Switching On:
Cambodia's Path to Sustainable Energy Security

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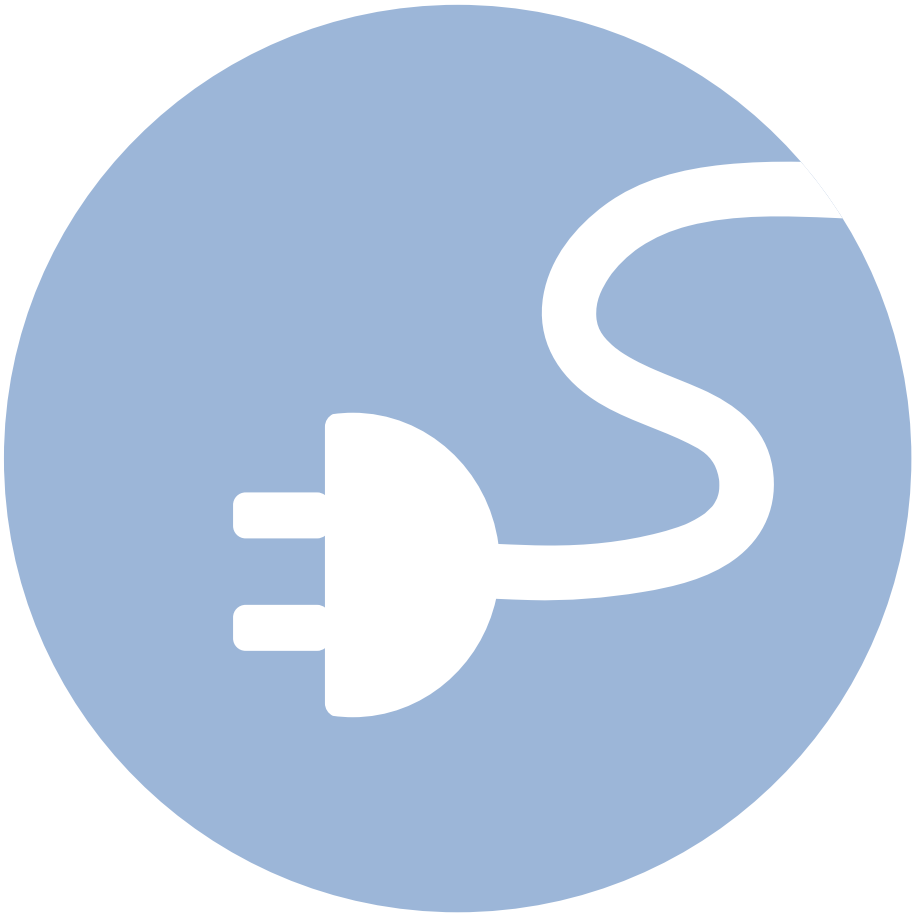

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Executive Summary

This report investigates the potential for Cambodia to diversify its power supply technology mix, for greater energy security and sustainability benefits, given changing technology cost relativities. To date almost all Cambodian investment in the power sector has focused on largescale hydropower and coal-fired generation. The Royal Government of Cambodia (RGC) has indicated investing in sustainable energy is a priority [1]: recent technology cost developments mean the RGC can pursue energy security, access, reliability and affordability goals, at least in part, through increased investment in (non-large hydropower) renewable energy.

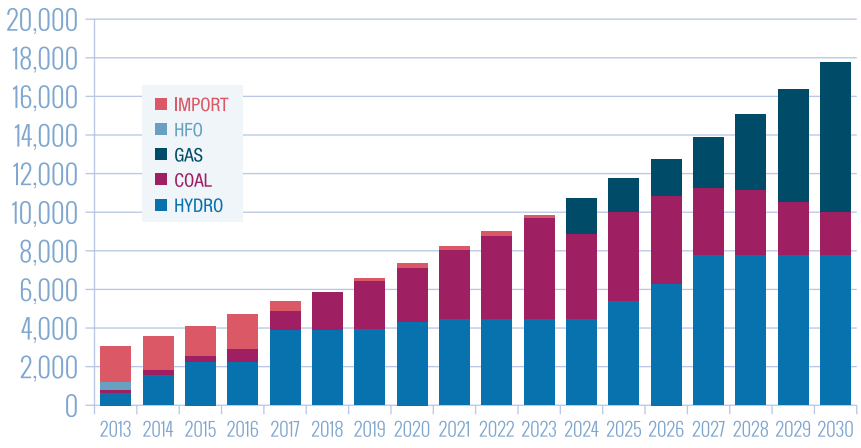
Cambodian power sector – context

The power sector in Cambodia, with domestic generation supply of around 3000 gigawatt hours (GWh) in 2015, is small compared with its ASEAN neighbours Thailand and Vietnam, but it is growing very rapidly. Generation capacity increased from 308MW in 2009 to 1584MW at end-2014, [2] accompanied by significant construction of a national grid network. This has contributed to the RGC making steady progress towards its overarching electricity access targets (100% of villages to be electrified by 2020 and 70% of households by 2030). Electricity consumption in Cambodia has also been growing very rapidly – with overall demand growth averaging nearly 20% per annum since 2010. This has largely been due to continuing rapid economic growth, notably in the electricity-intensive garment sector, and the extension of the national grid to more of Cambodia's population.

From 2018, the Ministry of Mines and Energy (MME) expects (Figure 1) power imports to have been reduced significantly as a proportion of electricity supply and to be able to meet demand almost entirely through domestic generation. MME demand projections are, however, based on a lower demand growth rate than has been evident since 2010.

Part of achieving lower demand growth will be implementing Cambodia's draft energy efficiency strategy [3], involving a range of actions including to introduce performance standards for the construction sector, industrial equipment and home appliances. If demand does not fall as rapidly as anticipated there may still be a need for additional electricity supply (potentially 1000 gigawatthours (GWh)) beyond MME's expected domestic generation supply in 2020 (around 7600 GWh).

FIGURE 1:
RGC forecast to 2030 for electricity supply (in GWhrs) by fuel mix type



Source: MME, September, 2015

While RGC has indicated that growing the power sector in an environmentally sustainable way is a key priority, to date investment in (non-large hydro) RE has yielded generation capacity in the order of 35 MW, compared with over 1200 MW put in place under Cambodia's Power Development Plan (PDP) since 2009. RGC planning for future investment in generation capacity currently remains focused on large hydropower and fossil fuel-fired technologies – which have considerable environmental impacts (and therefore external costs). Cambodia's PDP forecasts (to 2030, Fig.1) do not currently factor in any significant contribution from (non-large hydro) RE generation even though solar and biomass generation can offset low hydropower output in dry season. Rapidly falling renewable energy technology costs mean Cambodia can cost-effectively strengthen its energy security by balancing proposed investment in large-scale hydro and fossil generation with accelerated investment in solar and biomass technologies.

Global energy transition: dynamics and opportunities

Utilities, consumers and investors in developed and developing countries are switching to renewable energy to constrain environmental impacts and reduce the regulatory risk of emissions limits and carbon pricing but also because it is increasingly economic in its own right. Increasing scale is a driver of rapid declines in cost: globally, the installation cost (averaged) of wind and solar fell 28% from 2011 to 2014.

In particular, the following prices for utility scale solar and wind generation, achieved in Chile and China in 2015, were competitive against all fossil fuel and large hydro technology bids:

Costs are expected to continue falling in coming years due to increasing economies of scale, more efficient designs, and advances in materials and manufacturing. Technological

FIGURE 2:
2015 wind and solar costs [4]

Utility solar (global)	Wind 100 MW (China)	Overnight solar (Chile)	Wind (Chile)
6-8 ¢/kWh	4.5 ¢/kWh	9.7 ¢/kWh	7.8-9.5 ¢/kWh

developments such as affordable residential-scale storage devices will also increase the utility (and therefore competitiveness) of rooftop solar. The falling cost of consumer solar and storage raises the prospect of consumers disconnecting from the grid or using the grid for backup. As costs fall and incomes rise Cambodian households and businesses are also likely to become power producers within the next decade.

Rapid growth in renewable energy suggests that transition away from fossil fuels is under way. In 2014, global solar and wind annual installations set a record of 95 GW, almost half of all new generation worldwide. Established business models are now in question, after European utilities, mostly using coal and gas, lost $600 billion in value

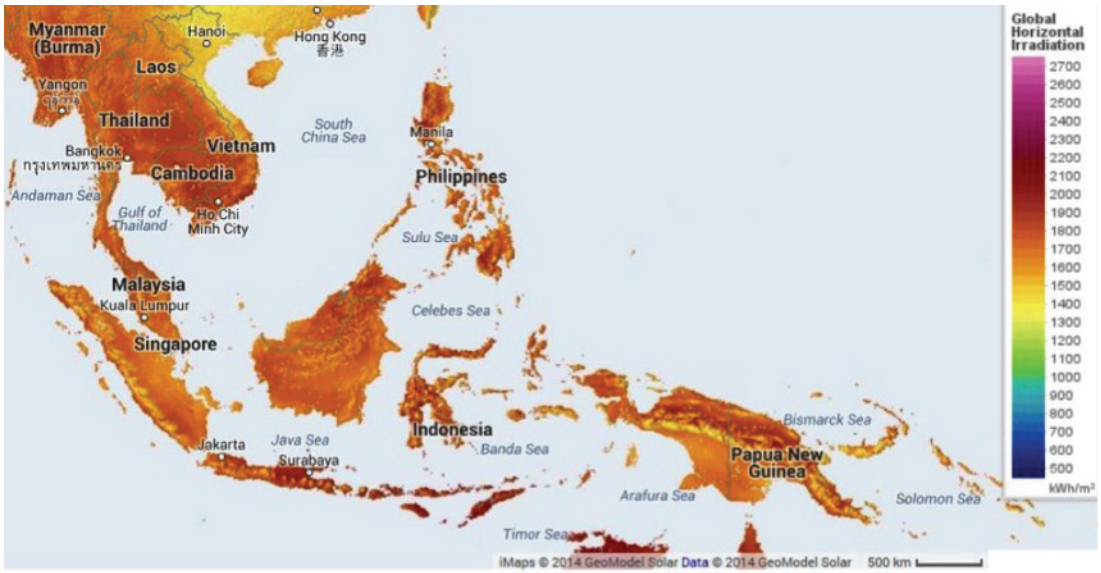
in the five years to 2014 [5]. Forecasts for power sector business growth suggest declining revenues and asset values for fossil fuel technologies (although current low international prices may moderate this trend somewhat) and growth opportunities for alternative generation.

While these dynamics clearly point to risk for Cambodia in continuing to invest in large-scale hydro and fossil fuel generation, there are also significant opportunities for accessing support for renewable generation uptake. Developed countries at COP21 reaffirmed their previous commitment to $100 billion per annum climate finance assistance to developing countries by 2020 as a baseline for possible increases post-2020. Development partners will likely make available increased technical assistance, grants and concessional loans to support diffusion of decarbonization technologies and practices. Capital will flow if policy and regulation are clear, simple and stable, putting in place a coherent framework for planning and investment.

Power sector market dynamics in Cambodia

Cambodia has very considerable potential for the uptake of distributed renewable generation. A recent ADB report [6]

FIGURE 3:
Regional solar irradiance profile



Source: Mott MacDonald presentation to Asia Solar Energy Forum, June 2015

found that very significant quantities of solar and biomass generation could be economically viable in Cambodia. It certainly has one of the best solar resources amongst ASEAN countries (Figure 3).

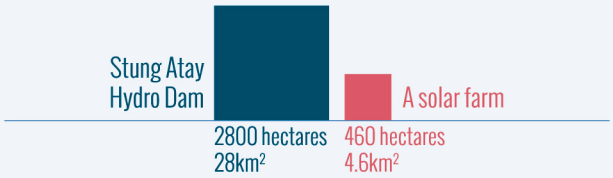
In Cambodia, large-scale hydro and coal-fired generation plants currently provide power for between 8 and 11 cents/kWh (taking into account transmission and distribution losses of 7-8% to get the electricity to Phnom Penh). Solar installations above 1MW (industrial facility scale) currently represent the most competitively priced alternative renewable energy technology as they can now provide electricity profitably for as low as 12 cents/kWh (or 10c per kWh if 20% grant funding is available) [7].

In addition to being close to par on price, solar (and other distributed technologies) also has benefits for electricity reliability which contribute to making renewable energy cost-effective compared with large hydro and coal-fired generation. Significant uptake of distributed generation would help meet daytime demand peaks (reducing the need for additional central generation and for consequent further investment in network upgrades) and boost supply during the hot/dry season when hydropower output is much lower. Daytime distributed generation is also complementary with using existing large hydroelectric power less during the day and more for evening peaks. In addition, utility-scale solar generation does not involve a significant land footprint (Figure 4) and can be constructed and put in operation more rapidly than hydropower or coal-fired generation. Cambodia could add 1,000 GWh to its generating output by constructing 700MW of utility scale solar on 1400 hectares of land (Figure 5). 1,000 GWh (additional to planned PDP generation), would mean the RGC's goal for achieving electricity self-sufficiency could be achieved in 2017.

Very large-scale central power generation involves significant external costs. Coal-fired power involves significant health impacts from particulate pollution and is highly carbon-intensive. In the US, the external costs have been estimated as being equivalent to an additional 18c/kWhr [8]. While nuclear generation at scale can appear cost-effective (if the potentially massive external costs of reactor breakdown are excluded) new safeguards to decrease further the likelihood of catastrophic events plus the full-costs of decommissioning will likely drive up costs (new nuclear in the UK is likely to be in the order of 13c per KWhr) [9]. Hydropower externalities are a matter for both national and regional consideration.

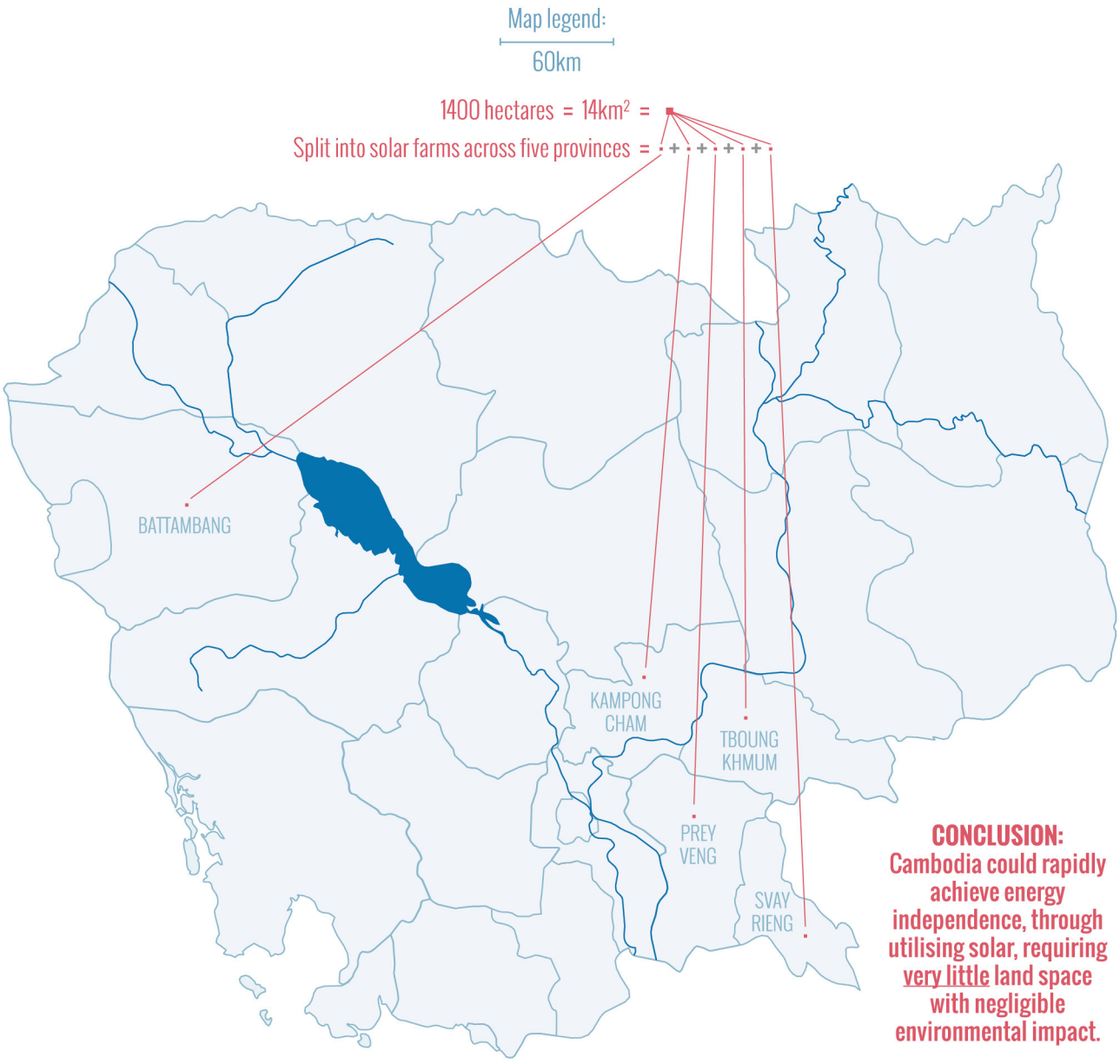
In Cambodia, solar installations above 1MW can now provide electricity profitably for as low as 12 cents/kWh.

FIGURE 4:
Total land space required to generate 327 GW Hours



(Above graphic compares land spaces relatively. Not to scale of below map.)

FIGURE 5:
Land space required to generate 1,000 gigawatt hours of electricity from solar PV by 2020



CONCLUSION:
Cambodia could rapidly achieve energy independence, through utilising solar, requiring very little land space with negligible environmental impact.

Greater Mekong energy policy and development

Gains in electricity supply from hydropower projects must be considered against local and broader impacts. In addition to large dam reservoirs increasingly being assessed as involving significant greenhouse gas (methane) emissions, there are risks for fisheries, farming and food security in Cambodia and Vietnam because multiple upstream hydropower dams disturb flood cycles, nutrient flows, sediment transport and migratory fish breeding. A recent Mekong River Commission study found that 11 hydropower dams under development in the Mekong River basin would reduce fish biomass by around 50% if all were in operation [10]. Farmers and fishers downstream would face declining yields and incomes, putting at risk Mekong delta food exports worth $10 billion annually. Transboundary impacts such as these have already raised considerable tensions between GMS countries. It may be possible that large hydropower projects can generate net benefits but it is important for countries to carefully assess all costs and benefits, including transboundary impacts (and possible compensatory payments) and the effects of climate change over time (which will exacerbate impacts).

GMS countries have made enhanced power trading across the region a policy objective, as this is expected to drive considerable economic benefits from economies of scale and drawing on the comparative advantage of economies' differing resource profiles. The volume of large hydro and thermal power projects currently under development raises questions, however, of regional saturation: not all proposed projects will prove viable if GMS supply outstrips forecast regional grid demand (which may well be lower than expected due to improving energy efficiency and widescale uptake of distributed generation and storage). This adds a further layer of risk around large hydro and fossil fuel generation.

Thailand, Vietnam and Laos have adopted non-large hydro renewable energy technology targets, in part to hedge against risk. Cambodia should also consider scaling up RE investment to hedge against these risks, including by adopting RE targets.

Barriers to uptake of distributed renewable energy generation

Current RGC actions to bring forward completion of its national grid to 2018 mean there are opportunities for significantly scaling up ongrid distributed generation, particularly from rooftop solar. Also, around 820,000 (30%) of Cambodian households are currently not scheduled to have access to the grid until 2030 at the earliest. There is considerable scope

Cambodia should adopt (non-large hydropower) renewable energy targets, as Thailand and Vietnam have done.

for accelerating existing rollout of solar home systems (SHSs) to provide them with earlier, affordable electricity access.

Although uptake of distributed RE in Cambodia has to date been on a small scale, the lessons learned from the programs already implemented are valuable in considering the scope for scaling up RE going forward. Key constraints holding back RE investment include:

Lack of an RGC renewable energy/ generation target: adoption of a target and a suite of policies to support their uptake is needed to give Cambodian and international private sector investors (as well as climate finance sources) confidence to invest at significant levels.

The ongrid RE regulatory environment is unclear: industry, commercial businesses and households have been deterred from investing by the lack of formal regulations around provision of distributed electricity to the grid. There has also been a lack of clarity in relation to utility scale solar generation where the rules for applying for tenders for additional supply under the power development plan are not widely understood.

Lack of fair value paid for excess generation sent to grid: an approach is needed that recognises the value of additional daytime electricity supplied close to the point of consumption. Initially, RGC could extend existing ad hoc net metering arrangements (customers are charged, over a billing period, for their consumption less any excess electricity sent out to the grid) to all distributed generation facilities. Net metering could then transition to 'fair value tariffs' (payment for electricity sent to grid at a rate to be determined, but likely between EDC's substation and retail rates). Such tariffs would require upgrading of metering facilities and capacity building in RGC power sector administration.

Access to finance: Cambodian banks have to date been cautious about investing in non-large hydro renewable energy: a revolving fund able to support concessional loans focused on distributed RE uptake, backed by development partner finance in partnership with the Cambodian banking sector, would help overcome up-front capital barriers.

Taxation issues: solar panels and equipment are still subject to VAT but suppliers are unable to pass on this charge to end-consumers, as is the case for most goods and services, given electricity purchases (usually from EDC) are VAT-exempt. Sustainable energy equipment generally does not attract import duties but a 7% duty still applies to solar equipment.

Developing a coherent vision for renewable energy uptake and putting in place a regulatory environment to support it will bolster energy security.

Support for uptake of distributed renewable energy generation

There is considerable international finance sector interest in looking for 'bankable' renewable energy projects in the Greater Mekong Subregion. As global emissions reduction ambition increases following COP21 in Paris there will likely be increasing incentives for developing countries, such as Cambodia, where energy infrastructure is still developing rapidly, to consider even more ambitious pathways towards very low carbon generation signatures in coming decades. Bilateral development partners and international funds, such as UNFCCC's Green Climate Fund, the multilateral development banks' Climate Investment Fund and the Global Environment Fund are all looking to leverage private sector investment to accelerate uptake of renewable energy. Projects will, however, be more readily considered 'bankable' where there is a clear policy and regulatory framework in place that will support uptake of renewable energy.

Development partners could support RGC to establish such an enabling environment by supporting the administration to address the key constraints identified above as well as supporting capacity building involving the following elements:

- education and training of MME, EAC and EDC staff in relation to managing:
  - a range of technologies, including RE, as part of electricity supply;
  - net metering and 'fair value' tariffs;
- upgrading existing grid management to include 'smart grid' monitoring/ management technologies;
- installation and maintenance standards to ensure performance and safety of RE equipment; and
- enhanced secondary and tertiary vocational training to address growing skills needs.

RGC officials have indicated on an informal basis that the RGC could consider looking to scale up RE, particularly solar, to 10% of 2015 peak demand capacity (around 100 megawatts) but have expressed concerns that Cambodia's power sector cannot accommodate significantly more than this level. Consistent with other developing countries having indicated ambitions for renewable energy uptake considerably higher than 10% of supply/ demand (eg India, Uruguay, Thailand), analysis and stakeholder discussions suggest RGC could readily achieve a target of around 150 MW using only rooftop solar for factories, offices and households, even before considering the potential contribution of biomass and other generation. If significant climate finance is available to support the capacity building package identified, then higher targets could be considered (see box).

To move towards a more diversified, more secure and more reliable power supply Cambodia should drive significantly enhanced RE uptake.

Potential targets for scaling up sustainable power generation

Officials have indicated informally that RGC could consider looking to scale up RE, particularly solar, to 10% of 2015 peak demand capacity (around 100 megawatts). A more ambitious target would be one representing 10% of RGC's anticipated peak demand in 2020 (1556 MW) – this would represent building from around 35 MW currently operating RE to 156 MW in 2020.

Cambodia could also, however, set a longer term target for 2025, of 10% of electricity supply (in gigawatt hours (GWh) sent out). On MME's current forecast for 2025 (12,000 GWh, Fig 1) that would represent 1,200 GWh, requiring 850MW solar generation capacity (if solar alone were used). In this case it would make sense for the 2020 target to be in the order of 350MW to come from RE. Pursuing such a target would enable RGC to defer plans for 220MW of the additional 530MW of coal-fired generation being considered for development by 2025. Pursuing a 20% target (2400 GWh), together with robust action on energy efficiency would mean there would be no need for additional coal-fired generation to 2025.

NEXT STEPS: Key steps for RGC to consider

Developing a coherent vision for putting Cambodia on a low-carbon development path, as well as designing a policy/regulatory environment to support such a transition will: bolster Cambodia's energy security and economic competitiveness; hedge against potential stranding of assets in a fluid technology cost environment; and enhance Cambodia's capacity to attract further climate finance. Some key potential steps towards these goals are set out below.

1. Adopt an interim renewable energy generation target for Cambodia, given contemporary pricing – pending establishing a target for 2025, based on detailed study of what would constitute a cost-effective but ambitious level of RE to integrate into the power mix. The study should take account of the external costs associated with large hydro and coal-fired electricity generation. Possible interim targets include:
   - 100MW before 2020 (representing 10% of peak demand in 2015 of around 1000MW)
   - 156MW in 2020 (representing 10% of peak demand in MME's low case (+20% reserve margin) forecast for 2020)
2. Clarify the regulatory environment regarding renewable energy for Cambodian and foreign investors, as well as development partners looking to leverage private sector investment flows.

- Formally recognise in law the right of onsite generation, notably rooftop solar, to supply electricity for own use and to supply excess electricity to the national or local grid.
  - > Establish, in 2017, appropriate 'fair value tariffs' (per kWh) for electricity sent out - following a detailed study of the value sustainable generation close to the point of consumption represents.
  - > Pending establishment of specific fair value tariff rates as above, a 'net metering' approach, similar to that proposed by the Solar Energy Association of Cambodia to MME in 2015, should apply (whereby usage over a billing period reflects consumption from the grid minus electricity sent out).

3. Develop a concept note to seek international development support to assess the scope for an incentive scheme that will help close the gap between the cost of non-large hydro renewable energy and other generation technologies and to establish a concessional loan rolling fund which could address initial capital barriers and support RE uptake.
4. Further develop a proposal for development assistance to assist RGC with implementing an enabling environment, involving:
   - education and training of RGC energy agency staff in relation to managing:
     - > a range of technologies, including RE, as part of electricity supply;
     - > net metering as a stepping stone to fair value tariffs;
   - upgrade of existing grid management technology to include appropriate RE 'smart grid' monitoring/management technologies;
   - installation standards to ensure performance and safety of RE equipment;
   - enhanced vocational training to address growing skills needs; and
   - consideration of fiscal instruments, such as a carbon tax, with revenue required to address the environmental impacts of fossil fuel generation.
5. Consider removing VAT and import duty from solar generation equipment, consistent with decisions to support sustainable energy by exempting sustainable biomass energy products from VAT, and also recognising that purchasers of solar equipment cannot pass on VAT costs as part of electricity prices.

Endnotes

Executive Summary

1. National Strategic Development Plan (NSDP 2014-18, p.47), Cambodian Climate Change Strategic Plan (2013), National Green Growth Policy (2013) and Intended Nationally Determined Contribution (INDC, prepared for the UN Framework Convention on Climate Change COP21).

2. Electricite du Cambodge Annual Report 2014, p.16. Does not include off-grid generation.

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Notes