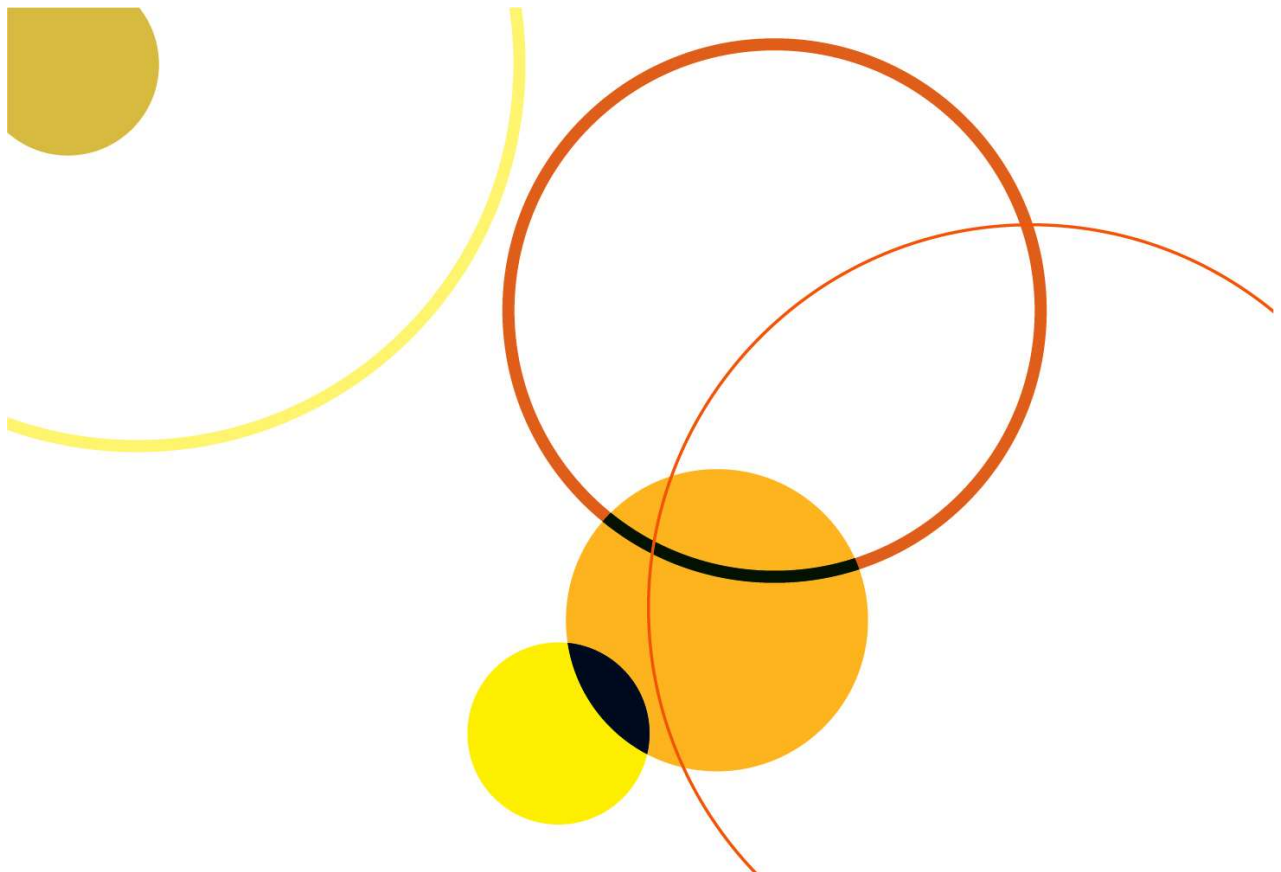


# Off-Grid Solar – Investment Mobilisation Implementation Roadmap

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**Report prepared for Government of Bangladesh**

February 2019



# Contents

|  |    |
|--|----|
| List of abbreviations.....                             | 3  |
| Executive Summary .....                                | 4  |
| 1 Introduction .....                                   | 9  |
| 2 Reform to mobilise finance for solar mini grids..... | 12 |
| 3 Reform to mobilise finance for solar irrigation..... | 28 |
| 4 Conclusion.....                                      | 39 |



## List of abbreviations

|              |  |
|--------------|--|
| <b>BADC</b>  | Bangladesh Agricultural Development Corporation        |
| <b>BAU</b>   | Business as Usual                                      |
| <b>BDT</b>   | Bangladeshi Taka                                       |
| <b>BPDB</b>  | Bangladesh Power Distribution Board                    |
| <b>CDKN</b>  | Climate and Development Knowledge Network              |
| <b>ESMAP</b> | Energy Sector Management Assistance Program            |
| <b>GOB</b>   | Government of Bangladesh                               |
| <b>IDCOL</b> | Infrastructure Development Company Limited             |
| <b>IKI</b>   | German International Climate Initiative                |
| <b>IMM</b>   | Investment Mobilisation Measure                        |
| <b>IRR</b>   | Internal Rate of Return                                |
| <b>MWh</b>   | Mega Watt Hour   |
| <b>kWp</b>   | Kilo Watt Peak   |
| <b>MPEMR</b> | Ministry of Power, Energy and Mineral Resources        |
| <b>MPI</b>   | Mobilising Private Investment                          |
| <b>MW</b>    | Mega Watts   |
| <b>NDC</b>   | Nationally Determined Contribution                     |
| <b>PGEL</b>  | Purobi Green Energy Limited                            |
| <b>PPA</b>   | Purchasing Power Agreement                             |
| <b>REB</b>   | Rural Electrification Board                            |
| <b>SHS</b>   | Solar Home System                                      |
| <b>SIP</b>   | Solar Irrigation Pump                                  |
| <b>SMG</b>   | Solar Minigrid   |
| <b>SPD</b>   | Small Power Distributor                                |
| <b>SPP</b>   | Small Power Producer                                   |
| <b>SREDA</b> | Sustainable and Renewable Energy Development Authority |
| <b>TSC</b>   | Technical Standards Committee                          |
| <b>USD</b>   | United States Dollar                                   |



## Executive Summary

**This report recommends priority investment mobilisation measures (IMMs) – policy measures that address barriers to private sector investment – for two off-grid solar technologies in Bangladesh – solar mini-grids and solar irrigation.** The selected investment mobilisation measures derive from a shortlist accounting for (i) their ability to address a constraint to investment identified Bangladeshi stakeholders, (ii) the impact of the IMM in terms of improving the financial returns of projects, and attracting public and private finance, and (iii) the feasibility of implementing the IMM in the near term.

**These recommendations represent the culmination of stakeholder consultations carried out between July 2018 and January 2019, supported by technical and financial modelling.** The project team consulted a range of stakeholders, spanning Bangladesh government institutions, local public and commercial financiers, project developers, development partners and development finance institutions. Financial modelling estimates the impact of each priority IMM on returns, assuming existing business models, and is used to highlight the investment opportunities presented by these business models.

**For both technologies, a shortlist of IMMs is presented first, then a roadmap to implement the priority measure is set out in detail.**

### Solar mini-grids (SMGs) shortlist of IMMs and implementation roadmap

**The shortlist of IMMs for SMGs consists of five measures, as shown in Figure 1:**

1. **Developing a policy and regulatory environment to address the financial risks arising if the electricity grid arrives over the course of the SMG asset life.** This addresses the major barrier identified by investors – and which is not within the control of investors once an initial decision to invest has been made. The implementation of a comprehensive policy response to this risks requires coordination across SREDA, REB and the Power Division.
2. **Allowing for project specific loan tenors and grace periods.** Customer acquisition in the early years is critical to the long term success of SMGs. Allowing project developers to put forward – and agree in advance – bespoke loan repayment profiles to IDCOL would allow them to match debt obligations to the expected profile of customer acquisition in early years. SREDA could help develop this policy, but it would need to be implemented by IDCOL.<sup>1</sup>
3. **Tariff reform to implement variable, cost reflective tariffs.** In particular, higher than anticipated night consumption loads, relative to daytime loads, increases system costs which can harm the financial viability of SMG operators. Dynamic, variable tariffs, which would allow SMG operators to reflect the higher system costs of night consumption loads could address this problem. This could be implemented by project developers but would require a clear regulatory framework developed by SREDA and REB, with industry consultation.
4. **Targeted grant finance to regions of low affordability.** Grant or concessional finance will continue to play a role in the deployment of SMGs in Bangladesh, but it can be more powerful if targeted to






<sup>1</sup> Currently, IDCOL provides loans for SMGs on a fixed basis of 10 year tenor, with a two year grace period before the capital is repaid



areas where the ability to pay of household and business customers is relatively low. SREDA and the Bangladesh Rural Electrification Board could undertake studies to identify how best to target grant funding, working with development partners.

5. **Reviewing technical standards to lower investment costs.** There is currently a trade-off between compliance with technical standards, which project developers must do to access concessional finance from IDCOL, and procuring more affordable components, which may not meet IDCOL's full technical requirements, and then seeking commercial finance. SREDA, working with IDCOL and the Technical Standards Committee, could review the current technical standards, with a focus on their implications for the cost-effectiveness of investments.

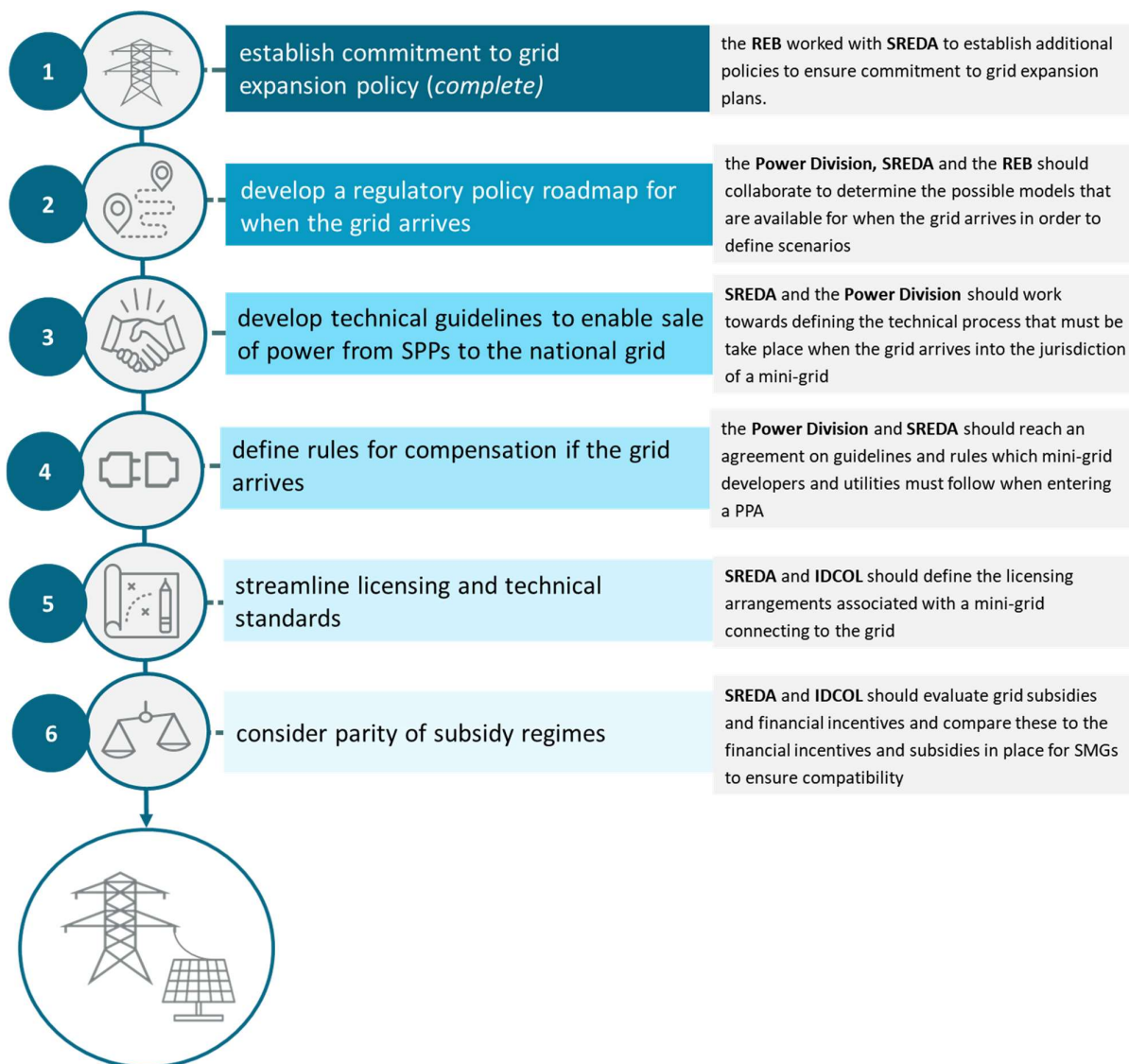
Figure 1. Shortlist of IMMs to mobilise finance for solar mini-grids

| Implementation measure  |  | Barrier addressed  | Immediate and medium term steps   | Long term goal   | Stakeholder responsible  |
|---|--|--|---|--|--|
|    | develop a compensation policy in the event of grid arrival                         | revenue uncertainty – if the grid arrives it may erode the SMG customer and revenue base                     | establish a clear national policy (technical and financial) for integration with the grid                                     | protection from fall in revenue from energy sales for the project sponsor due to unexpected grid expansion | REB in collaboration with SREDA and IDCOL to ensure streamlined communication                  |
|    | determine project-specific loan tenors and grace periods                           | mismatch between debt finance and revenue – especially in early years while acquiring customers              | carry out a study of existing SMG project costs to better model debt repayment packages                                       | improvement to project liquidity and accessibility of loans  | SREDA can carry out the cost study and work with IDCOL to design the financing packages        |
|  | tariff structure reform and best practice  | high cost of meeting night loads – cost reflective tariffs should reflect marginal cost of night consumption | a power demand study will determine tariff options to support efficient charging across customer segments and demand profiles | improving customer acquisition and balancing the night to day load ratio                                   | SREDA can work with REB data and project developer data to accurately model electricity demand |
|  | targeting higher grant finance to regions with low ability to pay                  | low incomes / affordability – in some regions which may be targeted for policy reasons                       | carry out a study on regional income disparities to determine ability to pay and eligibility for grant subsidies              | increasing access to electricity in areas with low purchasing power  | SREDA and the Bangladesh Rural Development Board collaboration                                 |
|  | review technical requirements and financial conditions for accessing IDCOL funding | high capital costs required to meet technical standards  | review existing technical and financial requirements, with a view to relax specifications where possible                      | reducing costs associated with technical and financial requirements which may not be necessary             | IDCOL in collaboration with project developers can review technical requirements               |

Source: Vivid Economics

From this shortlist, the research team prioritised one IMM – to develop a clear policy and regulatory framework for if the main grid arrives over the asset life of the SMG. Figure 2 sets out the steps that would need to be undertaken to put this policy and regulatory framework in place.

Figure 2. Roadmap to implement IMM to provide regulatory protection upon arrival of main grid within the asset life of the SMG



Source: Vivid Economics

## Solar irrigation pumps (SIPs) shortlist of IMM and implementation roadmap

The team shortlisted four investment mobilisation measures for SIPs, as shown in Figure 3.

1. **Sale of surplus power from SIPs to the main grid.** This addresses the main challenge – specific to the climate and agriculture conditions in Bangladesh – that the demand for irrigation from farmers is high for the *BORO* season [Feb-May], but relatively low across the rest of the year. There is therefore a need to diversify the customer base, which could be achieved by selling surplus electricity back to the grid


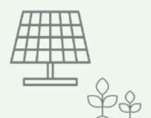


outside of the *BORO* season. These regulations should be developed by SREDA, but would need to be coordinated with REB as they would require purchase of surplus power by utilities or other large industrial and commercial users.

2. **Training and awareness for farmers of alternative revenue generating activities out of BORO season.** This measure seeks to mitigate the seasonal demand for irrigation by identifying alternative uses of the pumps outside of the main *BORO* season, such as production of fertiliser, alternative crop types and techniques, or sale of surplus power from the panels to nearby households or businesses. Project developers are developing training for farmers on alternative use of panels, and a demonstration facility could also be housed by, for example, SREDA.
3. **Flexible pricing models to encourage uptake and use of the pumps.** Making sure farmers see the full value of the pumps and maximise their use across seasons is important to generating viable commercial returns. A study on pricing options and customer business strategy could be developed by SREDA to support project developers in acquiring and retaining customers, and encouraging optimal use of the irrigation services provided by farmers through efficient pricing structures.
4. **Reviewing operational and replacement costs.** Operating pumps and replacing equipment has proven to be costly – above the expectations of some project developers. Working to reduce these costs through a review of how the pumps are constructed and operated could help lower the cost environment. SREDA could pilot a review of the 1,000 plus pumps in operation to review experience in driving low running and replacement costs, and share best practice and lessons learned.





Figure 3. Four shortlisted IMM were identified to mobilise finance for solar irrigation

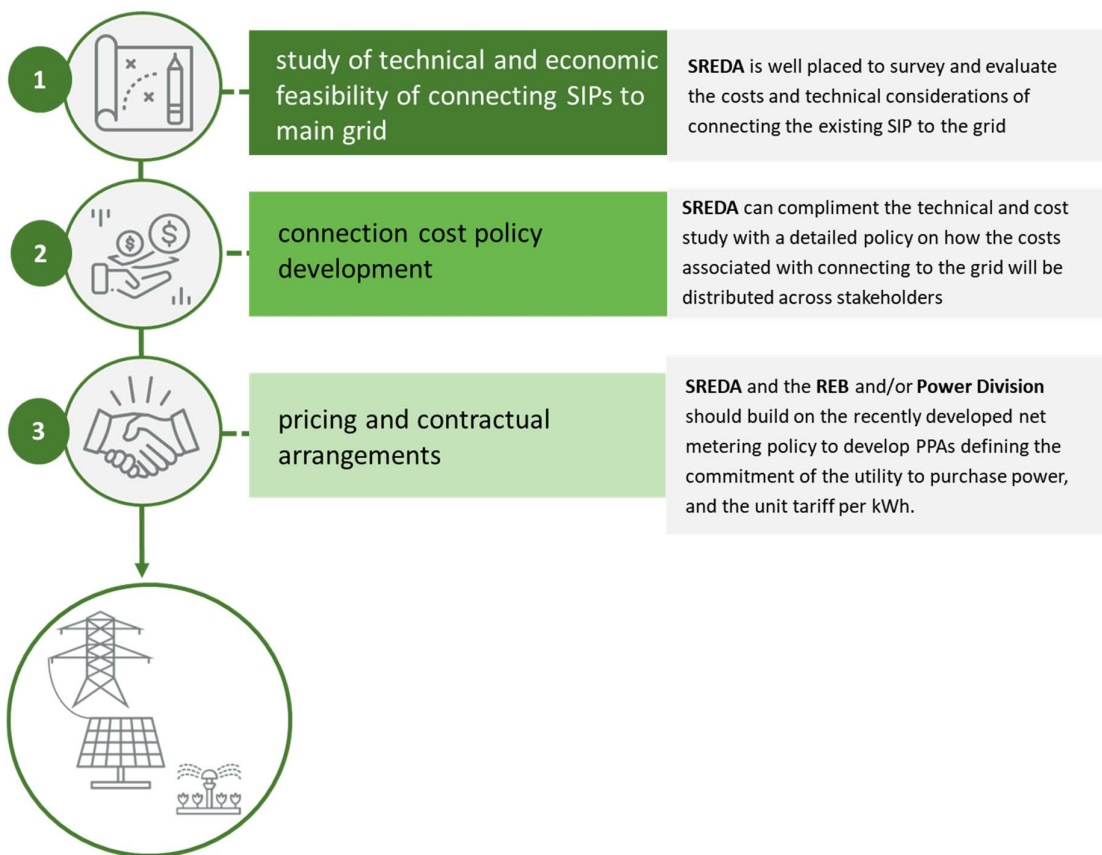
| Implementation measure  | Barrier addressed  | Immediate and medium term steps  | Long term goal   | Stakeholder responsible   |  |
|---|--|--|--|---|--|
|  | <b>develop policy on sale of surplus power from SIPs to grid</b>       | <b>seasonality of demand</b> - high utilisation of pumps in <i>BORO</i> season, but some idle capacity of the year | carry out technical and feasibility studies on the potential for connecting solar irrigation pumps to the grid<br><br>developing cost and pricing strategies | effectively mitigate risk from seasonality of demand and increase project returns   | <b>SREDA</b> , in collaboration with the <b>REB</b>                                  |
|  | <b>training and awareness of alternative use of panels and pumps</b>   | <b>seasonality of demand</b> - high utilisation of pumps in <i>BORO</i> season, but some idle capacity of the year | design and implement capacity building and training strategies for farmers and SIP project developers  | using the panels and land around the pump to generate revenue from alternative activities                                   | project developers with guidelines developed by <b>SREDA</b> and the <b>BADC</b>     |
|  | <b>flexible pricing in the initial seasons of implementing the SIP</b> | <b>low uptake of pumps</b> – in terms of customer connection and full hectare coverage                             | guidance and studies to support optimal price setting<br><br>engaging with farmers to raise awareness  | improving customer acquisition in the initial year of operation through lower and flexible pricing                          | the <b>REB</b> to issue guidance on pricing whilst <b>SREDA</b> engages with farmers |
|  | <b>reduce replacement and maintenance costs</b>                        | <b>higher costs than expected</b> – both in replacement costs and particularly in operating costs                  | carry out a review of the operating and replacement experience of project developers across pumps to identify opportunities to cut costs                     | reducing costs associated with the operating environment and replacement costs while gaining experience with the technology | <b>SREDA</b> to commission detailed studies on costs                                 |

Source: Vivid Economics

From this shortlist, the team prioritised one IMM – enabling the sale of surplus power from the SIPs to the main grid. Figure 4 sets out the steps that would enable this – recognising that this would require reform to the current framework of the rooftop solar net metering policy in place since July 2018.



Figure 4. Roadmap to implement IMM to enable sale of surplus power from SIPs to the main grid



Source: Vivid Economics

# 1 Introduction

## 1.1 Purpose and structure of this document

**This report recommends priority policy and regulatory adjustments to support mobilisation of investment in off-grid solar technologies.** It sets out the rationale for each policy recommendation, and describes the steps that would be required before and during implementation. It also summarises ongoing activity and policy change for each technology in order to identify the areas that need further focus or support.

**Section 2** describes the current business model for solar mini-grids in Bangladesh, and describes the investment opportunity for equity investors (generally private companies), public sector partners (who provide grant or concessional finance for the sector), and financiers such as Infrastructure Development Company Limited (IDCOL) or commercial banks. It sets out a shortlist of proposed policy measures to support growth of the technology, and develops a roadmap for implementation of one priority measure from this shortlist. In the SMG case, this is to put in place regulatory protection for mini-grid operators if the electricity grid is extended to their operating area at any point over the life of the asset.

**Section 3** follows the same structure as **Section 2**, but for solar irrigation, including a roadmap to enable the sale of surplus power from solar water pumps to the grid in times of surplus, and in particular outside of the main *BORO* cultivating season.

**Section 4** provides an overview of the recommended policies and next steps for implementation.

## 1.2 Introduction to the off-grid solar sector

**The Government of Bangladesh (GOB) has articulated the vision of providing quality electricity for its citizens by 2021.<sup>2</sup>** While expanding and improving national grid services will be important in delivering on this vision, it will also require a focus on off-grid renewable energy based solutions, especially for communities in remote areas where the grid is not likely to be extended.

**Off-grid solar technology can also play a crucial role in achieving Bangladesh's National Determined Contribution (NDC) pledge to the Paris Agreement, as well as its domestic target of having 10% of total energy capacity come from renewable sources by 2021.** The current total power generation capacity of Bangladesh is 19,000 MW, of which just 3% is from renewables. Of that renewable energy, 58% comes from solar energy, and the majority from off-grid sources. The government is planning to install 24,000 MW of additional electricity generation capacity by 2021, of which at least 10% of total capacity is expected to

<sup>2</sup> Planning Commission, Government of the People's Republic of Bangladesh (2012). "*Perspective plan of Bangladesh 2010-2021*".



come from renewable sources.<sup>3</sup> Additionally, Bangladesh's NDC pledge to the Paris Agreement states that it will reduce greenhouse gas emissions in the power, transport and industry sectors by 5% compared to a business as usual (BAU) scenario by 2030 (a reduction of approximately 12 Mt of CO<sub>2</sub> equivalent in 2030).<sup>4</sup> Off-grid solar technology has the potential to deliver on both these pledges, by providing clean, renewable energy to isolated communities.

**Solar has a very large technical potential in Bangladesh, with average daily solar radiation of approximately 5 kWh/m<sup>2</sup>.**<sup>5</sup> Daily sunlight hours in Bangladesh to range from seven to ten hours, although accounting for rainfall, cloud and fog, this reduces to about four to five hours per day. The maximum amount of radiation is available in the months of March-April and minimum in December-January.

**Bangladesh is already the largest market in the world for solar home systems, and is well placed to develop other off-grid solar technologies at scale.** The Rural Electrification Board (REB) introduced the first Solar Home System (SHS) in 1997, to 850 households in the remote areas of the Narshidi District, with Grameen Shakti developing the first commercial business models. The market grew quickly and there are now about 5.5 million SHS installed in Bangladesh. Growth has largely been supported by IDCOL, which has invested some USD 700 million (of which USD 600 million are loans and USD 100 million is grant money). The experience and familiarity that financiers like IDCOL have developed with solar technology, as well as the popularity SHS products have enjoyed with customers, mean that Bangladesh has a secure footing on which to develop other solar technologies like mini-grids.

**This report sets out a roadmap to mobilise resources for two off-grid solar technologies: (i) solar mini grids, and (ii) solar irrigation.** The roadmap offers a pathway to developing these technologies at scale, including identifying next steps to overcome key barriers, stakeholders best placed to action these steps, and a timeline for implementation. It builds on two previous outputs:

- **Business model briefs** for each technology, which outline current market activity, and suggest short term modifications to enable more rapid market development based on international experience.
- **Investment cases**, which summarise the financial, environmental and social returns of the project, and analyse key technical and financial parameters that have important impacts on the rate of return.

<sup>3</sup> Ministry of Power, Energy and Mineral Resources (2016). "Power System Master Plan".

<sup>4</sup> Ministry of Environment and Forests (2015). "Intended Nationally Determined Contributions (INDC)". Available at [https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bangladesh%20First/INDC\\_2015\\_of\\_Bangladesh.pdf](https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bangladesh%20First/INDC_2015_of_Bangladesh.pdf), last accessed on 16 January 2019.

<sup>5</sup> compared to a maximum of 7.5 kWh/m<sup>2</sup> for the hottest parts of South America and Africa, see: Deb et al (2013). "Prospects of Solar Energy in Bangladesh", and British Business Energy (2016). "World Solar PV Energy Potential Maps".



## 2 Reform to mobilise finance for solar mini grids

**This section looks at policy and regulatory reforms that could support scaling up public and private finance for solar mini-grids.** These are also termed investment mobilisation measures (IMMs) below. The section is structured as:

- **Section 2.1** describes the current business models and investment opportunities in SMGs, and builds on a separate *business model brief*, and *investment case*;
- **Section 2.2** provides an overview of the current barriers to investment, and describes how these could be addressed through policy or regulation;
- **Section 2.3** develops a shortlist of IMMs, to address the barriers described in Section 2.2; and
- **Section 2.4** sets out a more detailed implementation plan for one priority IMM – the regulatory environment for SMGs if the main grid arrives during the asset life.

### 2.1 Summary of the solar mini-grid (SMG) business model and current investment opportunities

**There has been increased interest and experience in mini-grid based electrification since the early part of the decade.** The first successful and commercial off-grid solar-diesel hybrid mini-grid in Bangladesh was implemented in 2010 on Sandwip Island.<sup>6</sup> The 100 kWp plant was sponsored by Purobi Green Energy Limited (PGEL).<sup>7</sup> Since then, IDCOL has financed 20 more SMG projects in various parts of the country and plans to finance 200 SMGs by 2025.<sup>8</sup>

**Initially, SMGs were designed as standalone off-grid energy solutions, but more recently the GOB has also focussed on designing and installing SMGs in ‘grid-ready’ conditions, taking into account possibility of grid expansion in the near future.** These grid-ready SMGs follow technical standards, which make subsequent integration with the main grid feasible if the grid arrives during their lifetime.

**The majority of projects to date have followed a common financing structure using capital from IDCOL.** This has provided an attractive mode of mobilising public and private finance in the early stage of market development, with a substantial grant portion and a concessional loan. However, commercial finance is also a viable option, and both IDCOL and commercial bank capital will be needed to achieve the full potential scale of the market. The right panel of Figure 10 shows the potential structure of a loan for solar mini-grids taking finance from a commercial bank, which, in turn, uses the Bangladesh Bank’s dedicated refinancing for green products.<sup>9</sup>

<sup>6</sup> The Sandwip mini-grid is powered by solar panels, but includes a backup diesel generator. The diesel generator is used if demand exceeds supply from the PV panels or solar energy stored in batteries.

<sup>7</sup> Aziz et al (2016). “*The Success of Solar Diesel Minigrids in Bangladesh: A Case Study of Sandwip Island.*”

<sup>8</sup> IDCOL (2017). Annual report, page 18.

<sup>9</sup> Bangladesh Bank offers a refinancing scheme for green products, including solar energy production. SMG projects can be refinanced at 9% interest per annum instead of the commercial rate of 12% per annum.



Figure 5. SMGs in Bangladesh have used one of two financing structures – IDCOL finance or commercial finance

| Financier                 | IDCOL  | Commercial Bank   |
|---------------------------|--|---|
| finance structure         | <br>0% 20% 40% 60% 80% 100%<br>■ grant (donor/DFI) ■ debt (financial institution) ■ equity (investor)      | <br>0% 20% 40% 60% 80% 100%<br>■ debt (financial institution) ■ equity (investor) |
| grant finance and sources | <b>Grant of 50%</b><br>Financed by DFIs / donors: to date (DFID, KFW and GPOBA)                            | <b>No grant component</b>   |
| cost of debt              | <b>6%</b><br>Concessional loan for 30% of project, subsidised by DFIS (JICA and IDA)                       | <b>9%</b><br>Commercial rate of 12% reduced by Bangladesh Bank refinancing scheme |
| pricing                   | <b>Price ceiling of c. 30 BDT per kWh</b><br>Variable per customer up to ceiling                           | <b>Variable pricing</b>   |
| technical standards       | <b>Specified component standards</b><br>Technical standards set by cross-institutional standards committee | <b>No restrictions</b><br>on technical specification and import restrictions      |
| # projects to date        | <b>20</b><br>Size: 100 kWp – 250 kWp   | <b>1</b><br>Size: 50 kWp  |

Source: Vivid Economics

**Under the current business models and financing structures, a typical investment would expect to make a return on equity of around 18%.** However, a number of factors could push this return higher or lower, as set out in Section 2.2. For example, project developers face substantial risk around the rate of customer acquisition, and are exposed to any revenue shortfall from failing to connect customers as quickly as expected, or falling short of full utilisation of the mini-grid over its lifetime.

**In addition to providing financial returns to investors, supporting the goal of installing 200 SMGs by 2025 would also deliver an environmental benefit, reducing annual CO<sub>2</sub> emissions by 52,200 tonnes, compared to the use of a diesel generator.** This annual saving of 0.05 Mt would bring Bangladesh closer to realising its target of reducing emissions by 5% under the BAU scenario (which amounts to an annual average saving of 12 Mt of CO<sub>2</sub>e in 2030), as per its Nationally Determined Contribution (NDC) pledge to the Paris Agreement.<sup>10</sup>

## 2.2 Key barriers to investment under the current business models

**This section identifies a number of barriers to scaling up public and private investment in SMGs using the existing business models.** The team identified these barriers through discussions with a range of stakeholders including policymakers, financiers, project sponsors, and development partners, and through

<sup>10</sup> Ministry of Environment and Forests (2015). "Intended Nationally Determined Contributions", page 3. Available at [https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bangladesh%20First/INDC\\_2015\\_of\\_Bangladesh.pdf](https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bangladesh%20First/INDC_2015_of_Bangladesh.pdf).

a review of cash flow models used by investors to estimate the potential financial returns of a project. The team analysed the key parameters and assumptions of these models and compared them to the realised experience of SMG projects. Table 1 summaries the challenges identified, alongside a set of investment mobilisation measures aimed at addressing each challenge.

**Table 1. Key challenges limiting investment in solar mini-grids**

| Barrier  | Description  | Investment mobilisation measure  | Stakeholder responsible for implementation |
|--|--|--|--|
| Long term revenue uncertainty if grid arrives                                  | <ul style="list-style-type: none"> <li>— SMGs are developed in areas not currently served by the national grid. However, there is a risk that a grid connection becomes available over the life of the asset. In this case, customers are likely to prefer a connection to the main grid that is less expensive and perceived as more reliable. This presents project sponsors with a difficult challenge, as revenues drop significantly and very quickly.</li> </ul> | <ul style="list-style-type: none"> <li>— Government commitment on areas to which the grid will not be extended.</li> <li>— Purchase agreement for sale of power where grid does arrive to provide certain revenue stream – described in <a href="#">section 2.3.1</a>.</li> <li>— Obligatory purchase of asset by grid as a generating asset if the grid arrives.</li> </ul> | Power Division                             |
|  | <ul style="list-style-type: none"> <li>— This has already happened in one case, and grid arrival is imminent at two other sites. This is expected to result in the majority of SMG customers shifting to grid connections.</li> </ul>  |  |  |
| Mismatch between project cash flows and debt service obligations               | <ul style="list-style-type: none"> <li>— The life of a SMG is typically 20 years. However, under IDCOL financing, loans have to be repaid in the first 10 years (albeit with a grace period of 2 years).</li> </ul>  | <ul style="list-style-type: none"> <li>— Allowing project sponsors to put forward project-specific repayment profiles that allow them flexibility to reach maximum revenue generation, described in <a href="#">section 2.3.2</a>.</li> </ul>  | IDCOL                                      |
|  | <ul style="list-style-type: none"> <li>— Revenue generation is typically at its lowest in early years, meaning that high debt service obligations can result in a net cash outflow for the first few years.</li> </ul>   | <ul style="list-style-type: none"> <li>— Providing long term debt finance and long term guarantees.</li> </ul>   |  |
| Difficulty in ensuring maximum uptake of connections and usage among end users | <ul style="list-style-type: none"> <li>— Gaining a critical mass of connections as quickly as possible, and making sure consumption is sufficient to generate revenues, is a priority for project investors.</li> </ul>  | <ul style="list-style-type: none"> <li>— Allowing project sponsors to put forward project-specific repayment profiles that allow them flexibility to reach maximum revenue generation, described in <a href="#">section 2.3.2</a>.</li> </ul>  | SREDA / IDCOL                              |
|  | <ul style="list-style-type: none"> <li>— However, establishing trust in a new technology can be difficult, particularly in the early years of operation.</li> </ul>  | <ul style="list-style-type: none"> <li>— Long term guarantee finance for loans to extend liquidity of long term debt offered by financial institutions, described in <a href="#">section 2.3.2</a>.</li> <li>— Collating and circulating best practice on marketing initiatives from SMGs that have been successful in customer acquisition.</li> </ul>                      |  |

| Barrier   | Description  | Investment mobilisation measure  | Stakeholder responsible for implementation |
|---|--|--|--|
| <b>Higher than expected night to day load ratio has leads to increased storage costs and running of expensive back up diesel generators</b> | <ul style="list-style-type: none"> <li>While solar panels can only generate power during daylight hours, consumption can also occur in the evening/night. SMGs therefore store part of the power generated during the day in batteries for night use, and use back up diesel generators when the batteries are exhausted.</li> <li>Higher than expected night time loads have necessitated spending on higher capacity batteries, or on more diesel generation than expected.</li> </ul>   | <ul style="list-style-type: none"> <li>Identifying key anchor industry and business customers with high daytime consumption and low night time consumption – as described in the business model brief and investment case.</li> <li>Differential day and night tariffs, to reflect the cost of providing electricity at different times, as described in <a href="#">section 2.3.3</a>.</li> </ul> | SREDA / IDCOL                              |
| <b>Low affordability in some rural areas</b>  | <ul style="list-style-type: none"> <li>Consumers in some poorer regions have lower willingness or ability to pay.</li> </ul>   | <ul style="list-style-type: none"> <li>Target grant finance at those communities where ability to pay is lowest. For example, instead of providing the same size grant for all SMGs, provide a grant size dependent on the average income of the community connected. Described in <a href="#">section 2.3.4</a>.</li> </ul>   | SREDA / IDCOL                              |
| <b>High investment and replacement costs</b>  | <ul style="list-style-type: none"> <li>Initial investment in equipment is significant, in the range of 85 million BDT for a 250 kWp mini grid<sup>11</sup>. Batteries, batteries, inverters and backup generators require periodic replacement. This has led to high cash outflows in early years when components such as batteries have had to be replaced earlier than expected.</li> <li>Commercially financed projects have been able to reduce these costs by procuring equipment from less expensive suppliers. However, projects using IDCOL finance are unable to use these suppliers, as they do not meet requirements set by its Technical Standards Committee.</li> </ul> | <ul style="list-style-type: none"> <li>Review standards to ensure quality is maintained while lowering costs where possible given effect on project effectiveness and safety. Described in <a href="#">section 2.3.5</a>.</li> <li>Introduce VAT and import duty incentives to bring down costs for renewable energy components.</li> </ul>  | IDCOL / SREDA                              |

Source: Vivid Economics based on stakeholder consultation and review of international case studies

<sup>11</sup> 85 million BDT covers the cost of equipment and accessories, equipment installation, and the distribution line. Total project cost is approximately 98 million BDT. These figures are based on the SMG project at Saint Martin Island developed by Blue Marine Energy Limited.





## 2.3 Shortlist of investment mobilisation measures for SMGs

**A range of policy and regulatory changes have been identified to address the barriers to market development at scale in Bangladesh.** Potential solutions to overcome the key barriers to investment (listed in Table 1) were filtered on the basis of their effectiveness in overcoming the barrier, implementation feasibility, and their ability to attract private finance, resulting in the shortlist presented below.

### 2.3.1 Develop policy on compensation for investor if grid arrives within the lifetime of the SMG project

**The arrival of the grid leads to a drastic fall in revenue from electricity sales as households and businesses switch from SMG connections to grid connections on account of lower tariffs and a perceived improvement in reliability.** Consequently, IDCOL only approves SMG projects in areas where grid expansion is not foreseen within the five to ten-year horizon.<sup>12</sup> However, since the asset life of a typical project is 20 years, the grid may well arrive beyond the window that IDCOL examines, affecting the project returns and cash-flow. Additionally, the grid may be expanded unexpectedly within the five to ten year horizon due to political pressure, technical advancement or a change in the power division's plans.

**Under current policy, if the arrival of the grid happens after 5 years from the completion of the mini-grid, then, ostensibly, the utility has an obligation to purchase power from the mini-grid.**<sup>13</sup> However, complete guidelines are still under development, and this policy has not yet been implemented. In the case of the Sandwip SMG project, the grid arrived after 8 years of operation and the operator lost 50% of its customer base within a year, and is anticipating further losses. A further two sites have been informed that the grid will be arriving in the regions they serve.<sup>14</sup>

**A well-defined and operational policy to safeguard revenue for SMGs operators if the grid arrives within the lifetime of the asset de-risks the investment, providing a more certain rate of return for investors.** In this section, we show indicative modelling results from allowing the SMG to sell power to the grid, as its customer base erodes over time.

**In a scenario where the grid arrives 15 years after the SMG has been established, depleting the SMG's customer base to 10% of its initial value over the following two years, halves the equity IRR (falling from 18% to 9%).** However, allowing the SMG to sell power to the main grid at a tariff of 30 BDT per kWh would offset much of this fall in profitability, as illustrated in Figure 6. However, it may be that the tariff agreed is in line with tariffs applicable to grid customers that range from 5 BDT/kWh to 12 BDT/kWh depending on

<sup>12</sup> ESMAP (2017). "Mini-Grids in Bangladesh: A Case Study of an Incipient Market"

<sup>13</sup> Power Division, Ministry of Power, Energy, & Mineral Resources (2013) "Guidelines for the Implementation of Solar Power Development Program"

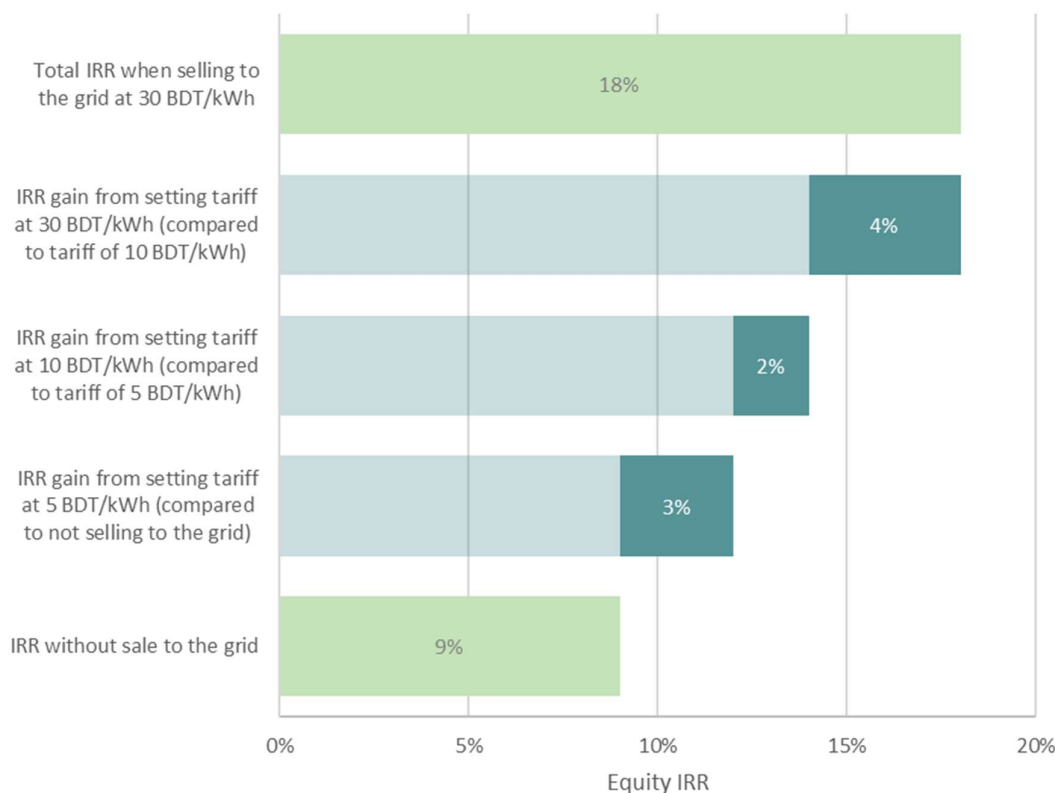
<sup>14</sup> The grid has arrived before the end of the SMG project life in Sandwip Island, and is expected to at Shourobangla (Narsingdi), and Baraka SMG (Narayanganj).



load demanded. These lower tariffs would only partially compensate the equity investor. Figure 6 presents three pricing scenarios:

- Setting the tariff at 5 BDT/kWh. This is based on the typical wholesale price (for conventional generation) in Bangladesh. Compared to no sale of power from the SMG to the main grid after its arrival, this would add another three percentage points to the IRR, and increase the equity IRR to 12%,
- Setting the tariff at 10 BDT/kWh. This is based on discussion around the prices offered to utility scale solar power generators under power purchase agreements (PPAs) with the Power Division. This improves the equity IRR by a further two percentage points relative to a 5BDT/kWh tariff, resulting in an overall IRR of 14%,
- Allowing a tariff of 30 BDT/kWh. This is equivalent to the unit tariff for customers at present, and would bring the IRR broadly back in line with the current investment opportunity under a scenario where the grid does not arrive.

**Figure 6. Project sponsors will only be partially compensated if they sell to the grid at a tariff below 30 BDT/kWh**



Source: Vivid Economics



**Immediate and medium-term next steps:**

- Establish a clear national policy (technical and financial) for integration with the grid – developed in more detail in Section 2.4.

**Key stakeholders for implementation:**

- REB in collaboration with SREDA, Power Division and IDCOL

### 2.3.2 Determine project-specific loan tenors and grace periods

**Tailoring loan tenors and grace periods to project specific cash flows would improve cash flow in the early years of the project.** During the construction phases and initial years of operation, mini-grid project developers have to cover construction costs as well as account for modest revenue streams as they build up a customer base. The construction phase and customer acquisition schedule differ by project, depending on the approach to customer acquisition and pricing models. Whereas debt service obligations tend to be standardised, particularly those financed by IDCOL. The loan-servicing schedule could instead be tailored to the project's specific cost and customer acquisition schedule so that debt servicing is delayed in time to match full customer acquisition. Matching the repayment profiles of debt finance to the revenue generated from customers would make for a more robust business model for project sponsors, who will be better able to meet the debt repayments on time, which may help reduce the risk of financing SMG projects and lower the requirements for bank guarantees and collateral.

**Immediate and medium-term next steps:**

- Carry out a study of existing SMG project costs to better model debt repayment packages

**Key stakeholders for implementation:**

- SREDA can carry out the cost study and work with IDCOL to design the financing packages

### 2.3.3 Tariff structure reform and best practice

**Innovative tariff structures, including differential pricing by customer type or different tariffs for day and night consumption, could improve customer acquisition and help balance the night to day load ratio.**

IDCOL-financed projects currently face a price ceiling of 30 BDT per kWh, for both industrial as well as residential tariffs. Allowing prices to vary between households, commercial customers and industrial anchor customers could accelerate customer acquisition. For example, commercial customers who may place a higher value on a reliable quality of service than households, may be able to support a higher tariff. Alternatively, or in addition, SMGs could also charge a higher tariff for night time use, reflecting the higher cost involved in purchasing and maintaining expensive batteries to store power overnight. This would bring down night time demand, and reduce the need for investment in large capacity batteries and/or the operational cost of running a diesel generator to meet excess demand.



**The next step would require carrying out a study to determine tariff options.** This should include a study of cost-reflective tariffs by time of use (i.e. day and night), and consideration of the demand from different customer categories, to determine the cost they impose on the SMG network. This study could be combined with the review of technical and financial out-turn of existing projects, and potential improvements to tariff structures currently being undertaken by IDCOL with support from the UK government's Department for International Development (DFID).

**Immediate and medium-term next steps:**

- A power demand study will determine tariff options to support efficient charging across customer segments and demand profiles

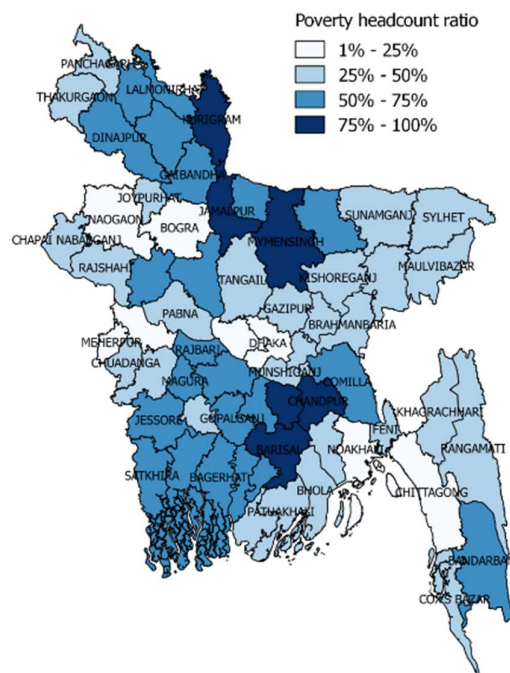
**Key stakeholders for implementation:**

- **SREDA** can work with **REB** data and project developer data to accurately model electricity demand

#### 2.3.4 Targeting higher grant finance to regions with very low ability to pay

**Grant finance could be allocated based on the difficulty of customer acquisition, which is typically higher in less affluent regions.** Grant finance is currently allocated equally across all projects, irrespective of the location of the proposed project or the income of the potential customer base. A customer base with a lower average income is less likely to be able or willing to pay mini-grid connection charges, tariffs or line rental fees. Grant finance could therefore be targeted to ease revenue constraints faced by a mini-grid provider in regions. Grant finance could be allocated to subsidising connection fees and line rental fees to increase the rate of customer acquisition, as well as to lower the per-unit consumption tariffs. There is a large variation in poverty levels across Bangladesh, as shown in Figure 7 – so to achieve a policy objective of universal electrification; it may be most effective to target grant funding to the most poor, rural areas.

Figure 7. There is a wide variation in poverty levels in Bangladesh



Source: World Bank “Bangladesh Interactive Poverty Maps”

#### Immediate and medium-term next steps:

- Carry out a study on regional income differences to determine ability to pay and eligibility for targeted grant subsidies

#### Key stakeholders for implementation:

- SREDA and the Bangladesh Rural Development Board

### 2.3.5 Review technical requirements and financial conditions for accessing IDCOL funding

**SMG projects financed by IDCOL face higher project costs due to the stringent technical standards for equipment.** IDCOL’s Technical Standards Committee prescribes precise technical specifications for all equipment, including solar panels, inverters, generators and batteries, to ensure efficiency, safety and compatibility with the grid.<sup>15</sup> However, interviews with project sponsors suggest that there are a limited number of suppliers who meet these requirements, and those suppliers tend to be more expensive than their competitors.

<sup>15</sup> IDCOL (2017). Supplier Enlistment Process under IDCOL Solar Mini-Grid and Rooftop Projects.

**IDCOL also requires collateral or a bank guarantee covering the entire loan amount, which can deter potential equity investors.** The concessional loan received by project sponsors (30% of total project cost) must be covered entirely by collateral or a bank guarantee. This is a substantial hurdle for potential project sponsors, and the costs involved in arranging a commercial bank guarantee can be significant.

**A review of existing technical requirements should be conducted, with a view to relax specifications where possible, keeping in mind concerns over quality and safety.** Reducing the requirement for 100% collateral or bank guarantee, or collaborating with third parties who specialise in providing guarantees for emerging technologies, could improve project cash flows and attract more project sponsors. Relaxing technical requirements would allow project sponsors to leverage less expensive suppliers and bring project costs down. For example, a private company (Angira Electronics) dramatically reduced equipment costs by sourcing components for its SMG project in the Manikganj district from a Chinese supplier.

**Immediate and medium-term next steps:**

- Review existing technical and financial requirements, with a view to relaxing specifications where possible

**Key stakeholders for implementation:**






- **IDCOL** in collaboration with project developers can review technical and financial requirements

### 2.3.6 Overview of the shortlist of IMM for SMGs

**An overview of the IMM shortlist, with the immediate next step and main stakeholders is set out in Figure 8.** This provides a summary of the IMM presented in the sections above.



Figure 8. Five shortlisted IMM have been identified as having potential to catalyse investment into SMG

| Implementation measure   | Barrier addressed  | Immediate and medium term steps   | Long term goal   | Stakeholder responsible  |
|--|--|---|--|--|
|  develop a compensation policy in the event of grid arrival                         | revenue uncertainty – if the grid arrives it may erode the SMG customer and revenue base                     | establish a clear national policy (technical and financial) for integration with the grid                                     | protection from fall in revenue from energy sales for the project sponsor due to unexpected grid expansion | REB in collaboration with SREDA and IDCOL to ensure streamlined communication                  |
|  determine project-specific loan tenors and grace periods                           | mismatch between debt finance and revenue – especially in early years while acquiring customers              | carry out a study of existing SMG project costs to better model debt repayment packages                                       | improvement to project liquidity and accessibility of loans  | SREDA can carry out the cost study and work with IDCOL to design the financing packages        |
|  tariff structure reform and best practice  | high cost of meeting night loads – cost reflective tariffs should reflect marginal cost of night consumption | a power demand study will determine tariff options to support efficient charging across customer segments and demand profiles | improving customer acquisition and balancing the night to day load ratio                                   | SREDA can work with REB data and project developer data to accurately model electricity demand |
|  targeting higher grant finance to regions with low ability to pay                  | low incomes / affordability – in some regions which may be targeted for policy reasons                       | carry out a study on regional income disparities to determine ability to pay and eligibility for grant subsidies              | increasing access to electricity in areas with low purchasing power  | SREDA and the Bangladesh Rural Development Board collaboration                                 |
|  review technical requirements and financial conditions for accessing IDCOL funding | high capital costs required to meet technical standards  | review existing technical and financial requirements, with a view to relax specifications where possible                      | reducing costs associated with technical and financial requirements which may not be necessary             | IDCOL in collaboration with project developers can review technical requirements               |

Source: Vivid Economics

## 2.4 Next steps for implementation of the priority IMM -- regulatory protection if grid arrives during SMG asset life

### 2.4.1 Importance of regulatory and policy if the national grid arrives

Discussions with project sponsors and cash flow analysis suggest that the lack of certainty on long term revenues in areas where the grid could arrive is the most important barrier to investment. This has an important impact on the financial performance of projects; if the grid arrives in an area served by an SMG, the SMG will see a substantial drop in revenue as a large proportion of its customers opt for a grid connection due to cheaper tariffs and a perception that the grid is more reliable than SMGs.

While SMGs are only approved in areas where the grid is not expected to arrive in the next 5-10 years, there is a risk that a grid connection becomes available over the 20 year life of the asset. This is a risk that investors and project developers cannot control, once the initial decision to invest has been made. Exposure to this risk raises the cost of finance, making SMG less cost competitive, without sharpening incentives to improve design or operation of the SMG.

Internationally, the arrival of the grid is also identified as the major constraint to attracting investment in mini-grids. In a review during 2017, ESMAP, a World Bank-led technical assistance initiative notes:



*Experience has shown that significant private investment will not be forthcoming if a country's policy and regulatory rules of the game are unclear or overly burdensome. Of all the rules and policies that can affect private investment in isolated rural mini grids, the one potential private investors cite most frequently concerns what happens to their operations after the main grid arrives.*

[ESMAP, 2017]

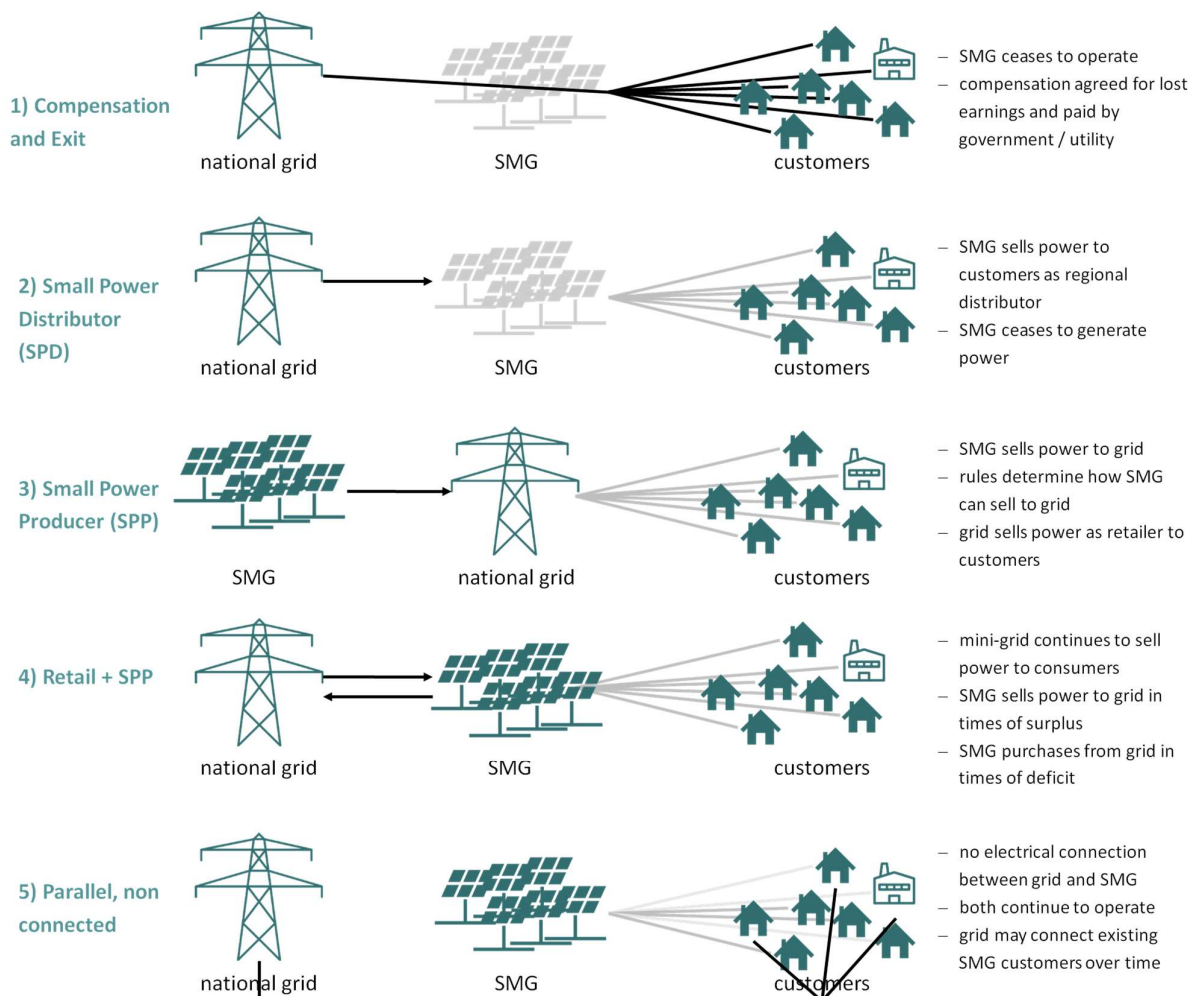
#### 2.4.2 Policy and regulatory options for mini-grid operations if the national grid arrives

**Building on this international experience, Figure 9 sets out five broad options for SMG when the grid arrives, and summarised in the paragraphs below:**

- 1) cease operations, with compensation for the SMG operator;
- 2) become a small power distributor, as retailer to customers but no longer generating power;
- 3) become a small power producer, selling all power to the national grid;
- 4) become a small power producer and retailer, maintaining service to customer and selling (buying) surplus (deficit) power to (from) the national grid; or
- 5) continue operations in parallel to the grid's own connections.



Figure 9. Typical regulatory options for SMGs on arrival of the national grid



Note: grey icons represent no power generated by the SMG

Source: Vivid Economics based on ESMAP 2017

The first option is to cease operations of the mini-grid, and (potentially) provide a compensation payment to the operator in lieu of the revenue they will no longer collect from customers. The rationale for this option is to provide (some) certainty for the mini-grid operator that once the grid arrives it will be compensated for (a share of) the remaining value of the asset, which it will no longer be able to collect through user charges. The operator will also not have to compete with the grid, which on a forward-looking basis, may represent a more efficient, cost-effective source of power.

A more common solution is for the SMG operator to become either (i) a small power distributor (SPD), or (ii) a small power producer (SPP), or a combination of both. As set out in Figure 9, under a small power distributor model, the SMG would retain its role as the distributor of power to end customers, but would no longer generate power. Alternatively, as a small power producer, the SMG would become a distributed

generation asset, which sells power directly to the grid. The grid then takes over responsibility for balancing services and acts as the retailer to customers. Alternatively under a SPP + Retail model, the SMG would be served by a point of connection to the national grid, from which it could purchase power in hours of deficit (reducing the need for storage or diesel back-up generators), and sell in hours of surplus, and would remain the point of retail to end users.

**International experience highlights the importance of regulatory protection if the electricity grid arrives, as otherwise SMG operators tend to go out of business.** There are relatively few examples of countries that have directly addressed the challenge of what happens to mini-grid operations once the grid arrives. ESMAP carried out a review of experience in Cambodia, Indonesia and Sri Lanka, which is summarised in the following sections.<sup>16</sup> This review makes clear that SMG operators often struggle to continue operations once the grid arrived, although a few have successfully converted to SPDs and SPPs as set out in Table 2.

**Table 2. International experience in mini-grid operations shows that in many cases mini-grids ceased operation once the main grid arrived**

| Country   | Type of Mini-grids                   | Result after grid arrival  |
|-----------|--------------------------------------|--|
| Indonesia | Hydro mini-grids, community operated | <ul style="list-style-type: none"> <li>Most were abandoned; some turned into small power purchasers (SPP) whereby they cease supplying power through individual connections and instead sell 100% of their power to the grid. Others operate alongside the grid where they can offer lower tariffs than the grid (as grid has high connection costs).</li> <li>Only 6% of total mini-grid projects remain in business after the arrival of the grid.</li> <li>Law states that government funded infrastructure cannot be used for private profits (electricity company was private), so could not connect to the grid as a power provider. This meant many mini-grids could not operate under the SPP model as they had received government funding.</li> <li>Grid-tariffs are low, so on arrival of the main grid customers preferred the cheaper grid-based connection.</li> </ul> |
| Sri Lanka | Hydro mini-grids, community operated | <ul style="list-style-type: none"> <li>Initially 150 mini-grids, almost all stopped operations: only 3 converted to SPP.</li> <li>Conversion to a SPP required connection infrastructure investment and change from a socially owned enterprise to a limited liability company that was typically not pursued, nor did the mini-grids typically did not meet the Electricity Board Standards.</li> <li>Mini-grid size of &lt;10 customers meant they were not commercially viable as small power distributors (SPD) (a model whereby they would cease generation and buy 100% of the load demanded from the grid and then sell onto their customers).</li> <li>Grid offered highly subsidised tariffs and a higher tier of service.</li> <li>Regulatory requirements were designed for larger generators – which proved too costly for SPDs to continue operations.</li> </ul>       |

<sup>16</sup> ESMAP (December 2017) “Mini-grids and arrival of the main grid: lessons from Cambodia, Sri Lanka, and Indonesia

| Country  | Type of Mini-grids                 | Result after grid arrival  |
|----------|------------------------------------|--|
| Cambodia | Diesel mini-grids, privately owned | <ul style="list-style-type: none"> <li>— Most mini-grid projects underwent a conversion to SPDs.</li> <li>— The grid offered longer hours of service and lower prices.</li> <li>— Initially each SPD charged its own cost-reflective tariff.</li> <li>— Since early 2016, government announced retail tariffs for SPDs would be uniform nationwide, with government commitment to provide an operational subsidy to close the gap between the retail tariff and the cost reflective tariff.</li> <li>— Regulatory authority forced SPDs to meet certain distribution standards.</li> <li>— SPDs have grown and spread fixed costs over more customers and more kWh sales.</li> </ul> |

Source: Vivid Economics

### 2.4.3 Steps to be taken to develop policy and regulatory framework for arrival of the national grid

Various steps will need to be taken to operationalise a policy and regulatory framework for mini-grids when the grid arrives. These are set out in Table 3.

Table 3. Steps to implement policy and regulation for SMG operations when the national grid arrives

| Step   | Description   | Current status in Bangladesh   |
|--|---|--|
| 1. Clear policy for grid extension                 | A clear national policy for extensions to the national grid, that provides commitment to SMG project developers that the grid will not arrive in their region of operations.  | <p>Grid extension plans with commitments to not extend to certain areas do exist, although not to the fully 20 year life of the asset.</p> <p>However, these have not always been upheld, and in general there will always be a political pressure to extend the grid, so other policies will need to be put in place as safeguards (see below).</p>   |
| 2. Regulatory policy roadmap for when grid arrives | <p>Regulatory roadmap that details all business options permissible under regulation to the mini grid developer when the main grid arrives.</p> <p>Ideally this should offer a range of options for what happens when the main grid arrives, as set out in the section above.</p> | <p>Currently, the policy framework in Bangladesh is set up to enable SMG operators to operate under the SPP model, with tariffs set such that the operator can feed electricity generated into the grid for the rest of the asset life, with cost reflective tariffs to include a 15% return on equity.<sup>17</sup></p> <p>However, this policy is not operational, and has not been implemented in the three instances where the grid has arrived.</p> <p><b>Power Division, SREDA, REB to develop policy framework.</b></p> |

<sup>17</sup> Power Division, Ministry of Power, Energy, & Mineral Resources (2013) "Guidelines for the Implementation of Solar Power Development Program"



| Step   | Description   | Current status in Bangladesh   |
|--|---|--|
| 3. Develop guidelines to enable sale of power from SPPs to the national grid | Once the options for SMG operators have been developed, there will be need to develop technical codes to determine how the interconnection with the main grid will work.  | <p>A net metering policy has been in place since July 2018.</p> <p>However, this is targeted at rooftop solar installations for existing utility customers, with sales from power generated offset against the utility bill. These rules are not suitable for SMG operators under an SPP model, and would need to be modified.</p> <p><b>SREDA and Power Division to develop guidelines on technical aspects of grid connection.</b></p> |
| 4. Define rules for compensation if the grid arrives                         | <p>Accounting and cost categorisation protocols will need to be developed to determine for which costs SMG project developers should be compensated if the grid arrives.</p> <p>This would be needed for any of the options included in Figure 9.</p>                                 | <p>Yet to be undertaken.</p> <p><b>Power Division and SREDA to determine process for compensation agreements.</b></p>  |
| 5. Streamline licencing and technical standards                              | <p>Ensure clear and transparent regulatory processes for licencing when connecting to the main grid, to minimise bureaucracy.</p> <p>Include clear guidance on when SMGs should be built to 'grid-ready' standards.</p>   | <p>All SMGs financed under IDCOL are required to meet the Technical Standard Committees standards to ensure they are 'grid-ready'.</p> <p>However, there is no guidance for SMGs developed by private sponsors using commercial finance.</p> <p><b>SREDA, IDCOL, and TSC to review and streamline technical requirements grids.</b></p>  |
| 6. Consider parity of subsidy regimes  | Review the current financial incentives and subsidies in place for grid extension, and compare these to the financial incentives and subsidies in place for SMGs. This should result in 'efficient' decisions being taken on where to extend the grid and where to deploy mini-grids. | <p>Yet to be undertaken.</p> <p><b>SREDA and IDCOL to lead study and revisit the role and need for concessional finance.</b></p>   |

Source: Vivid Economics



### 3 Reform to mobilise finance for solar irrigation

**This section looks at the policy and regulatory reforms that could support scaling up public and private finance for solar irrigation.** These are also termed investment mobilisation measures (IMMs) below. The section is structured as:

- **Section 3.1** describes the current business models and investment opportunities in solar irrigation, and builds on a separate *business model brief*, and *investment case*;
- **Section 3.2** provides an overview of the current barriers to investment, and describes how these could be addressed through policy or regulation;
- **Section 3.3** develops a shortlist of IMMs, to address the barriers described in Section 3.2;
- **Section 3.4** sets out a more detailed implementation plan for one priority IMM – to enable the sale of surplus power from the solar panels of the pump, outside of the main *BORO* cultivation season.

#### 3.1 Summary of the Solar Irrigation business model and current investment opportunities

**Irrigation plays a vital role in Bangladesh at least for half of the year when water scarcity would otherwise present a major challenge for farmers.** Different crops are grown in different seasons through year, so irrigation has potential to be used year-round. However, so far it has been most valuable the '*BORO*' rice season only, and irrigation pumps are often not well utilized outside of this *BORO* season.


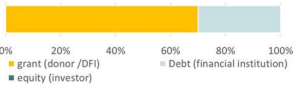
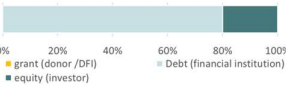
**IDCOL has financed 1,031 of the 1,131 solar irrigation pumps in Bangladesh.** Eligible solar irrigation projects can receive IDCOL finance comprising 50% grant, 35% concessional loan with the remaining 15% provided as equity by the project sponsor. To access IDCOL loans, the project sponsor must provide a bank guarantee for 100% of the loan, or alternatively provide collateral (such as land).

**Between 2013 and 2018, over 1,000 SIPs have been deployed, almost all by the Infrastructure Development Company Limited (IDCOL), a government owned financial institution.** IDCOL has financed 1,031 of the 1,131 solar irrigation pumps (SIPs) in Bangladesh, with the Bangladesh Agricultural Development Corporation (BADC), and the Rural Electrification Board (REB) financing another 100 in total. Across all the SIPs installed, this represents a total solar PV installed capacity of approximately 21 MW.<sup>18</sup> Commercial banks have played a very limited role to date. Figure 10 summarises the main elements of these different financing options.

<sup>18</sup> IDCOL (2017) "*Annual Report 2017*"



Figure 10. Financing structure using IDCOL or commercial bank capital

| Financier                 | IDCOL   | REB or BADC  | Commercial banks / DFIs   |
|---------------------------|---|--|---|
| finance structure         | <br>0% 20% 40% 60% 80% 100%<br>■ grant (donor /DFI) ■ Debt (financial institution) ■ equity (investor) | <br>0% 20% 40% 60% 80% 100%<br>■ grant (donor /DFI) ■ Debt (financial institution) | <br>0% 20% 40% 60% 80% 100%<br>■ grant (donor /DFI) ■ Debt (financial institution) ■ equity (investor) |
| grant finance and sources | Grant of 50%<br>Financed by DFIs / donors: to date (DFID, KFW and GPOBA)  | Grant of 70%<br>Govt provides 70% - remainder recovered from farmers   | No grant component  |
| cost of debt              | 6%<br>Concessional loan for 30% of project, subsidised by DFIs (JICA and IDA)   | 0%<br>Nominal fees charged to farmers to recover 30% of investment cost over 20 years  | 9%<br>Commercial rate of 12% reduced by Bank of Bangladesh refinancing scheme   |
| pricing                   | Price ceiling of c. 30 BDT per kWh<br>Variable per customer up to ceiling   | 10,000 BDT fixed fee per year<br>Annual fees are collected from farmers to cover a portion of the initial investment cost  | Variable pricing  |
| technical standards       | Specified component standards<br>Technical standards set by cross-institutional standards committee   | System provided by GoB meeting own design specifications   | No restrictions on technical specification and import restrictions  |
| # projects to date        | 1,000 +   | 100  | Limited   |

Source: Vivid Economics

**Alternatives to the IDCOL financing model are developing, such as finance from commercial banks or from DFIs.** Some project developers have developed smaller pump systems without using the IDCOL financing structures, working directly with commercial banks. The Asian Development Bank is also looking at offering finance for solar water pumps under a part-grant, part-loan model with REB, and is in the process of determining the business models and financing structures to implement this programme.

**Under the current business models and financing structures, a typical investment would expect to make a return on equity of around 18%.** Eligible solar irrigation projects can receive IDCOL finance comprising 50% grant, 35% concessional loan with the remaining 15% provided as equity by the project sponsor.

**A number of factors could affect the anticipated 18% equity IRR.** The commercial success of the project will depend on customer acquisition, as well as on market penetration. If the uptake of irrigation service is lower than expected, or operation and maintenance costs are higher than expected, the project will generate lower returns. Other factors are considered in more detail in Section 3.2.

**The government's ambition to introduce 50,000 SIPs to replace diesel irrigation pumps could represent between 0.4 and 0.9 mega tonnes of CO<sub>2</sub> abatement per year.** This will be a contribution towards lowering



emissions from the agriculture sector, which contributes approximately 40% of national emissions.<sup>19</sup> If Bangladesh achieves its goal of introducing 50,000 solar pumps by 2025, they could contribute between 4% and 8% of the NDC target to abate 12 MtCO<sub>2</sub> by 2030.

## 3.2 Key barriers to investment under the current business models

**Financiers, investors, project developers, and policy makers face a number of key challenges when considering investment into solar irrigation projects.** These are summarised in Table 4, alongside a set of potential solutions to each challenge. The potential solutions are then discussed in detail in section 3.3. Finally, one priority measure – providing investors with long term revenue certainty if the grid arrives within the life of the asset – is described in section 3.4.

Table 4. Key challenges limiting investment in solar irrigation

| Barrier   | Description   | Investment mobilisation measure  | Key stakeholder |
|---|---|--|-----------------|
| Low utilisation of the SIPs outside of the main <i>BORO</i> irrigation season | <ul style="list-style-type: none"> <li>— The maximum demand for pump irrigation comes in the <i>BORO</i> season, which only lasts 3-4 months from January to April. In the remainder of the year the pumps are under-utilised / unused.</li> <li>— This means only a small proportion (less than 50%) of technical power potential from the pumps is used. This is different from other countries where demand for irrigation is more stable across the year, so revenue streams from pump operation are more regular.</li> </ul> | <ul style="list-style-type: none"> <li>— Sale of surplus power from panels to main grid – discussed in <a href="#">section 3.3.1</a>.</li> <li>— Alternative use of panels for revenue generation outside of <i>BORO</i> season – discussed in <a href="#">section 3.3.2</a>.</li> </ul> | SREDA / REB     |
| Mismatch between project cashflows and debt service obligations               | <ul style="list-style-type: none"> <li>— The life of a SIP is typically 20 years. However, the loan typically has to be repaid in the first 10 years, albeit with a grace period of 2 years.</li> <li>— In these early years, revenue generation is also typically at its lowest which may coincide with an extended construction time.</li> </ul>  | <ul style="list-style-type: none"> <li>— Allowing project sponsors to put forward project-specific repayment profiles that provide greater repayment flexibility before maximum revenue generation.</li> </ul>   | IDCOL           |

<sup>19</sup> USAID 2016, “GHG Emissions fact-sheet Bangladesh”. Accessed: [https://www.climate-links.org/sites/default/files/asset/document/GHG%20Emissions%20Factsheet%20Bangladesh\\_4-28-16\\_edited\\_rev08-18-2016\\_Clean.pdf](https://www.climate-links.org/sites/default/files/asset/document/GHG%20Emissions%20Factsheet%20Bangladesh_4-28-16_edited_rev08-18-2016_Clean.pdf)



| Barrier                             | Description   | Investment mobilisation measure  | Key stakeholder |
|-------------------------------------|---|--|-----------------|
| Low uptake of SIPs by farmers       | <ul style="list-style-type: none"> <li>— In some cases, project developers have found that farmers do not fully utilise the pumps as expected. This may be due to the cost of the system, or that it is a relatively new technology whose benefits are not fully demonstrated.</li> </ul>   | <ul style="list-style-type: none"> <li>— Time construction to make sure that the pumps are operational in time for the BORO season when there value is most evident</li> <li>— Offer discounts to farmers in first seasons to maximise uptake and demonstrate technology – discussed in <a href="#">section 3.3.3</a>.</li> </ul>  | SREDA           |
| High investment and operation costs | <ul style="list-style-type: none"> <li>— Technical standards set by the Technical Standards Committee must be met by any project receiving IDCOL finance. These standards are designed to ensure international standard quality of systems. However, there may be components that could be acquired at lower cost.</li> <li>— Operations can be expensive when manually operated, and when there is a need to guard against theft.</li> </ul> | <ul style="list-style-type: none"> <li>— Review standards to reduce costs where the impact on project effectiveness and safety would be limited.</li> <li>— VAT and import duty incentives to bring down costs for components.</li> <li>— Continue to bring down O&amp;M costs as the technology evolves and developers gain experience – discussed in <a href="#">section 3.3.4</a>.</li> </ul> | IDCOL           |

Source: Vivid Economics based on stakeholder consultation and review of international case studies

### 3.3 Shortlist of investment mobilisation measures for SIPs

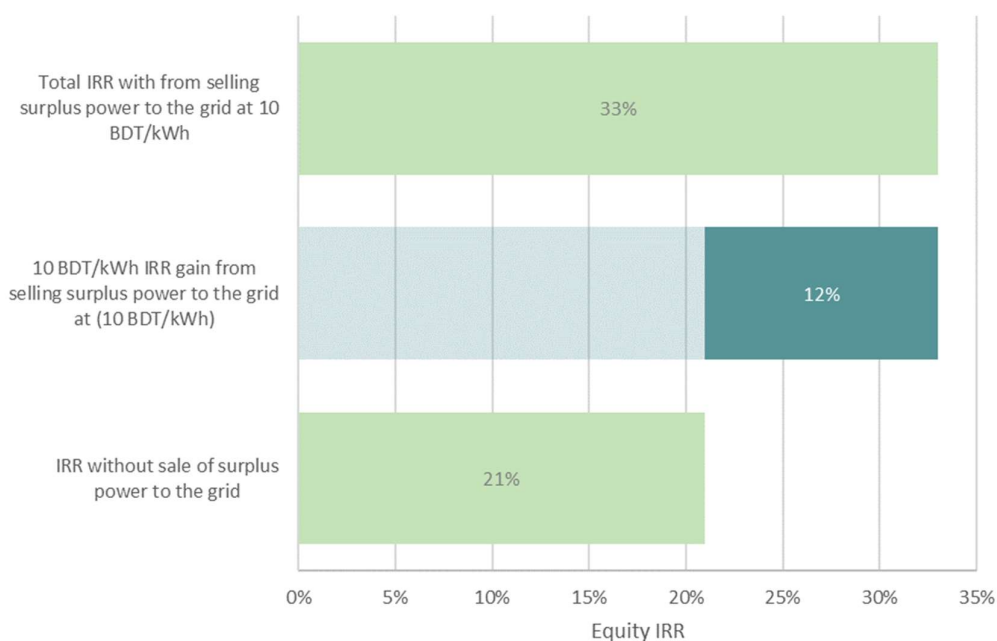
The team filtered potential solutions to overcome the key barriers on the basis of their effectiveness in overcoming the barrier, implementation feasibility, and their ability to attract private finance resulting in a shortlist of four. The section below discusses each shortlisted measure in turn, including a high-level overview of their effect on cash flow and returns, and a mapping of ongoing policy initiatives related to each measure.

#### 3.3.1 Develop policy on sale of surplus power from SIPs to the grid

**Demand for SIP irrigation typically accounts for only 40% of the potential power generation of the SIP.** Discussions with project developers and financiers consistently highlight this idle capacity as the most important barrier to investment. It means that the full cost of the asset must be recovered over a short period of time each year. This is a challenge to Bangladesh and its climate.



**Figure 11. Selling surplus power pack to the grid could increase the equity IRR by 12 percentage points**



Source: Vivid Economics

**Generating revenue from the untapped power generation would be an effective way of mitigating risk from demand seasonality and increasing project returns.** Figure 11 shows that selling surplus power to the grid at 10 BDT per kWh could increase the equity IRR of a typical project by 12 percentage points (from 21% to 33%). The modelled scenario assumes that the SIP would be able to sell up to 75% of surplus power at 10 BDT/kWh to the grid but with a 25% efficiency loss. However, this scenario does not consider the connection costs associated with establishing and maintaining a connection to the grid. Section 3.4 explores this and other considerations in more detail.

**Immediate and medium-term next steps:**

- Carrying out technical and feasibility studies on the potential for connecting solar irrigation pumps to the grid
- Developing cost and pricing strategies

**Key stakeholders for implementation:**

- SREDA, in collaboration with the REB

### 3.3.2 Training and awareness to develop alternative revenue generating activities from SIPs outside of BORO season

**An alternative / supplement to selling surplus power to the main grid is to use the panels and land around the pump to generate revenue from activities other than irrigation.** This is being pursued by



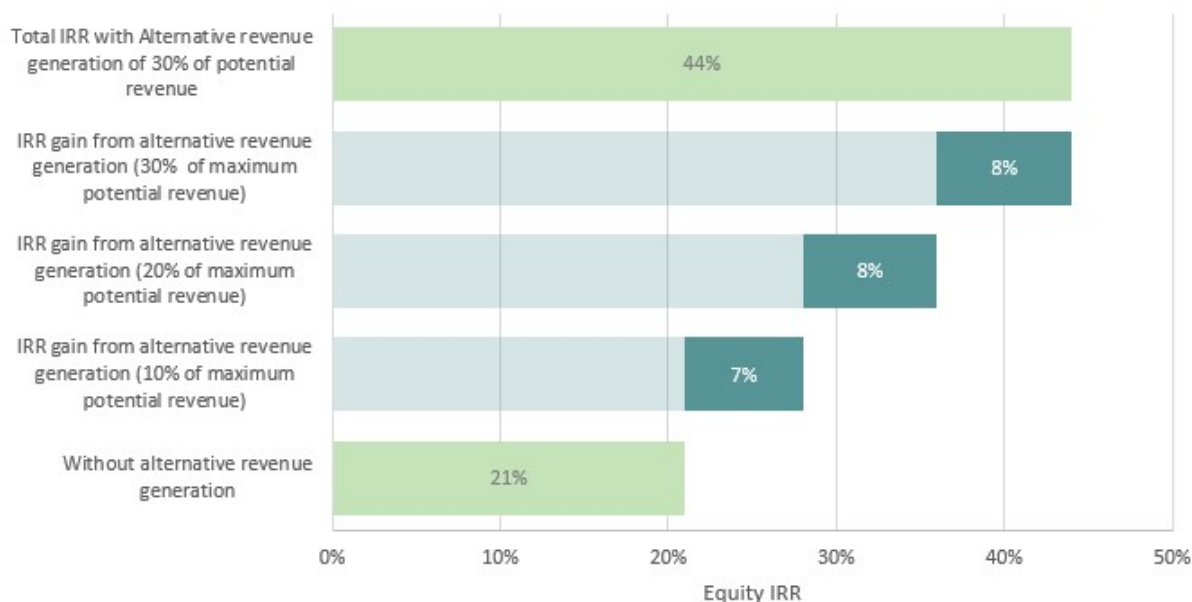
project developers, such as Solar Gao – and discussed in a separate *investment case* document, with a summary discussion in the paragraphs below. As shown in Figure 12, even generating just 10% of the difference in revenue between the *BORO* season and other seasons would boost the equity IRR by seven percentage points with further return increases possible if more of the revenue gap closes.

**Activities to generate alternative sources of revenue could include growing other crops in the shade around the panels, or using the power from the panels for other productive use purposes.** For example, leasing farmers the land in and around the panels to grow additional crops. Alternatively, the power from the panels could be put to productive use for other purposes outside of the main *BORO* season. SolarGao designs and constructs a range of cold storage units that can be leased to farmers for storing produce and cultivating specialised crops such as mushrooms. Additionally, they carry out bio-composting on the SIP sites to manufacture bio-fertilizer which is then sold to farmers or used to cultivate crops under the solar panels. These activities could be done in parallel to the sale of surplus power to the grid, as described in section 3.3.1 above.

**Alternatively, solar irrigation pumps could be connected directly to nearby household and businesses, and sell power directly to these customers.** This could be done by developing a hybrid SIP-SMG model, where the SIP solar panels connect directly to households or business customers who buy the power when it is not needed for irrigation. This may be more attractive than selling power to the grid where the grid is (relatively) remote, and where customers could connect directly to the panels and use electricity. SolarGao is developing trials using 50 kWp capacity SIPs which will provide electricity to farmers for irrigation on a fee-for-service model in the first instance, and then sell surplus power to other customers. The latter could also be done on a fee-for-service basis, rather than on a per-unit of consumption basis. More information on SolarGao's SIP-SMG hybrid approach can be found in the '*Solar Irrigation Pumps – Investment Case*'.



**Figure 12. Generating 30% of maximum potential revenue during the off-season could boost the project equity IRR to 44%**



Source: Vivid Economics

#### Immediate and medium-term next steps:

- Design and implement capacity building and training strategies for farmers and SIP project developers
- Consider potential hybrid SIP-SMG models and framework to connect household and business customers to the SIP, and to sell electricity directly to customers, similar to the SMG model described in Section 2

#### Key stakeholders for implementation:

- Project developers with guidelines developed by SREDA and the BADC

### 3.3.3 Encourage farmer uptake by allowing for flexible pricing in the initial seasons

**Lower pricing in the initial seasons of using the SIP service could improve customer acquisition in the initial year of operation.** In the early stages of development of a new technology like SIPs, farmers may not immediately see the full value and could be reluctant to switch from familiar diesel powered pumps. Even though tariffs offered will be equal or lower than the cost of irrigation from diesel,<sup>20</sup> there will be costs associated with switching pumps and they may not be familiar with the technology.

<sup>20</sup> Power Division (2013) "Guidelines for the Implementation of the Solarx Power Development Program - 2013"



**While project developers may be able to offer lower tariffs independently, guidance and studies to support optimal price setting would support sustainable business strategy.** This could draw on international experience in rolling out solar irrigation technology using innovative business models in the region and internationally. For example, in addition to irrigation services, SunCulture provides farmers with crop analysis, advisory and finance and technical support.<sup>21</sup>

**Immediate and medium-term next steps:**

- Guidance and studies to support optimal price setting
- Engaging with farmers to raise awareness

**Key stakeholders for implementation:**

- The **REB** can issue guidance on pricing while **SREDA** engages with farmers

### 3.3.4 Reduce investment and maintenance costs, including improving the operating cost environment and technical standards

**Project developers identify that the high costs of operating equipment whilst in the process of gaining experience with the technology can be an important investment barrier.** In particular, the costs of operating the pumps has proved high, with additional costs associated with requiring both security against theft of the components and additional SIP operators. A review of the operating experience of project developers across the existing 1,000 pumps would help understand cost drivers and where operating costs can be better managed and brought down.

**Immediate and medium-term next steps:**

- Carry out a review of the operating experience of project developers across pumps to identify opportunities to cut costs

**Key stakeholders for implementation:**

- **SREDA** can undertake detailed review of costs across existing pumps

### 3.3.5 Overview of the shortlist of IMM for SIPs


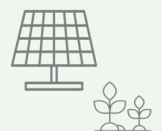


**Figure 13 sets out the IMM shortlist, along with the immediate next steps and main stakeholders to undertake these.** This provides a summary of the IMM presented in the sections above.

<sup>21</sup> <https://www.reeep.org/projects/solar-powered-irrigation-kenya-sunculture>



Figure 13. **Four shortlisted IMMs to mobilise finance for solar irrigation were identified**

Source: Vivid Economics

| Implementation measure  | Barrier addressed  | Immediate and medium term steps  | Long term goal   | Stakeholder responsible   |  |
|---|--|--|--|---|--|
|    | <b>develop policy on sale of surplus power from SIPs to grid</b>       | <b>seasonality of demand</b> - high utilisation of pumps in <i>BORO</i> season, but some idle capacity of the year | carry out technical and feasibility studies on the potential for connecting solar irrigation pumps to the grid<br><br>developing cost and pricing strategies | effectively mitigate risk from seasonality of demand and increase project returns   | <b>SREDA</b> , in collaboration with the <b>REB</b>                                  |
|    | <b>training and awareness of alternative use of panels and pumps</b>   | <b>seasonality of demand</b> - high utilisation of pumps in <i>BORO</i> season, but some idle capacity of the year | design and implement capacity building and training strategies for farmers and SIP project developers  | using the panels and land around the pump to generate revenue from alternative activities                                   | project developers with guidelines developed by <b>SREDA</b> and the <b>BADC</b>     |
|    | <b>flexible pricing in the initial seasons of implementing the SIP</b> | <b>low uptake of pumps</b> – in terms of customer connection and full hectare coverage                             | guidance and studies to support optimal price setting<br><br>engaging with farmers to raise awareness  | improving customer acquisition in the initial year of operation through lower and flexible pricing                          | the <b>REB</b> to issue guidance on pricing whilst <b>SREDA</b> engages with farmers |
|  | <b>reduce replacement and maintenance costs</b>                        | <b>higher costs than expected</b> – both in replacement costs and particularly in operating costs                  | carry out a review of the operating and replacement experience of project developers across pumps to identify opportunities to cut costs                     | reducing costs associated with the operating environment and replacement costs while gaining experience with the technology | <b>SREDA</b> to commission detailed studies on costs                                 |

### 3.4 Next steps for implementation of priority IMM -- sale of surplus power from SIPs to main grid

Project sponsors consistently identify selling surplus power from SIPs at times when they are not fully utilised for irrigation as a major opportunity to boost the attractiveness of investing in SIPs. This section explains the rationale for such a policy, and sets out the considerations and steps that would need to be undertaken to operationalise such a policy:

- [Section 3.4.1](#) summarises the rationale for enabling sale of surplus power to the main grid;
- [Section 3.4.2](#) discusses technical requirements and cost of connecting to the grid;
- [Section 3.4.3](#) describes pricing and purchasing arrangements once the pumps are connected; and
- [Section 3.4.4](#) sets out a roadmap of the three key next steps to develop a policy framework to enable sale of surplus power to the main grid.

#### 3.4.1 Importance of regulatory and policy framework for selling power from SIPs to main grid

A major challenge consistently highlighted by project developers in achieving commercially viable financial returns is seasonal demand for irrigation. Unlike many other settings in which solar pumps have



been deployed at scale (e.g. areas in Sub-Saharan Africa), the crop seasons in Bangladesh mean that there is high irrigation demand during the BORO growing season from January to April but demand for irrigation is much lower for the rest of the year. SIPs are therefore designed to a capacity to meet the BORO irrigation requirements, but then very lowly utilised in the remaining months of the year. SIP are achieving lower levels of revenue relative to what they could achieve if they were operating at capacity throughout the rest of the year. Additionally, they face a high risk of losing an important proportion of annual revenue if they were to face issues during the BORO growing season.

**Low use across most of the year means that either (i) the cost of the investment has to be fully recovered over the (below capacity) time which the pump is used for irrigation, or (ii) alternative ways to generate revenue when the pump is not used for irrigation need to be developed.** The former would require raising the price of irrigation per hectare in the months when the pumps are used. However, there is no evidence to suggest that farmers could support higher tariffs – indeed encouraging farmers to maximise usage of the pumps under the existing tariffs has been a challenge.

**Selling surplus power from the solar panels when the SIPs are not used for irrigation represents a good opportunity to maximise utilisation of the asset and recover investment costs.** If project developers can sell power generated from the panels to the grid when farmers do not need it for irrigation, revenues can increase and risks will fall. This would build on the recently developed net metering policy that enables the sale of power generated from rooftop solar panels, as a credit against bills to the utility company.<sup>22</sup>

### 3.4.2 Costs and technical requirements for connection

**Connecting a solar pump to the grid involves costs that will depend on distance between the main grid and the solar pump.** The further away from the grid, the higher the cost of extending a connection. Traditionally, when electric pumps seek a connection to the grid, the project owner is responsible for executing and covering the costs of connection.<sup>23</sup>

**Given the fixed costs associated with grid connection, project developers may need to develop aggregation models.** Pooling generating capacity to make up a larger single generating asset would allow the costs of connection to the grid to be spread across multiple pumps.

**The cost of connection to the grid will also depend on how compatible the pump technology is with the grid.** For an independent generator to be able to safely inject power into the grid, the generating technology must meet certain technical conditions. SREDA is currently undertaking a study on the technical requirements to connect SIPs to the main grid. Depending on the results of this study, SREDA can develop pilots to increase understanding of the cost implications of grid connection.

<sup>22</sup> Available from SREDA website at [http://www.sreda.gov.bd/d3pbs\\_uploads/files/Guidelines%20for%20NEM%20in%20Bangladesh%20\(Final%20with%20Edit%20Protection\)%2028%20July%2018%20\(1\).pdf](http://www.sreda.gov.bd/d3pbs_uploads/files/Guidelines%20for%20NEM%20in%20Bangladesh%20(Final%20with%20Edit%20Protection)%2028%20July%2018%20(1).pdf)

<sup>23</sup> ADB (2015). “Bangladesh: Solar PV Pumps for Agricultural Irrigation”



### 3.4.3 Pricing and power purchase arrangements

**The current net metering guidelines in Bangladesh are unlikely to enable sale of power from SIPs, as they do not allow for the utility to be a ‘net purchaser’ of power from the pumps.** Utilities are unlikely to be selling power from the grid to the SIP against which the SIP’s surplus power can be offset. This may mean that SIP developers need to be treated as independent power generators, which will require defining the terms of the contract, including the price, and whether or not the utility is obliged to purchase any available power – for example under a PPA.

**The pricing and operational codes to allow for sale to the grid will also need to be defined by SREDA and the REB and Power Division.** Prices should take into account the contribution of the panels to renewable energy targets, and could be offered at the same tariff as those for utility scale solar (currently around 12 cents per kWh). Alternatively, they could be defined on a site-by-site basis, although this would raise the cost of administration of the policy.

### 3.4.4 Steps to be taken to develop policy and regulatory framework for arrival of the national grid

**Various steps will need to be taken to operationalise a policy and regulatory framework for selling surplus power generated by SIP to the grid.** These are set out in Table 5.

*Table 5. Roadmap to implement policy and regulation for SMG operations when the national grid arrives*

| Step   | Description  | Current status in Bangladesh  |
|--|--|---|
| 1. Study of technical and economic feasibility of connecting SIPs to main grid | <p>SREDA should undertake a study to set out the technical requirements for connecting SIPs to the grid. This should include both a detailed assessment of the technical options for connection, and the potential range of economic costs.</p> <p>The study should also consider the key factors that will determine the cost-effectiveness of connection of pumps at different types of site, including the size of the pump, and the distance from existing grid infrastructure.</p> <p>Study to be completed by <a href="#">SREDA</a>.</p> | <p>The Power Division completed a draft net-metering study looking at both the technical and financial feasibility of connection.</p> <p>This should be finalised, and extended. A follow on to this initial study should include pricing options for connection fees, and consideration of who should bear these costs (i.e. the grid, or the pump owner) – see connection cost study below.</p> |



| Step  | Description   | Current status in Bangladesh   |
|---|---|--|
| 2. Connection cost policy should be developed | <p>A policy will need to be developed to determine who bears the cost of connection to the grid, once the technical feasibility of connection has been established.</p> <p>This will need to consider whether a single connection cost will be defined, or whether the cost of connection will be determined on a site-by-site basis.</p> <p>Study to be completed by <a href="#">SREDA</a>.</p>  | Connection cost study to follow on completion of the technical and financial study above.  |
| 3. Pricing and contractual arrangements       | <p>The current net metering policy does not allow for the sale of power to the main grid from distributed energy sources that are not current customers of the utility.</p> <p>Determining if the utility has an obligation to buy all power generated from SIPs once they are connected, and under what terms is key.</p> <p>This will need to be undertaken by <a href="#">SREDA</a> and <a href="#">REB</a> and/or <a href="#">Power Division</a>.</p> | <p>Net metering policy has been in place since July 2018.</p> <p>Utility scale solar generation works with PPAs defining the commitment of the utility to purchase power, and the unit tariff per kWh.</p> |

Source: Vivid Economics



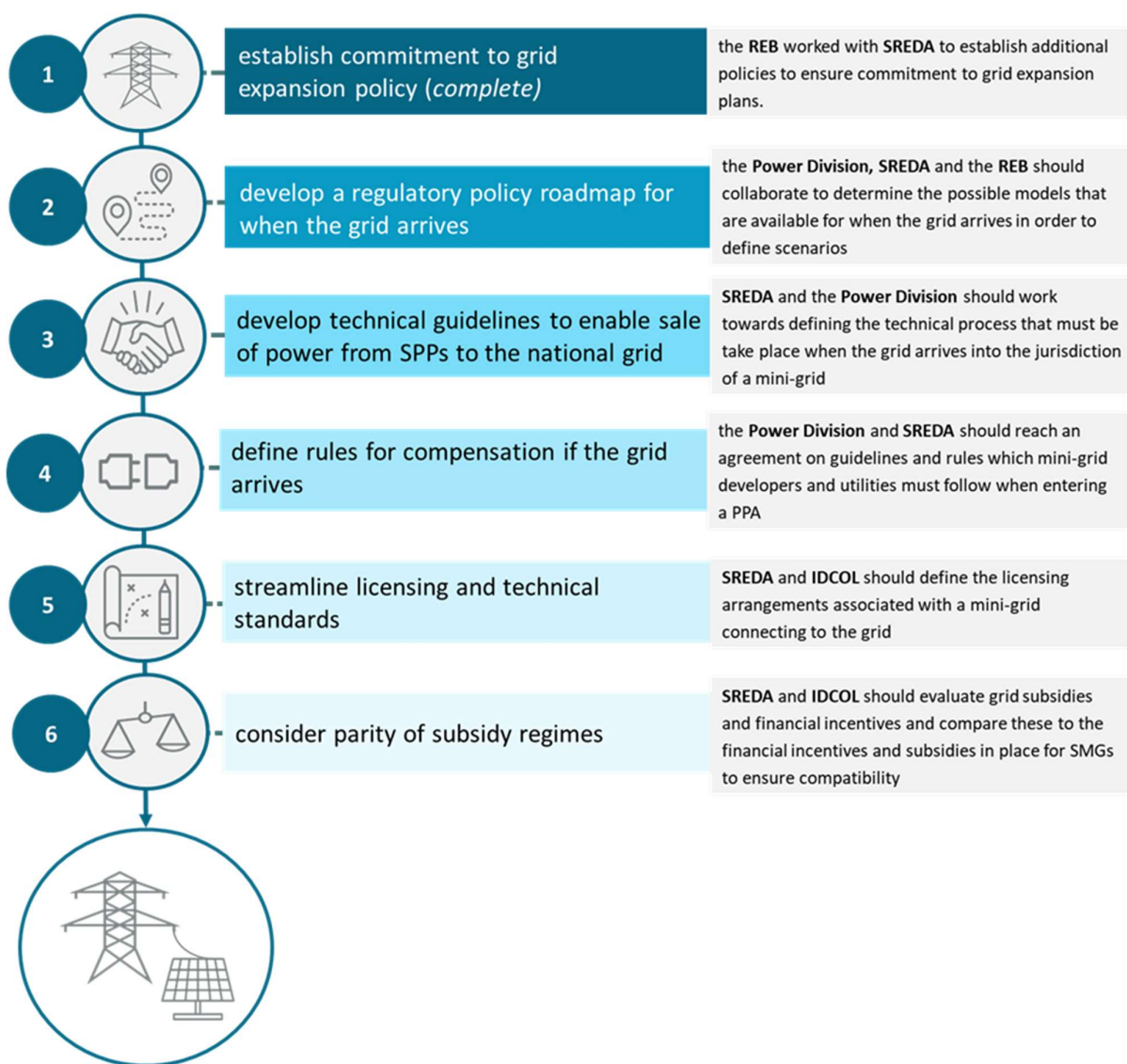
## 4 Conclusion

**Section 2.3 and Section 3.3 set out a range of investment mobilisation measures to scale up public and private finance have been developed for both solar mini-grids and solar irrigation.**

**This concluding section lays out a sequenced work plan to implement each of the priority IMMs.** These two IMMs were selected on the basis of being (1) impactful on attracting investment, and (2) feasible to implement in the near term. Figure 14 describes the next steps to put in place a clear policy and regulatory framework for if the national grid arrives to a region served by a mini-grid within the life of the asset. Figure 15 sets out the steps to put in place a policy for sale of surplus power from solar irrigation pumps to the main grid, out of the main *BORO* irrigation season.

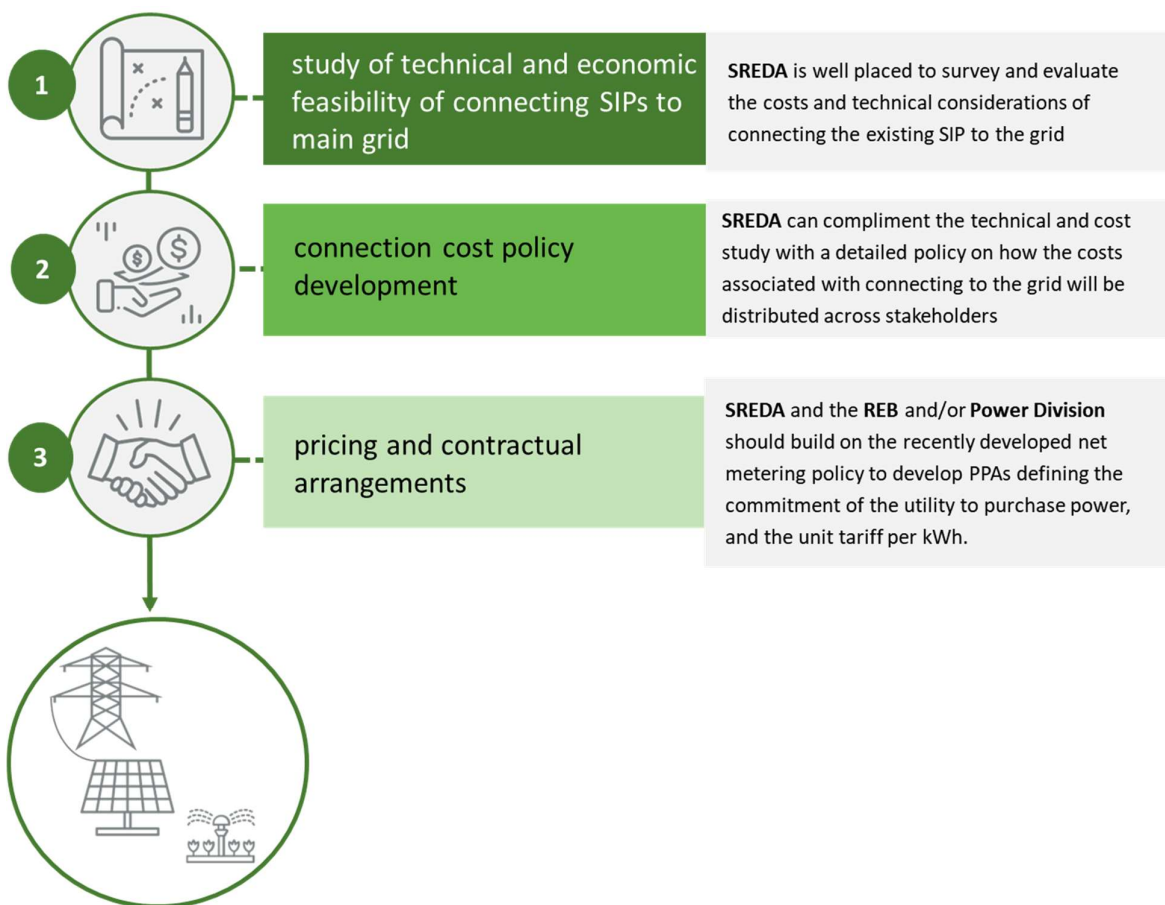


Figure 14. Implementation roadmap to provide regulatory protection for SMGs where the grid arrives



Source: Vivid Economics

Figure 15. Implementation roadmap to enable SIPs to sell surplus power to the grid



Source: Vivid Economics



Federal Ministry  
for the Environment, Nature Conservation  
and Nuclear Safety

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