ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

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IKI INTERNATIONAL CLIMATE INITIATIVE

solutionsgateway Climate, Energy, and Finance Solutions

100% RENEWABLES SOLUTIONS PACKAGE

Energy storage for distributed solar PV systems

This solution is part of a package of solutions meant to guide local and regional governments in implementing a local renewable energy transition by providing guidance on mechanisms, applications or technologies that can help accelerate their climate and energy action.

It was produced as part of the 100% Renewables Cities and Regions Roadmap project, which supports nine cities and regions across Argentina, Indonesia and Kenya to develop bankable renewable energy projects and in-depth local strategy and action plans to achieve one hundred percent renewable energy. The 100% Renewables Cities and Regions Roadmap project is implemented by ICLEI – Local Governments for Sustainability and funded through the International Climate Initiative (IKI), which is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA).

DISCLAIMER

All cities are unique. The Solutions Gateway has been developed as an advanced knowledge catalogue to provide an overview of possible Low Emissions Development Solutions. The Solutions and Packages it contains provide guidance on general conditions, which may not correspond to the existing conditions in your city or jurisdiction. The consultation and use of the Solutions Gateway does not waive the need for the Local Government to assess the feasibility of a Solution or Package in the local context in its city or jurisdiction, prior to implementation. Please note that the impacts, benefits and co-benefits indicated are generally valid but may not materialize in particular circumstances.

ABOUT SOLUTIONS GATEWAY

Solutions Gateway is an online resource platform for Local Governments where they will be able to find possible Low Emissions Development (LED) Solutions for their cities. In the context of the Solutions Gateway, Solutions are processes, or groups of actions, which Local Governments can implement to deliver climate change mitigation results and enhance local sustainable development. Taking an integrated approach, and focusing on Local Governments usual responsibilities and roles, Solutions include core actions as well as enabling and multiplying actions essential to maximize their effectiveness and efficiency. These include policy, regulatory, governance, capacity building, awareness raising, stakeholder engagement, etc.

ABOUT ICLEI – LOCAL GOVERNMENTS FOR SUSTAINABILITY

ICLEI – Local Governments for Sustainability is a global network working with more than 2,500 local and regional governments committed to sustainable urban development. Active in 125+ countries, ICLEI influences sustainability policy and drives local action for low emission, nature-based, equitable, resilient and circular development. ICLEI's Members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

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1. INTRODUCTION

Energy storage refers to technologies that capture one form of energy (usually electrical) when generated and store it as another (chemical, thermal, mechanical or electrochemical) for release when required [1]. Storage is essential for enabling the use of variable renewable energy (vRE) such as solar and wind due to its intermittent nature.

Pumped hydro currently makes up the largest installed capacity of energy storage globally with 153 GW [2] but other examples include batteries, molten salt (used with concentrated solar power), and hydrogen fuel cells, among others. Different energy and power capacities of storage can be used to manage different tasks. For example, short-term storage can enable the smooth functioning of the grid over minutes or hours, in situations where vRE producing is low, while longer-term storage can provide supply over days/weeks/months to account for seasonal variations in energy supply and demand. Storage supports system flexibility, efficiency, resilience and power quality by ensuring demand and supply is seamlessly in sync.

Local governments can enable storage for distributed vRE by establishing regulations to ensure quality storage facilities, devise investment plans, set up financing mechanisms and create awareness for all stakeholders. This can serve to expand energy access or act as a backup to unreliable electricity.

1.1 RELEVANCE

Coupled with solar, storage systems can overcome one of the main constraints of solar energy—the variability of sunlight during the day. Solar energy production can be affected by season, time of day, clouds, dust, haze, obstructions from shadows and trees, even rain, snow and dirt. Storage ensures no generation is wasted or curtailed, and that energy produced during the day can be used during peak demand periods or at night, ensuring autonomous operation (if relevant) and reliability through the day. Solar with storage can also support the reduced reliance on the grid or energy independence for residential and commercial consumers who wish to generate their own reliable, cheap and green electricity [4].

Decentralized energy storage can also enable grid services such as demand management to provide frequency regulation, and offer peak shaving [4], can help defer infrastructure costs for transmission and distribution networks or generate additional income via arbitraging.

1.2 SDGs ADDRESSED

SDG 3: Ensure healthy lives and promote well-being for all ages.

SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

SDG 11: Makes the cities and human settlement inclusive, safe, resilient, and sustainable.

SDG 12: Ensure sustainable consumption and production patterns.

SDG 13: Take urgent action to combat climate change and its impacts.

SDG17: Strengthen the means of implementation and revitalise the global partnership for sustainable development.

1.3 MAIN IMPACTS

SOCIO-ECONOMIC

- The expansion of solar-plus-storage systems can help expand access to energy in remote areas that are not always easy or feasible to connect to the grid, increasing welfare and resilience.
- Solar-plus-storage can also help provide backup power in situations where the available source of electricity is unreliable.

ENVIRONMENTAL

- Given that storage can enable the expansion of renewable energy, which is low-to-zero emissions compared to fossil fuels, it can help reduce GHG emissions from power generation and contribute to progress towards national and international climate goals.

TECHNICAL

- Electricity is a commodity that has to be used as it is generated. However, incorporating storage systems allows surplus generation to be banked for peak-use. For renewable energy-power systems in particular, energy storage allows an energy reservoir to be charged when generation is high and demand is low, and then released when generation diminishes and demand grows
- Solar-plus-storage systems can pose a challenge to the grid from a technical perspective, although still the impact to the energy system as a whole is still mostly positive. While they can reduce some of the load on the grid and even provide some grid services if technically feasible, not all grids are able to handle two-way flow, which might create issues. This can also present a challenge for network operators if there are no specified rules for usage - for example no immediate usage after a black-out, or the know-how on how to balance the energy system.
- With energy storage systems facilitating rapid development of decentralized energy systems and microgrids, the power sector begins to develop new policies and frameworks at the national and regional levels to benefit from these changes.

1.4 BENEFITS

TECHNICAL BENEFITS

- Energy storage allows for power system flexibility and frequency regulation for the grid, ensuring that demand is matched seamlessly with supply from various and intermittent generation sources.
- Using storage coupled with variable renewable energy systems stabilizes the system, ensuring a more reliable and stable power supply.
- Ensures more resilience and efficiency in the system by ensuring that energy generated is not wasted or curtailed.
- It enables the integration of cleaner renewable energy systems known to have intermittent supply thus contributing to more reliable power supply. Through the use of more renewables, storage systems also indirectly contribute to reducing greenhouse gas emissions.
- Storage systems can reduce the need to costly upgrades to the transmission and distribution network infrastructure, thus saving costs for the utility.
- Storage allows for energy trading - when generation exceeds consumption, one can sell energy to a neighbouring entity or network operator. Businesses can also choose to buy and supplement their supply with 'green energy' from energy storage systems.

ECONOMIC BENEFITS

- Expanded access to energy can also enable various productive uses, especially for small businesses. In addition, the proliferation of this technology can also create jobs through the associate value chain.
- Energy storage supports sector-coupling and the electrification of other sectors that can boost economic growth., e.g. e-mobility, industry, etc.
- Households with storage systems, in addition to a backup to unreliable power, have the flexibility to use electricity and charge their storage systems when tariffs are low, and then switch to the storage systems when the tariffs are higher and enable cost savings. It could also provide additional income for homeowners as they can feed back extra electricity into the grid (although this depends on the specific tariff mechanisms that allow this).
- Energy storage is a viable, proven technology with a good return on investment. It supports higher levels of self-consumption which makes the business case for solar stronger. It can further offer grid independence or reduce reliance on the grid for electricity.
- Lower electrical bills due to lower-cost generation and using less from the grid.
- Allows for citizen participation in the energy market through being prosumers who can sell excess energy back to the grid (feed-in tariff mechanisms), or offset grid supply costs (net metering).

SOCIAL BENIFITS

- Distributed energy, enabled through small-scale storage technologies, can enable electrification in remote areas, thereby improving access to modern technologies.
- Increased resilience by providing a backup source of energy that can provide power during load shedding or power cuts, and can in some cases operate as an island.
- Improved health of communities due to lower lifecycle greenhouse gas emissions, and pollutants from green energy technology. Energy-plus-storage systems often replace diesel generators in off-grid backup applications, and so their benefits are magnified.
- Stored energy can enable the use of lighting, ventilation and related electrical appliances at night, which can expand the possibility of productive uses and improve socio-economic outcomes.
- The creation of a local supply chain can improve socio-economic outcomes by providing local jobs and training.
- Access to modern energy through solar power and storage can reduce dependence on traditional labour-intensive fuels such as biomass.

ENVIRONMENTAL AND CLIMATE IMPACTS

- Lower lifecycle greenhouse gas emissions and effluents from solar energy and storage compared to other traditional forms of energy production.
- Contributes to the reduction in CO_2 and other greenhouse gas emissions.
- Reduced noise pollution compared to other distributed sources, e.g. diesel generators.

1.5 SUGGESTED INDICATORS FOR MONITORING RESULTS

- Electricity generated from distributed systems (kWh/year).
- Number of jobs created in the solar-plus-storage value chain (number/year).
- Number of households or business with energy storage solutions (number of customers per year).
- Number of commercial and industrial (C&I) scale renewable energy power plants with storage systems (number per year).
- Amount of energy generated from commercial and industry scale RE power plants (MW/h).
- Reduction in the local government's greenhouse gas (GHG) emissions attributed to distributed energy and storage systems (tCO_2e/year).
- Improved energy reliability (number of power cuts per month/year, total blackout hours per month/year; SAIDI; SAIFI).

1.6 TYPICAL LOCAL GOVERNMENT ROLES

- Planner
- Legislator or Regulator
- Coordinator
- Operator of Municipal facilities and infrastructures
- Role-model
- Mobilization and stakeholder engagement
- Education and awareness raising.

2. INTEGRATED SOLUTION OVERVIEW

	Enabler Actions	Required Actions	Multiplier Actions
Policy	• Learn from peer cities and regions to understand the opportunities and challenges posed by a proliferation of energy-plus-storage systems. • Work with national ministries to establish clear standards and procedures required to obtain a permit for installing storage systems.	• Create an internal governance structure and train staff on the technical aspects of storage in order to implement applicable policies and regulation if the city is a network operator. • Develop policies and by-laws for energy storage usage via processes/rules/standards, etc. for household usage; incentives for the uptake of storage for C&I consumers; and/or wheeling guidelines if the city is a network operator. • Develop policy to deal with solar-plus-storage systems and their end of life e.g. battery second hand usage, recovery, etc. to promote diversion from landfills and support alternate livelihoods.	• Development and promotion of incentives for utilizing energy storage systems for C&I energy system customers.
Stakeholders and Awareness	• Targeted awareness raising on the benefits and rules (if applicable) of using storage technology coupled with vRE, particularly for households and commercial businesses. • Enable pilot projects in city-owned buildings.	• Facilitate stakeholder engagement with the utilities, commercial sector and residential areas for policy-making around storage and enact any public participation processes as required.	• Cooperation with the private sector to use power from C&I energy storage facilities to support the city's electrification goals e.g. energy access to households in the vicinity, integration of e-mobility in the city, etc. • Establishment of partnerships with research institutions and the private sector to explore options for second-life applications of batteries, enhance recovery and practise safe recycling measures, etc.

	Enabler Actions	Required Actions	Multiplier Actions
Governance	• Work with the utility to offer net metering tariffs that can attract more RE prosumers (residences and C&I) to install energy storage systems. • Establish a storage technology working group with industry expertise to support the development of policies/ processes/ rules/standards for energy storage usage if the city is a network operator.	• Establish an internal working group with the relevant expertise on energy storage and renewable energies, namely technical and managerial, dedicated to the development and implementation of related policies/ processes/rules/ standards. Assign roles and responsibilities.	• The establishment of partnerships with other public administrations and institutions particularly with responsibilities and interests in the field of energy, universities, and professional associations can help to share roles, costs, and act as multiplier in the dissemination of information and awareness raising. • Working with the national government to create standards and certifications for the quality of products available in the market, and grievance redressal mechanisms.
Capacity Building	• Collaborate with partners and institutions engaged in capacity building related to energy and storage systems, particularly those certified by competent authorities.	• Train staff on the technical requirements in order to develop and implement policy and regulations on energy storage. • Promoting training and certification of solar and storage technicians in the local community.	• Establish training centers for distributed energy and storage technicians in collaboration with local institutions and NGOs as relevant.
Technical	• Map local value chain, availability of assemblers/ retailers within the city. • Pursue opportunities to support the local assembly or manufacturing of batteries as part of the city's local economic development goals. • Provide easily accessible information to the community regarding the safe operation of such systems.	• Supporting the development of local skills and training for the maintenance and servicing storage equipment. • Establishing and strengthening a local value chain for equipment production and maintenance/service. • Work with the national government and other partners to establish standards and certifications for safe installation, warranties, liabilities, etc. for suppliers/ installers. • Establish collection centers for the safe disposal of batteries and panels.	• Development of wheeling and energy trading processes. • Have in place mechanisms to quantify other impacts of storage solutions, especially large-scale ones. • Identify open available spaces that private and public stakeholders can use for large scale installations of distributed RE, and streamline processes for e.g. classify it a special economic zone.

	Enabler Actions	Required Actions	Multiplier Actions
Finance	• Creating awareness of various financing mechanisms for people to access energy storage solutions.	• Allow for creative business models e.g. subscription-based/rental, etc. and exploring other financing pathways such as public-private partnerships. Pilot projects can help trial different approaches. • Engage financing institutions to facilitate financing of energy storage systems for C&I customers.	• Incentives/subsidies and other assistance for solar-plus-storage systems, particularly for vulnerable populations who lack access to grid electricity, as well as small businesses. • Explore innovating financing options such as blended finance, pooled finance, etc.

3. WORKFLOW /PROCESS PHASES

3.1 PREPARATION

- Create working groups internally to prepare, plan and coordinate initiatives around energy storage such as the development of policies and regulations should the city be a network operator.
    - Establish external working groups with expertise on energy storage and vRE to support any internal decision-making processes.
- Train staff on technical requirements to develop and implement policy/processes and regulations on energy storage.
- Identify open available spaces that private and public stakeholders can use for large scale installations of distributed RE, and streamline processes for e.g. classify it a special economic zone.
- Investigate if the city's own assets can be used to host solar-plus-storage system, as trial cases and to develop local awareness/skills.

3.2 APPROVAL

- General political will, as well as county/municipal council approvals for the relevant policies/regulations/processes, etc. that are developed.

3.3 PROCUREMENT

- Procurement of RE and energy storage systems to support the generation of sustainable energy on city owned buildings.
    - Consideration of creative business models e.g. subscription-based/rental, etc. and exploring other financing pathways such as public-private partnerships to support the city with green energy provision.

3.4 IMPLEMENTATION

- Implementation of the relevant established policies and regulation on storage to guide customers on their usage.
- Engage financing institutions and other external partners to facilitate access to finance and investment for large scale energy storage systems.
- Set clear equipment standards and grievance redressal mechanisms to ensure quality products.
- Promote the warranty of solar equipment by the suppliers/ retailers.

3.5 MONITORING

- Monitoring framework to be developed with indicators and verification methods to ensure the good performance of the solar-plus-storage system.
- Share lessons learnt and good human impact stories to inspire other adopters of the technology.
- Ensure proper implementation by ensuring policies, guidelines, infrastructure development, financing and compliance in terms of quality and standards, with commensurate penalties for non-compliance.

4. REALITY-CHECK

This solution is applicable in both urban and rural areas , and can support local governments (including those who are network operators) and their communities with their energy access, own generation and diversification of their energy supply. It is essential for local governments to consider storage solutions alongside distributed RE to ensure a more sustainable energy system.

4.1 REQUIRED PRE-CONDITIONS

- If the local government is a network operator as well, it may be useful to conduct grid impact studies to guide the development of regulations and policies for storage usage.
- Availability of quality and affordable solar-plus-storage suppliers.
- From the customer and market perspective, enabling regulatory frameworks to allow and support energy storage.

4.2 SUCCESS FACTORS

- Energy efficiency—reduced loads can help with the overall improved functioning of a solar-plus-storage system.
- Political commitment to support an enabling framework for distributed RE and energy storage.
- Performance of energy storage systems including warranties to prove their reliability and sustainability.
- Well-trained workforce for installation, maintenance, etc. as well as standards/certifications to ensure this.
- More research and development, and market maturity to support lower costs of storage and applications of after-life usage.
- Leveraging collaboration with the private sector e.g. wheeling agreements, public-private partnerships, etc. to advance just transition goals in the city.
- End-of life strategy for storage developed and supported. Reusing existing resources, such as used EV batteries, can also be explored to reduce the cost of the system.

4.3 BARRIERS

- Lack of political will to establish customer friendly policies and regulations. However, often demand outpaces policy action, and so governments should try to get ahead of any potential issues such as unsafe installations.
- Lack of awareness of benefits to the stakeholders can be addressed through communication campaigns or partnering with NGOs etc.
- Lack of financing mechanisms for household-level systems can be addressed through partnerships with the private sector or other donors, as well as national-level assistance if available.
- Unhealthy competition from fossil fuels can be addressed by low-enough prices, and highlighting the benefits of cleaner energy sources such as solar-plus-storage.
- Poor quality of solar energy storage systems and products can be addressed through advocating for better national standards and enforcement.

4.4 RISKS

- Introduction of poor quality energy storage equipment in the market can damage trust, and so LRGs should aim to get ahead of this risk and institute policies addressing quality, safety, and skills for safe operation of such systems.
- No/poorly trained energy storage technicians, which can lead to failure/damage, etc. Inadequate skills to troubleshoot or maintain the systems. Collaborating with academic or vocational institutions and other organizations to develop these skills can help mitigate this risk.
- Slow uptake of the solution due to the associated cost. Finding ways to reduce costs for purchasers, through subsidies, awareness, or other alternatives (e.g. used EV batteries) can help mitigate this risk.

5. CLIMATE CHANGE MITIGATION POTENTIAL

Energy storage is key to maximise efforts to reduce carbon emissions, improve national energy security, create green jobs and advance the just energy transition.

6. NATIONAL – SUBNATIONAL INTEGRATION IN THE CONTEXT OF THIS SOLUTION

6.1 BENEFITS TO LOCAL GOVERNMENT

- Decentralized solutions are easier for local governments to implement, and so can make them more active participants in the energy system (which is typically quite centralized).
- Potential for attracting investment into the region.
- Contributing to national and international climate targets while addressing local socio-economic priorities.

6.2 BENEFITS TO OTHER LEVELS OF GOVERNMENT

- Allowing opportunities for pilot testing and demonstration at local level, facilitating the replication of energy storage initiatives nationally.
- Multi-level action and local contribution to national mitigation targets.
- Local contribution to reduce the national dependence on fossil fuels use.
- Establishment of relevant policies frameworks and also infrastructure which are of other economic benefits.
- Reducing the reliance on centralized and expensive electrical systems, especially in remote areas, that would require significant investment in grid expansion.

7. RESOURCES/SUPPORT

7.1 CASE STUDIES

NEIGHBOURHOOD BATTERY SYSTEM CONCEPT USING A COLLABORATIVE BUSINESS MODEL [NETHERLANDS]

Proka A., et al. 2020, When top-down meets bottom-up: Is there a collaborative business model for local energy storage?

In 2017, the Haarlemmermeer municipality, distribution system operator (DSO) Liander and Energy Service Company (ESCO) Tegenstroom joined forces to support a community in the Netherlands with a solar and battery pilot project to test a neighbourhood battery system concept. 35 residents who were renting a solar system, were offered the option to increase their self-consumption. The system consisted of 280 solar panels, 140kWh capacity batteries with a 125kW inverter, and offered the DSO to examine the interaction and impacts between the battery system and the network, as well as explore the social benefits the system offered.

While there were contrasting perspectives from residents regarding the pilot, they did find that the addition of the battery system supported their energy independence and allowed them to use more of the sustainable energy their solar system produced. They also preferred this option where the ownership of the battery and maintenance obligations lied with Liander. However, they were also concerned about how safe it was, how much space this would need and environmental impacts if it had to be scaled up, and the aesthetics of it.

As part of the lessons learnt from the network operator perspective, it was also found that the community battery concept is viable at specific locations for e.g. more community engagement and awareness raising to solicit inputs of needs, blockchain technology to increase transparency.

USING ENERGY STORAGE TO ENHANCE DISTRIBUTED RENEWABLE ENERGY TO PROVIDE ACCESS TO REMOTE COMMUNITIES [WESTERN AUSTRALIA]

Energy Storage News

In 2022, the state government of Western Australia announced that it will be leading an initiative to install a minimum of 1000 stand alone power systems in remote areas which include solar PV and battery storage over the next four years, in order to increase access to energy for communities. Instead of erecting power lines over long distances from centralised power generation plants which is costly and leads to technical losses, customers can receive access to electricity from power generated on-site. The initiative is also expected to support the local economy by using locally manufactured panels and will create 90 installation jobs and 15 apprenticeship positions. The government has ensured that the first step was to assess the load profile and consumption patterns of these communities, and match them to the design of the off-grid stand-alone power system. This initiative supports the transition to a renewable energy future as well as reduces network costs whilst improving the reliability of the energy system in remote areas.

AN ENERGY STORAGE ROADMAP FOR INDIA

India Smart Grid Forum

India has committed to reducing emissions by 33-35% by 2030 and part of this will be achieved through pursuing a target of 40% of green energy in their energy mix. By 2030, India would like to have 350-500 GW of RE installed and in this regard, energy system storage and system flexibility is required. The India Smart Grid Forum together with the India Energy Storage Alliance through grant funding has prepared a energy system storage roadmap for the country in 2019. The roadmap aims to assist state governments with guiding their RE expansion whilst including strategies for grid integration and storage investment. The plan is integral for facilitating the achievement of India's renewable energy goals. This is an important planning step for all cities to undertake and can ensure that implementation is strategically co-ordinated for maximum impact.

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