promotion Strategies for Increasing Market Share of RES-E in a Dynamic European Electricity Market - Green X'. Within the framework program of the European Commission supported by European Commission Directorate General of Research (2004), 52. http://www.green-x.at/downloads/WP2%20-%20Modelling%20risks%20of%20renewable%20energy%20investments%20(Green-X).pdf.

[52] World Bank Group/Global Environment Fund (GEF) 'Assessment of the World Bank Group/GEF Strategy for the Market Development of Concentrating Solar Thermal Power (2006), Table 3.1 Technological Risks related to the WB/GEF Portfolio, 24. http://documents.worldbank.org/curated/en/118911468316144032/Assessment-of-the-World-Bank-Group-GEF-strategy-for-the-market-development-of-concentrating-solar-thermal-power.

[53] World Bank Group/Global Environment Fund (GEF) 'Assessment of the World Bank Group/GEF Strategy for the Market Development of Concentrating Solar Thermal Power (2006), Table 3.1 Technological Risks related to the WB/GEF Portfolio, 24. http://documents.worldbank.org/curated/en/118911468316144032/Assessment-of-the-World-Bank-Group-GEF-strategy-for-the-market-development-of-concentrating-solar-thermal-power, Table 3.3, 27–28.

[54] World Bank Group/Global Environment Fund (GEF) 'Assessment of the World Bank Group/GEF Strategy for the Market Development of Concentrating Solar Thermal Power (2006), Table 3.1 Technological Risks related to the WB/GEF Portfolio, 24. http://documents.worldbank.org/curated/en/118911468316144032/Assessment-of-the-World-Bank-Group-GEF-strategy-for-the-market-development-of-concentrating-solar-thermal-power, Table 3.2, 25.

[55] World Bank Group/Global Environment Fund (GEF) 'Assessment of the World Bank Group/GEF Strategy for the Market Development of Concentrating Solar Thermal Power (2006), Table 3.1 Technological Risks related to the WB/GEF Portfolio, 24. http://documents.worldbank.org/curated/en/118911468316144032/Assessment-of-the-World-Bank-Group-GEF-strategy-for-the-market-development-of-concentrating-solar-thermal-power, 40.

[56] Kistner, Rainer, and Price Henry, W 'Financing Solar Thermal Power Plants' (Report for the US National Renewable Energy Laboratory, 1999), 1. https://www.osti.gov/servlets/purl/3532.

[57] EU Greenex report above n. 51, 53.

[58] EU Greenex report above n. 51, 65.

[59] N. Enzensberger, W. Fichtner, O. Rentz 'Financing renewable energy projects via closed-end funds—a German case study' (2003) 28 *Renewable Energy* 2027.

[60] See generally Berry, C 'Conventional and Non-conventional Risks Insurance for Mining Projects' in Tinsley et al. *Finance for the Minerals Industry* (Society of *Mining Engineers*, 1985), 472.

[61] See generally Berry, C 'Conventional and Non-conventional Risks Insurance for Mining Projects' in Tinsley et al. *Finance for the Minerals Industry* (Society of *Mining Engineers*, 1985), 550.

[62] EU Green X report above n. 51, 65.

[63] Richter, Dr. Christophe, Short, Rebecca and Teska, Sven (Greenpeace International, International Energy Agency, SolarPACES and European Solar Thermal Association 'Concentrating Solar Power Global Outlook 2009' (2009), 39. www.solarpaces.org/wp-content/uploads/concentrating-solar-power-2009.pdf.

contractors is adopted by the World Bank's International Competitive Bidding Process, contributing to the mitigation of procurement, planning, and contracting risks. This process was used to minimize operational risks of the relatively inexperienced Moroccan Solar Agency Masen (the primary off-taker). This was done through selection of the International Company for Water and Power ("ACWA Power Ouarzazate") as the turnkey contractor to design, build, and operate the plant on the basis of its experience with complex projects in the Middle East. This risk was also addressed by extensive use of external consultants and capacity building.[64]

The usual approach in construction contracts is for a fixed cost, definite date of completion subject to cost overruns and limited force-majeure provisions.[65] Liquidated damages (LDs) are generally negotiated in the contract although realistically they will represent a compromise as opposed to the full value of the potential loss due to construction delay or defects. Similarly, LDs provisions may be negotiated between the project vehicle and equipment suppliers and O&M contractors. It is common for such LDs to be combined with such securities as bank guarantees or unconditional bank bonds and retentions.

Typically a turnkey contractor will remain on risk for a longer period in a CSP project than under a standard design contract. Similarly, equipment suppliers may be required to extend guarantees beyond a normal period to the whole operational life of the project.[66] This additional assumption of risk may be partially offset by long-term contractual agreements for maintenance and supply of spare parts. Equipment suppliers also often become equity investors in projects, and may also agree to performance guarantees. This provides shared motivation in the overall success of the project. The same can be said for O &M contactors or power purchasing utilities.'[67] The typical capital structure of an RE project is not essentially different from other financings, although non-recourse project financing enables significantly higher leverage levels, with debt commonly up to 95%. This can be critical, as while expected ROE in project financing, in general, has been estimated at around 14%,[68] given higher risk factors involved a 14–20% ROE has been estimated as required by investors for RE projects.[69]

While non-recourse financing has been widely adopted for large-scale, high-risk projects, this is not the only context in which it is currently seeing significant uptake. Non-recourse project financing is also being widely adopted for lower-risk and smaller-scale projects in developed countries. Through an analysis of such renewable energy project financings in Germany, Steffen concludes that this is to address debt overhang, by enabling smaller project developers to borrow more than their corporate balance sheet would otherwise permit the strength of projected project revenue.[70] In the context of the Australian wind industry, Kann concludes that project financing enables smaller investors to manage the risk of larger-scale projects, resulting in the investment in most Australian wind farms on the basis of financial incentives created by the Australian Renewable Energy Target.[71] Thus non-recourse project financing is proving a relatively flexible means of delivering viable investments in a broadening range of locations and plant sizes.

In the context of capital-intensive plants, particularly in developing countries, contractual risk mitigation approaches can be combined with complementary de-risking strategies. In this way, the role of non-recourse financing in scaling-up CSP investment to meet projected future energy demand may be significantly augmented.

5. Complementary de- risking measures

Techniques for de-risking projects for private sector investors and financiers can be combined with contractual risk mitigation measures, to further reduce risk premiums on financings.[72] Such approaches have been proposed as a means of attracting institutional investment into renewable energy. Given estimates of over $53US trillion required globally for the clean energy transition to 2035,[73] the need for institutional scale investors in the sector is apparent. Project-level financing from insurance, pension, private-wealth, and sovereign-wealth funds could contribute to addressing this need. For example, the OECD estimates that around $2.80 trillion USD per annum is potentially available from pension funds and insurance companies for new clean energy investment.[74] Institutional investors have been estimated to manage over $90 trillion USD in total assets in developed countries alone (OECD, 2015).[75] Hall et al. characterise institutional investors as relatively risk-averse, and lacking knowledge and expertise in renewable energy investment.[76] This can be particularly so in developing countries with only recent experience of renewable energy deployment.[77] Moreover, many financial institutions adopted a more cautious position with respect to perceived high-risk investments after the global financial crisis of 2008–2009.[78] Despite the dramatic decline in the capital cost of renewable energy projects due to falling technology, investors continue to perceive CSP risks as high.[79] Thus the desirability of utilising institutional capital to drive CSP scale-up, together with the perceived high-risk nature of such investment, further underscores the potential role of contractual risk mitigation and de-risking for future development.

A 2016 IRENA report on RE risk mitigation discusses a wide range of financial instruments and structured finance mechanisms that could potentially be used for de-risking. These include government guarantees, political risk insurance, and currency hedging instruments, as well as more innovative measures such as renewable energy asset securitisation.[80] This section summarises approaches in large-scale renewable energy project financings that have adopted some of the more common de-risking measures, namely, various kinds of concessional finance, debt guarantees, and insurance. Such measures characteristically involve a substantial degree of risk shifting to institutions such as multilateral development banks and governments.

[64] African Development Bank Project Appraisal Report: Ourzazate Solar Power Station – Phase 1′, April 2012, 20. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Morocco_-_AR_Ouarzazate_Project_I_.pdf See Section 5 for further discussion of this project.

[65] See Craven, Clive 'Financing Private Power Stations' 1992 Australian Mining and Petroleum Law Association (AMPLA) Yearbook, 138. http://www.austlii.edu.au/au/journals/AUMPLawAYbk/1992/11.pdf.

[66] Kistner and Price above n. 56, 5.

[67] Kistner and Price above n. 56, 4.

[68] World Bank above n. 52, 5.

[69] World Bank above n. 52, 10.

[70] World Bank above n. 52, 294.

[71] Shayle Kann 'Overcoming Barriers to Wind Project Finance in Australia' (2009) 37 Energy *Policy* 3139–3148, 3144.

[72] Schmidt, T. S. 'Low-carbon investment risks and de-risking' (2014) 4(4) *Nature Climate Change*, 237–239, 2.

[73] Hall, Stephen, Foxon, Timothy J and Bolton, Ronan 'Investing in low-carbon transitions: energy finance as an adaptive market' (2017) 17 (3) *Climate Policy* 280–298, 2.

[74] Hall, Stephen, Foxon, Timothy J and Bolton, Ronan 'Investing in low-carbon transitions: energy finance as an adaptive market' (2017) 17 (3) *Climate Policy* 280–298, 2.

[75] IRENA report above n, 24, 24.

[76] Hall et al. above n. 73, 12–14.

[77] See for example, in relation to Chile, Shahriyar Nasirov, Carlos Silva and Claudio A. Agostini 'Investors' Perspectives on Barriers to the Deployment of Renewable Energy Sources in Chile' (2015) 8 *Energies* 3794–3814.

[78] Hall et al. above n. 73, 11.

[79] IRENA report above n. 24, 25.

[80] See generally Henning Wuester et al. 'Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance (report for the International Renewable Energy Agency, 2016). (This report does not consider non-recourse project financing).

The Belwind offshore energy project, comprising three 55 MW wind turbine generators, was financed by ASN Bank, Dexia Bank Belgium, and Rabobank International as 'lead arrangers' with Rabobank and *Participatiae Maatschappij Vlaandeeren* mezzanine lenders. The European Investment (EIB) provided EUR 300 million. The project was supported by risk guarantees provided by *Eksport Kredit Fonden* ('EKF'), and the Danish export-credit agency, in an amount of EUR 210 M. Contractual risk mitigation elements included 'tailored availability guarantees under the O&M contract with the turbine manufacturer' and a long-term PPA.[81] A combination of feed-in tariffs, a PPA, experienced specialist equipment suppliers, comprehensive insurance, innovative banks with specialist renewable energy expertise and European Central Bank underwriting together with sovereign risk/debt guarantees formed the basis of risk mitigation. In this way, private investment was incentivised by the assumption of a considerable degree of project risk by both the EIB and the EKF.

This approach has significant common elements with the non-recourse financing of the 580 MW Noor CSP plant in Morocco, which will be one of the largest CSP plants in the world.

The 170 MW Phase 1 of the project was completed on December 15, 2015. It utilised a BOOT structure between the Moroccan Agency for Solar Energy ("Masen"), and the International Company for Water and Power ("ACWA Power Ouarzazate"), a special purpose vehicle incorporated under Moroccan law. ACWA is under a turnkey contract to design, finance, construct, operate, and maintain the power station. Its experience in solar investments in the Middle East and Africa was also seen to limit the risk involved with Masen's relative lack of experience in complex projects as the primary off-taker.

The debt financing of the project included a €200m traditional loan by the African Development Bank ("AfDB") to Masen, plus a €165m concessional loan by the African Development Bank Clean Technology Fund ("CTF") to Masen.[82] Both loan amounts will be on lent by Masen to ACWA Power, which has primary responsibility to repay AfDB. The first or intermediary off-taker is Masen. As the intermediary off-taker, Masen re-sells the power generated to the *Office National de l'Electricité et de l'Eau Potable* ("ONEE"), Morocco's sole electricity distribution utility. The first PPA between ACWA and Masen is twenty-five years based on production costs, at US$ cents 18.9 per kWh. The second PPA, also for twenty-five years, applies to the on-selling by Masen to ONEE, and is based on the net rates applicable in Morocco. As net rates applicable in Morocco (for coal-fired power) were expected to be lower than (CSP) production costs, this created a revenue risk for the project vehicle ACWA. This risk was addressed by a guarantee over both loans by the Kingdom of Morocco to the extent of the differential between the two PPA rates.[83] Thus multilateral development bank financing and sovereign guarantee over the likely extent of revenue risk was central to project viability. Hence, both the Belwind project and Noor 1 relied on concessional financing by development-oriented banks and sovereign guarantees for risk mitigation. While the $A650 million, 150 MW Aurora CSP plant in South Australia has achieved record low bid prices for CSP capacity,[84] this was facilitated by a $A 110 million concessional loan from the South Australian government.[85]

While de-risking investment in renewable plant capacity is a prevalent goal in many contexts, policymakers in more mature markets may seek the reverse, that is, to expose renewable investment to market competition in order to reduce the burden of policies such as feed-in tariffs in state budgets. This has been an important rationale for the move to competitive renewable energy auctions in Germany, although modified feed-in tariffs continue to be an element of payments to winning bidders.[86] As the Aurora plant in South Australia has demonstrated, CSP plants utilising project-financing risk mitigation and complementary de-risking techniques can produce cost-competitive bids in such market-oriented policy contexts in developed economies. As such CSP projects may be in an increasingly better place to attract large-scale institutional investment conducive to global industry scale-up.

6. Non-recourse finance in the Chinese policy context

Chinese targets for CSP deployment are a major driver of CSP development globally. These domestic targets are likely to be augmented by China's state-directed 'Go Global' strategy. This suite of policies has involved concessional finance from state-owned banks and export credit agencies, together with debt guarantees.[87] The strategy has been designed to create globally competitive 'dragons head' corporations in sectors specified by state policy.[88] While it was primarily motivated to develop export markets for China's excess manufacturing capacity in the solar PV sector,[89] it is also contributing to global solar PV scale-up and associated cost reductions.

Nonetheless, the nature of Chinese debt markets has limited the utilisation of non-recourse project financing of CSP and other renewable energy projects to date. The prevailing model is loans made by Chinese state banks to state-owned enterprises (SOEs), at rates commonly around 20% lower and up to 40% lower than rates for private companies.[90] Arguably, this has distorted allocation of capital towards

[81] European Investment Bank Project Data Sheet 'Belwind Offshore Wind Farm' https://www.eib.org/en/projects/loan/loan/20080507 'Belwind, Belgium's Largest Renewable Energy Facility' (European Investment Bank Climate Action Case Study, 2009). file:///C:/Users/sgeroe/Downloads/climate_action_case_study_belgium_en.pdf Dexia Bank Press release 24 July 2009 http://www.dexia.com/EN/journalist/press_releases/Documents/20090724_belwind_UK.pdf.

[82] World Bank Report No: PAD1007 'International Bank for Reconstruction and Development Project Appraisal Document on a Proposed Loan in the amount of Eur 234.50 million and US$80 million (US$400 million equivalent) and a Proposed Loan from the Clean Technology Fund in the Amount of US$119 million to the Moroccan Agency for Solar Energy with Guarantee from the Kingdom of Morocco for the Noor-Quarazate Concentrated Solar Power Plant Project', September 4, 2014′, 10 and 81. http://documents.worldbank.org/curated/en/748641468279941398/pdf/PAD10070PAD0P100disclosed0120220140.pdf See also African Development Bank above n. 64, 20.

[83] World Bank Report No: PAD1007 'International Bank for Reconstruction and Development Project Appraisal Document on a Proposed Loan in the amount of Eur 234.50 million and US$80 million (US$400 million equivalent) and a Proposed Loan from the Clean Technology Fund in the Amount of US$119 million to the Moroccan Agency for Solar Energy with Guarantee from the Kingdom of Morocco for the Noor-Quarazate Concentrated Solar Power Plant Project', September 4, 2014′, 10 and 81. http://documents.worldbank.org/curated/en/748641468279941398/pdf/PAD10070PAD0P100disclosed0120220140.pdf See also African Development Bank above n. 64, 20.

[84] See Section 3 'CSP Costs' above.

[85] Government of South Australia 'Our Energy Plan: New Generation for More Competition' http://ourenergyplan.sa.gov.au/new-generation.

[86] M. Pahlea and H. Schweizerhof 'Time for Tough Love: Towards Gradual Risk Transfer to Renewables in Germany' (2016) 5 (2) *Economics of Energy and Environmental Policy*, 2.

[87] Xiaomei Tan, Yingzhen Zhao, Clifford Polycarp and Jianwen Bai 'China's Overseas Investments in the Wind and Solar Industries: Trends and Drivers' (Working Paper for World Resources Institute, April 2013), 15.

[88] Xiaomei Tan, Yingzhen Zhao, Clifford Polycarp and Jianwen Bai 'China's Overseas Investments in the Wind and Solar Industries: Trends and Drivers' (Working Paper for World Resources Institute, April 2013), 9–10.

[89] Xiaomei Tan, Yingzhen Zhao, Clifford Polycarp and Jianwen Bai 'China's Overseas Investments in the Wind and Solar Industries: Trends and Drivers' (Working Paper for World Resources Institute, April 2013), 2.

[90] Jeffrey Ball, Dan Reicher, 'Loosening the Logjam: Enabling More-Efficient Clean-Energy Finance in China' (Introductory Report for "The New Solar System," Stanford's Steyer-Taylor Center for Energy Policy and Finance October 2017), 8.

inefficient producers.[91] Additionally, this constitutes a disguised subsidy, with both direct and opportunity costs for the Chinese economy. Arguments in favour of more competitive debt markets are in line with stated Chinese policy of increasing market orientation as a means to drive continuing economic growth.[92]

The provision of low-cost credit to state-owned producers has, however, been identified as a major driver of renewable energy (predominantly wind and PV) development in China,[93] with associated global cost reductions. The continuing provision of concessional finance from the state banking sector is not necessarily inconsistent with increased private-sector involvement. Indeed this would be consistent with de-risking techniques discussed in the previous section. It would also be consistent with a global trend to use public funds to leverage private funds, such by the Clean Energy Finance Corporation in Australia.[94] This approach could be particularly useful for large-scale higher risk projects earlier in the R&D and commercialisation process that may otherwise be difficult to finance. Indeed, there is evidence of the increasingly significant role of public finance in development of earlier stage, larger-scale technology development beyond the scale and risk profile of venture capital and corporate finance.[95]

Rather than an argument against state involvement in CSP financing per se, we suggest that evolution towards a more competitive market for project financing in China could have multiple benefits. It would enable financiers to take advantage of the suitability of non-recourse project finance for risk management to contain the costs of CSP scale-up, and to combine it with aspects of state support and participation consistent with project risk profile and public policy objectives. The higher transaction costs of non-recourse project financing would be justifiable in context of large-scale projects. These arguments are equally applicable to Chinese and international investors. Chinese stated policy is encouragement of foreign investment in RE.[96] This is not, reflected in the financing of large-scale wind and solar in China, which is dominated by state-owned banks, especially the China Development Bank and the Export-Import (ExIm) Bank of China.[97] Openness to international banks would bring access to capital, experience and expertise, and synergies with leading global technology contractors. While access to bank loans at concessional rates has not been an obstacle for Chinese renewable energy financing in the past, increasing use of corporate bonds, structured finance, and capital markets indicates that funding sources may be changing as the market matures.[98]

Increased involvement of international investors may be a means to address implementation issues seen in Chinese wind and PV scale-up, such as inadequate plant capacity factors and curtailment,[99] through joint technology development of global best practice CSP technology and grid upgrading and integration.[100] This would support Chinese plans for higher levels of science and technology based economic development,[101] while offering the opportunity for international firms to participate in the expansion of the Chinese industry. This approach would not preclude Chinese equity and debt participation, including majority ownership. Involvement of developed country firms in project financing and related technology development in China could also facilitate Chinese involvement in the renewable energy sector in developed countries. In this way, synergies in non-recourse project financing could be an aspect of broader international investment and technology development cooperation, based on the ongoing integration of China into the global economy.

While China is the largest developing country CSP market, the potential for CSP deployment in India is also substantial. India could have the potential to compete with China and other countries as a CSP-related manufacturing base, supplying its own domestic market, and both developed and developing country markets. Based on the cost projections and technology diffusion calculations of Sharma, India has the potential for CSP deployment in the tens of GW by 2030–2050.[102] Together with accelerating CSP development in Morocco, the Middle East, Latin America and South Africa, this indicates that market development in developing countries is likely to be a major driver in global CSP scale-up.

7. Conclusions

Non-recourse project financing is designed to identify, allocate and mitigate project risks. Risk mitigation can lower risk premiums on project finance, thereby reducing costs. In this way non-recourse project financing can play a significant role in expanding global CSP capacity. This actuality is illustrated by the increase in the increasing proportion of RE plants financed on a non-recourse basis from 16% in 2004 to 52% in 2015.[103] This paper has examined how this approach has been implemented, through a summary of CSP risk analysis and contractual mitigation techniques. Risk premiums for private sector investors and financiers can be further reduced through complementary de-risking strategies, such as concessional finance and debt guarantees. This combination of contractual project-financing risk mitigation and complementary de-risking/risk shifting strategies is contributing to an emerging model to support viable large-scale CSP development in developing countries, as utilised for the Quarzazate CSP plant in Morocco.

While project-financing techniques are being used to develop a wide range of CSP plant scales in many contexts, large-scale plants in developing countries have the potential to be a major factor in global CSP deployment. Prominent examples of developing countries deploying CSP at scale are Morocco, Dubai, India, and especially China. A key barrier to investment in China and other locations is the perception by financiers of technology risks of CSP, particularly as compared to solar PV. Project financing techniques addressing technology and other risks can play a significant role in addressing these concerns.

Projected CSP deployment in China, India, major developed markets such as the United States, Spain, and many other countries provide the basis for cost reductions through scale economies and learning by

[91] Jeffrey Ball, Dan Reicher, 'Loosening the Logjam: Enabling More-Efficient Clean-Energy Finance in China' (Introductory Report for "The New Solar System," Stanford's Steyer-Taylor Center for Energy Policy and Finance October 2017), 8–9. See also Richard Bridle and Lucy Kitson 'Public Finance for Renewable Energy in China: Building on international experience' (Report for the International Institute for Sustainable Development, August 2014), 12.

[92] Ball et al. above n. 90, 9.

[93] See for example Joel Eisen 'New Energy Geopolitics?: China, Renewable Energy and the "Greentech Race" (2011) 86 *Chicago-Kent Law Review*, 28-29.

[94] 'Accelerating Clean Energy Investment – CEFC Annual report 2016–2017' https://www.cefc.com.au/media/files/accelerating-clean-energy-investment-cefc-annual-report-2016-17/.

[95] Mariana Mazzucato, Gregor Semieniuk 'Financing Renewable Energy: Who is Financing What and Why it Matters' (Science Policy Research Unit Working Paper, 2016-12 (June), 3, 6 and 7.

[96] Chinese Ministry of Commerce, Revised Foreign Investment Guidance Catalog 2017, Paragraph 293. http://www.fdi.gov.cn/1800000121_39_4851_0_7.html.

[97] Tan et al. above n. 87, 15; Ball et al., 8; Bridle and Kitson above n 91, 11.

[98] Bridle and Kitson above n. 90, 11.

[99] See for example Ball et al. above n. 90, 2. For an example of international approaches to address such issues see Eric Martinot 'Grid Integration of Renewables in China: Learning from the Cases of California, Germany and Denmark (White Paper for the China Variable-Generation Integration Group, 2015) http://www.martinot.info/re_publications.htm.

[100] Kelly Sims Gallagher *The Globalisation of Clean Energy Technology*: Lessons from China (MIT Press, 2014), Chapter Three.

[101] For a list and links to such plans see Chinese Ministry of Science and Technology web site http://www.most.gov.cn/eng/.

[102] Sharma et al. above n. 36, Table 11, 126.

[103] Steffen above n. 50, 281.

doing. CSP plants such as Aurora in South Australia and DEWA IV are already establishing the viability of CSP with TES as a cost competitive technology in the marketplace. Integral to these projects are non-recourse project financing combined with concessional loans, debt guarantees, and other tailored de-risking elements. The increasing application of project financing in a wide variety of project types and contexts underscores its utility in managing risks and reducing financing costs for CSP development. As a proven means of dealing with large-scale, higher risk projects with potential for major economic and environmental benefits, non-recourse project financing has the potential to play a significant role in the very large-scale investments required for CSP, and thus for low-carbon energy development more broadly.