SHAPING THE LOCAL 100% RENEWABLE ENERGY TRANSITION

From Vision to Action

ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

This document is aimed at local and regional governments undertaking a sustainable energy transition in their territories. It provides recommendations to address the various barriers and challenges at the planning and strategizing stage i.e. the roadmap development process, as well as those encountered during the implementation phase. The recommendations are intended as general guidelines based on experiences and learnings from the 100% Renewables Cities and Regions Roadmap projects as well as ICLEI's broader work in sustainable energy, with each local and regional government following their own unique path depending on their context.

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ABOUT 100% RENEWABLES CITIES AND REGIONS ROADMAP PROJECT

The 100% Renewables Cities and Regions Roadmap project facilitates the energy transition by raising local awareness on renewable energy sources, showcasing how local and national governments can create coordinated enabling frameworks and policies, exploring access to public and private sector finance, and building local renewable energy projects to address electricity, heating, and cooling. The project is implemented by ICLEI and funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) through the International Climate Initiative (IKI).

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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THE JOURNEY TO 100% RENEWABLE ENERGY

Reaching net-zero emissions by mid-century will be critical to limit the rise in global temperatures to well below 2°C and meet the goals of the Paris Agreement. This will require an unprecedented transformation in our energy and economic systems—at times referred to as the 'sixth technology revolution' [1]—resulting in the electrification of most end uses, stronger energy efficiency and conservation measures, and for these needs to be met primarily with **renewable energy** (RE) sources.

Renewable energy is a key pillar of the energy transition that also brings with it a host of socio-economic and environmental benefits. However, at a global level, it is clear that progress is not being made at the required pace. While energy and climate plans are often decided at the national and international level, it is at the local and regional levels that these targets are realized on the ground while also accounting for various environmental, social and economic realities. **Local and regional governments** (LRGs) are at the forefront of not only the implementation of this transition, but in guiding their communities to adapt to and become more resilient against the worsening effects of climate change, while simultaneously fostering innovation through locally-adapted solutions.

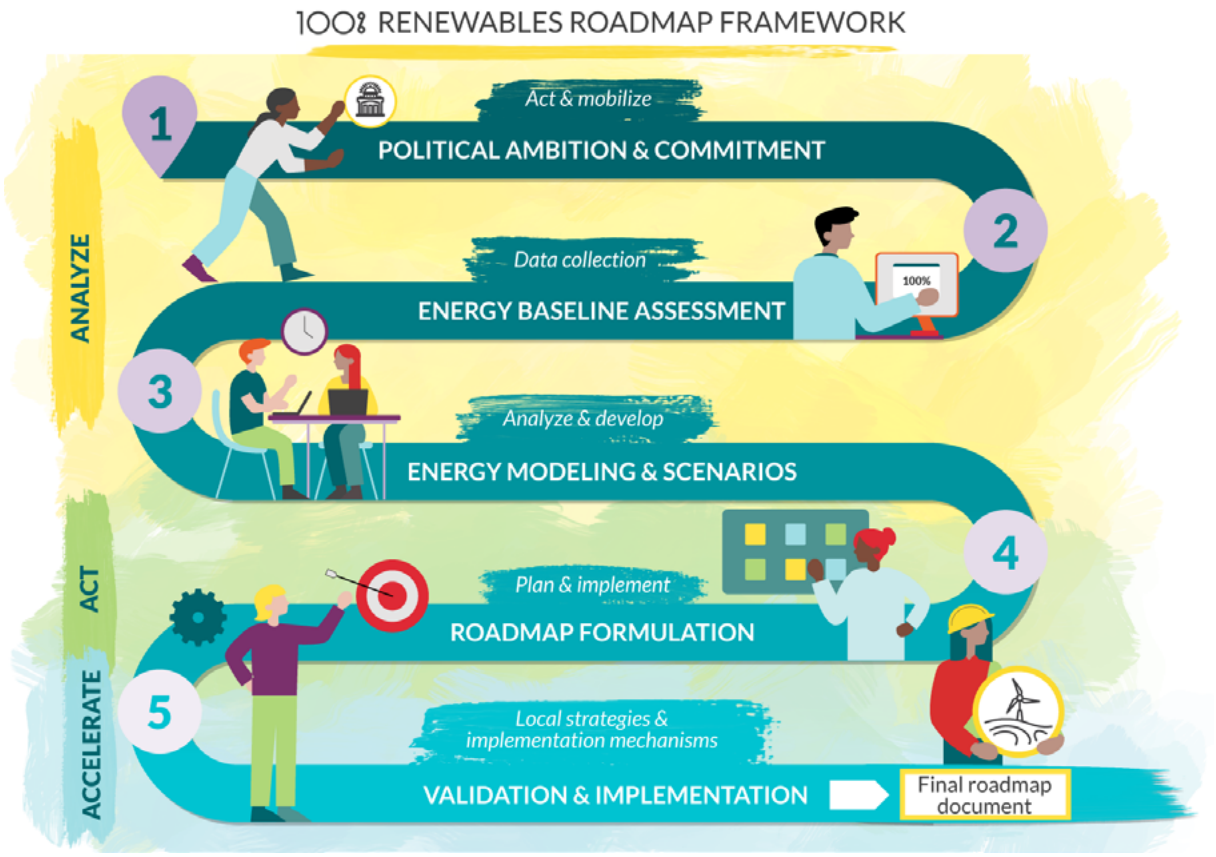
Local and regional governments can exercise their policymaking authority in order to encourage the effective uptake of renewable energy in their territories. While the policy options are myriad, typical areas where LRGs have a lot of sway include **buildings, transportation, land use planning, and public services** (electricity, water, waste, etc.), with a more limited—but still important—role in energy generation. Ambitious local and regional **targets**, such as 100 percent renewable energy use, can also serve as a powerful motivator and provide certainty over a longer time horizon.

This set of policy recommendations builds on the learnings from the **100% Renewables Cities and Regions Roadmap** project, and provides LRGs with a number of recommendations on how to address the various challenges and pitfalls they may encounter on their journey towards 100% renewables. Given the wide gap in terms of access to resources and geographic, social, and environmental contexts for cities/regions across the globe, these recommendations are meant as a collection good practices and should be carefully adapted to the local situation to ensure an inclusive and sustainable process.

THE 100% RENEWABLES CITIES AND REGIONS ROADMAP FRAMEWORK

Every journey begins with a plan—in this case, a local strategy or **roadmap** that lays out a local or regional government's (LRG) target and the steps necessary to get there. A roadmap provides an overarching strategy—based on a city or region's specific context (in terms of geography, resource availability, demographics, economic activity, etc.)—for reaching a particular goal. It attempts to align the various sectors that are active in a city or region—such as transport, electricity generation, waste, etc.—and find synergies across them, establishing milestones and assigning responsibilities along the way. It can serve to bring on board various stakeholders to work towards a common goal, including public authorities, the private sector, and local communities.

In order to disseminate the lessons learnt from the 100% Renewables Cities and Regions Roadmap project, where LRGs in Argentina, Indonesia and Kenya were supported in turning their sustainable energy ambitions into actionable strategies, a **framework** was developed to provide guidance to other cities interested in undertaking a similar journey [2].



This **100% Renewables Cities and Regions Roadmap Framework** lays out the four stages of the roadmap development process. While this is a general overview of the process, it is not linear—changing political priorities, newly available data or technologies, and periodic reassessments can require revisiting past stages or steps. Indeed, LRGs are encouraged to periodically revisit and revise their roadmaps. The stages outlined in the Framework are:

1. Political ambition and commitment, where LRGs lay out the initial vision, commitment, and requisite resources and teams for planning the local strategy;

2. Baseline/progress assessment, where the LRG's baseline socio-economic, energy and environmental data is collected and identified;

3. Modeling and scenario development, where the pathways and timelines i.e. scenarios are developed based on the gathered/simulated data, constraints, and assumptions;

4. Roadmap development, where a local strategy is mapped out for a set period, which can then be periodically reviewed and updated. This document answers the 'how' of undertaking a sustainable energy transition. This roadmap can be aligned with other relevant development objectives and plans in order to the mainstream an evolving energy system.

Once the roadmap is developed, the logical next step is **realization of the actions laid out in the roadmap,** where implementation mechanisms are identified and eventually undertaken to realize the transition on the ground.

STRUCTURE OF THIS DOCUMENT

The **first section** of this document builds on the structure of the 100% Renewables Cities and Regions Roadmap Framework, with a particular emphasis on the roadmap development process itself. Each section will begin by discussing the rationale behind each stage of the Framework. It will then discuss the various barriers that can be encountered along the process and propose a number of best-practices and recommendations for LRGs to overcome them.

The **second section** of this document outlines a more practical set of recommendations for LRGs in the implementation stage of their local energy transition. Even if their overall targets are broadly similar, each city/region will have a unique implementation pathway depending on its resource endowment, socio-economic challenges, and its national and regional context. While a general set of policy recommendations cannot account for all of these variations, they can provide a direction for LRGs to begin taking action.

SECTION 1

CONSTRUCTING A 100% RENEWABLE ENERGY ROADMAP

POLITICAL AMBITION AND COMMITMENT

The first step in undertaking the local sustainable energy transition is to secure the **political will** required for its implementation. Without effective policy direction, it is less likely that resources (financial, technical etc.) will flow in the most efficient or inclusive way, which may lead to unintended negative consequences. The main function of this stage is to gather commitments and buy-in, and in doing so create momentum for further action. And so, this stage involves working with a range of stakeholders to understand their priorities and concerns bringing them on board. This can include identifying core departments and teams within the local government that can take responsibility for moving the process forward, as well as working with the broader community and community-based organizations (CBOs). This stage can culminate in a **common vision** for the city/region, and ideally an explicit **target** towards 100% renewable energy territory-wide or even in a specific sub-sector. This section lays out the various barriers that can be encountered at this stage, their associated risks, and recommendations on how to address them.

BARRIER

LACK OF POLITICAL COMMITMENT

RISKS

Effective action requires that the various LRG departments be coordinated, as climate and energy action affects virtually all of them. An initial lack of commitment can hinder the widespread adoption and mainstreaming of climate change mitigation, adaptation, and resilience actions. Without this political will, development can continue along existing patterns that are—more often than not—unsustainable socio-economically and environmentally. With climate change impacts projected to worsen, this can create the risk of losses (in terms of lives, economics, and nature) down the line—especially for vulnerable areas and communities—that could have otherwise been addressed in the planning stages.

RECOMMENDATION

Naturally, it might be challenging to influence political will through policy measures. Frameworks adopted at the national and regional levels can be used to spur local action by mandating the development of specific targets and plans, such as a regional energy plan, showing the importance of **multilevel action** [3]. **Advocating** for greater support and resources for LRGs at the national or international level can also help inspire and upscale action. This also highlights the importance of a **robust civil society** and significant political engagement from the community. Those interested in spurring local sustainable energy action can attempt to influence political priorities by highlighting the benefits of renewables in alignment with **pre-existing priorities** for the government, such as energy access, economic development and job creation, local environmental benefits, and so on. This can create awareness and generate buy-in among the local community, which can then translate to **bottom-up mobilization** and ultimately be reflected in a city or region's political direction. Collaborating with **academia and research institutions** can also contribute, particularly to develop robust assessments and disseminate reliable information about the value of investing in sustainable energy measures.

BARRIER

LACK OF A CLEAR TARGET, SCOPE, AND TIMELINE

RISKS

Similar to a lack of political commitment, a lack of a clearly communicated target and timeline can lead to continued uncertainty and a lack of coordinated action across departments. Certainty is important for long-term planning for both the public and private sector. Alignment across various stakeholders is important for a successful energy transition.

RECOMMENDATION

Targets are merely the first step, however clear, well-defined, and science-based targets can showcase the **commitment** of LRGs to goals such as 100 percent renewable energy. Some examples of targets include achieving a certain reduction in emissions, or ensuring a certain share of energy demand is met with renewable sources. Governments can identify the **key principles** underpinning such targets—such as expanding energy access or reducing energy poverty—to provide an overall direction. **Codified targets** can also help ensure their durability across changes in governments. Targets can be further developed to target certain **priority sectors**, provided they are anchored in viable pathways to achieve the desired outcome. Harder-to-abate sectors such as heating/cooling, heavy transportation, industry, etc. are often sidestepped owing to their economic importance and the complexity of decarbonizing them, but they must specifically be included for the transition to renewable energy to be successful. To encourage **innovation** and healthy competition, a flexible approach towards implementation can be adopted, such as by setting a target and timeline while leaving open the specific blend of solutions required to achieve it.

Sub-national governments signaling their commitment to renewables

In 2021, over 830 sub-national governments across 73 countries had adopted renewable energy targets in at least one sector, out of which 630 cities had 100% renewable energy targets for either city-wide or municipal operations. [4]

BARRIER

LACK OF INCLUSIVE CONSULTATION PROCESSES

RISKS

A lack of proper consultation can affect the acceptance and sustainability of local solutions. The energy transition allows for communities to be more active participants in the energy system, which in turn requires greater inclusion in decision-making processes to be sustainable over the long term. Communities may not be aware of the options available to them, or may even resist solutions that do not account for their needs and appear to be top-down. The timing of their involvement is also important—the sooner they are brought on board, the earlier problems their can be addressed with minimal disruption.

RECOMMENDATION

Listening to local communities about their needs, priorities and expectations can help create a more

just and inclusive transition, and help address cross-cutting issues such as climate adaptation and mitigation concerns simultaneously by improving the flow of information. Such a process can lengthen project timelines, but may have other benefits such as increasing community trust and avoiding undue resistance further down the line. Care should be taken to involve the community **early-on** in the process, and not just to validate decisions that have already been made. This can also help create a sense of ownership and ensure that any local energy solutions are sustainable over the long term. Inclusive stakeholder consultations must involve a **wide range** of stakeholders to ensure that the energy transition is not simply top-down. They can be structured so that they are accessible for a broad range of community members including the most vulnerable, such as by holding them outside working hours, or offering multiple locations and formats, etc. Overcoming misconceptions or resistance through **transparency and communication** is key. Consultation processes can be enabled by providing easily accessible information for the public, through communication campaigns, brochures, websites, etc. to reduce the information gap and allow for broader participation.

Renewables for resilience in Galena, Alaska

Galena, Alaska, faced severe floods in 2013. During post-flood recovery efforts, the community collectively identified a number of priorities, including 'improved energy generation and efficiency'. Given the community's remote location, it was quite reliant on fossil fuels, which created a vulnerability. Several options were identified, including a biomass plant fueled by locally-available sources. Renewable energy and energy efficiency were seen as critical for improving the town's energy security and its adaptation and resilience efforts in the face of future natural disasters [5].

BASELINE ASSESSMENT

The second stage is important for establishing a **baseline** from which forward-looking plans can be developed. With the baseline as a reference, targets and timelines can be set, and progress can be monitored. The lack of an adequate baseline to start from can affect the **feasibility of a target**, making the target either unfeasible, or not ambitious enough to meet relevant international climate goals. A baseline assessment can also help identify sectors or areas that require special attention. At this stage, accurate and readily-available **data** is critical, although this is often a big challenge for LRGs. However, the better the data and granularity, the better the planning. Investing in data capabilities pays dividends in all segments of integrated urban planning, not just energy and climate, and can help harmonize various sectors and approaches. **Progress monitoring** is improved and greater transparency/accountability can also be achieved, which can help improve trust between communities and LRGs. The following are certain barriers that can be encountered in this stage, and recommendations to address them.

BARRIER

LACK OF ACCURATE AND SUFFICIENTLY GRANULAR QUANTITATIVE DATA

RISKS

Policies may not be as effective without accurate assessments of local renewable energy potential or the most emissions-intensive sectors. A lack of quality data can result in plans that do not address critical needs or priority sectors, or in the worst case, result in solutions that are more damaging in the long-run. Without accurate data and reporting, it is also difficult to monitor progress and take course-correcting actions where needed. This is particularly critical for measures such as energy efficiency and conservation whose effects and benefits are not immediately obvious.

RECOMMENDATION

This is one of the most common challenges faced by local and regional governments. Enabling the greater availability of data alongside capacities to **collect, use, and analyze** it can be a great boon for LRGs. This can pay dividends in terms of planning and strategy development across all sectors, as well as identifying opportunities for holistic or cross-sectoral approaches. For example, greater **data literacy** can help develop indicators adapted to a city's context. Investing in data-related **training and skill development** for LRG officials can help build LRG capacities over the long term, as can investing in the right talent. If greater investments in **digital infrastructure**, talent, and technology

are not always possible, then LRGs can try to address this through **partnerships** with local data organizations, research and academic institutions, entities such as utilities, or even exploring alternatives such as open-source data. There are also several **international platforms** and initiatives that provide assistance and guidance related to data collection and reporting, such as CDP-ICLEI Track and the Global Covenant of Mayors for Climate and Energy's Common Reporting Framework (CRF). In case there is a lack of granular data, certain statutory reporting requirements can also be enacted to ensure that it is collected and reported properly. However, relevant data protection laws must be complied with to understand what kind of data can be used and in what situations.

BARRIER

LACK OF STREAMLINED DATA MANAGEMENT AND DATA GOVERNANCE

⚠ RISKS

The risk here is that even if there is sufficient data, it is not always easily accessible, is not well-managed, or that there is too much 'noise' in the system. For example, incompatibilities between different departments and their data practices or software can hamper integrated planning. There are also privacy concerns for sensitive data if enabling frameworks for data governance are not established at the national level [6] [7].

✔ RECOMMENDATION

Local and regional governments should take care to establish good **data governance** practices. There are a number of best-practices and frameworks available which can help improve service delivery for one, and a greater focus on data can also improve planning efforts [8]. Investing in **talent and training** is once again a promising way of addressing this gap, as can collaboration with consultancies or academic and research institutions that can offer recommendations. Coordinating with national-level frameworks for data governance and privacy should also be seen as essential.

MODELING AND SCENARIO DEVELOPMENT

Once suitable and reliable data has been collected, it can be analyzed further to develop an energy systems model of the city/region. This model can help in the development of a scenario that outlines a way forward to achieve the desired outcome, such as 100% renewable energy use across the territory. It can provide a potential timeline or a transition pathway while accounting for the various constraints or priorities of the LRG (such as ensuring the full use of certain energy sources, or determining the lowest-cost system). A scenario, once chosen, forms the backbone of the development of the roadmap. However, it is not a prescription or a prediction. The roadmap must be developed in accordance with ground realities and existing policies, regulations, and resources. So while energy systems models can be extremely useful to understand the scope of what is possible and feasible for a local energy transition, the actual implementation stage involves many more layers and detailed assessments. Care should be taken regarding these points when communicating with communities and other stakeholders. Further barriers and recommendations are outlined below.

BARRIER

LACK OF FAMILIARITY WITH ENERGY MODELING FOR PLANNING

RISKS

There may not be adequate capacity or know-how within LRGs to work with detailed energy models, particularly if resources are constrained. Without the ability to formulate their own energy models or at the very least update them to include new information and insights, models can easily become outdated and their utility as a planning tool is hampered. Translating modeling results into communicable messages and actionable items also requires familiarity with the modeling process and the assumptions that fed into it. Without this familiarity, there is a risk of miscommunication and unrealistic expectations.

RECOMMENDATION

The skills and capacity required to work with energy models can always be developed, including through hiring the right **talent**. If there are insufficient resources for a dedicated energy modeling team, LRGs can **collaborate** with academic, research institutions, consulting firms, etc. for the initial modeling stages. Along the way, they can improve their capacities to conduct the work themselves.

The participation of LRG staff in training programs and certifications offered by various organizations should also be encouraged to further develop skills and knowledge. Alongside technical capabilities, the ability to **communicate** results effectively should also be developed. This can help avoid misconceptions about the purpose of energy systems models in planning efforts, particularly to manage expectations about the differences between modeling results and actual implementation.

Fraunhofer ISE's KomMod software

Given the requirements of the 100% Renewables Cities and Regiosn Roadmap project, Fraunhofer ISE's KomMod modeling software was used to create the modelling scenarios for each of the project's deep-dive cities. KomMod was chosen due to its suitability for local/regional energy systems. The model optimizes the supply side of the energy system to achieve the minimal total costs of the energy system while adhering to given constraints, and provides an output of the entire energy system (electricity, heating/cooling, and energy for transport) over one year in an hourly temporal resolution.

BARRIER

IDENTIFYING A SUITABLE ENERGY SYSTEMS MODEL

RISKS

There exist several types of models for energy systems. Models and software that are used at the national-level may not always be suitable for the granular, implementation-oriented modeling that is often required at the city level, resulting in imprecise or insufficient outputs that do not effectively aid local policy development [9].

RECOMMENDATION

Before choosing a modeling approach, LRGs should identify available models that are the most suited for their purposes based on a number of criteria. These can include the **data** required by the model, whether it is better suited to a specific **sector** (such as transport or buildings), its **constraints**, its **interoperability** with existing government processes/databases, as well as the skills available within the LRG to analyze and use the results generated. **Partnerships** and consultations with research institutions and academia can help identify a suitable model. For example, some models may not allow for energy imports and exports, while others may not be able to calculate emissions savings or incorporate all feasible technologies, and yet others may only be able to provide monthly snapshots of the energy system rather than hourly. This also highlights the importance of **monitoring** implementation progress to account for imperfections in the modeling process.

BARRIER

INADEQUATE INTEGRATION OF QUALITATIVE DATA TO SUPPLEMENT QUANTITATIVE DATA

RISKS

Relying solely on **quantitative** data can lead to incomplete information. Some information about on-the-ground impacts is better gathered through **qualitative** methods. This can create challenges

as quantitative data is somewhat limited to indicators that are measurable. Quantitative data may not always capture the ways in which different communities interact with their environment, such as vulnerable groups whose behavioral patterns may differ from the 'norm'. Turning qualitative data (such as end-user behavior) into data that can be incorporated into models can also require additional expertise [9]. Since a lot of consultation processes produce qualitative data, translating insights from them into energy models can also be a challenge.

RECOMMENDATION

While this challenge is not unique to local governmental planning, the consequences of missing out qualitative aspects of local planning can be significant. Finding ways to access and utilize qualitative data into the modeling and planning process can help create more tailored strategies. This can be partially addressed through the choice of **modeling software or approaches**, as some may allow for the incorporation of qualitative indicators, and combining it with consultations with the local community. Such considerations may also be kept in mind when devising **methodologies for such consultations,** such as the format of gathering input. **Collaboration** with academia and research institutions can also offer novel solutions to this challenge [10]. Any insights from the data that cannot be adequately incorporated in the modeling process should be mentioned and addressed in the creation of the roadmap itself i.e. when defining actionable implementation mechanisms.

BARRIER

LACK OF PARTICIPATION IN SCENARIO DEVELOPMENT

RISKS

Limiting scenario development, particularly the technical aspects, to only a few actors within the government can create a silo-ed approach and close avenues for input from other experts, such as academia or the broader community.

RECOMMENDATION

The data used in scenario development should also be made **publicly available**, in line with some of the considerations mentioned above. This can allow a wider range of stakeholders to create their own scenarios and provide potential input or improvements to the scenario, and ultimately the roadmap development process. A more **accurate scenario** can help develop actions in the roadmap that are highly relevant to the specific context of a city or region, and additional input from experts can help better understand the **limitations** of the modeling process.

ROADMAP DEVELOPMENT

In this final stage, inputs from earlier stages are compiled to ultimately develop the roadmap itself. Based on discussions and findings from the energy modeling and consultations, certain overarching sectors/themes can be prioritized. Here, local actions can be aligned with regional and national-level policies in order to identify potential resources that can help with implementation. Responsibilities for undertaking actions can be assigned. Intermediate targets can also be determined based on the pathways identified in the modeling stage. The roadmap can be supplemented by a policy review that can help identify gaps or obstacles in the local policy environment that can be addressed to facilitate implementation.

BARRIER

LACK OF CONTEXT-SPECIFIC PLANNING AND POLICY MEASURES

RISKS

When finally outlining a roadmap, it is critical to remember that while a certain scenario or pathway may indicate a certain end goal, there are myriad ways to realize it on the ground. For example, the model may indicate a certain share of renewables in the electricity mix, but perhaps the local value chain is not sufficiently developed to enable this and adjustments are needed. Putting forth actions that do not correspond to the city or region's specific context can affect its likelihood of being adopted and realized in the long-run, which ultimately affects the utility of the roadmap.

RECOMMENDATION

Extensive stakeholder consultation or feedback rounds should be deployed to help develop and validate the roadmap and to outline a way forward, with a particular focus on highlighting the challenges that might be encountered on the ground. **Local knowledge and expertise** should be prioritized, as global best practices may not always be feasible in every context. Local and regional governments should especially keep in mind their existing priorities and plans and how these goals can be aligned with the sustainable energy transition. For example, clean cooking or electricity access could be a priority for the government, in which case the question should be posed regarding what renewable energy sources are best suited to achieving these goals. There should also be a thorough study and understanding of the challenges of the LRG's particular **national context**, particularly with regard to industrialization, the business environment, the cost of finance, energy security concerns, etc. and how local action can work within these constraints.

Serious gaming as an innovative stakeholder consultation methodology

As part of the 100% Renewables Cities and Regions Roadmap, participating cities/regions West Nusa Tenggara, Kisumu County, and Avellaneda all utilized the 'serious gaming' methodology as part of their roadmap development process. Through the use of the Sustainable Energy Transition Strategy (SETS) game, a number of stakeholders were convened to offer their inputs into the roadmap as well as to validate its findings. Given the unique setup, participants were able to discuss challenges they might encounter during the implementation of the roadmap, and translate those insights into improved actions and policy recommendations [11].

BARRIER

LACK OF ADEQUATE HUMAN RESOURCES OR CAPACITIES

RISKS

A lack of information or know-how is not unique to roadmap development. This can hamper the process from planning and implementation, as well as affect the long-term sustainability of plans and implementation efforts. It can negatively affect the ability of a robust and dynamic planning process that takes into account evolving policies, approaches, and technologies.

RECOMMENDATION

A first step can be a **needs assessment** that is meant to identify knowledge gaps and any lack of experience or skills in the LRG that are necessary for a successful sustainable energy transition. **Continual learning and training efforts** can help local and regional government officials keep up-to-date with emerging trends and technologies, as well as developments in their communities, helping them formulate more dynamic, responsive, and innovative policies that are suited to their local contexts. Such measures can also help tackle **inertia**—entrenched beliefs or preferences for certain technologies that can lock communities into unsustainable pathways. Collaborations with organizations or academic institutions for specialized training aimed at LRGs can be explored. This way, the former group can also gain insight into the policymaking process and better tailor their offerings. **Engaging citizens** in the decision-making process, as well as exchanging with peer LRGs, can provide valuable insights about **innovative and cross-cutting solutions**, especially as many local solutions must now address adaptation and resilience alongside climate change mitigation.

BARRIER

LACK OF ALLOCATED RESPONSIBILITY FOR ROADMAP IMPLEMENTATION

RISKS

The challenge here is to involve a sufficient number of relevant departments and for each to take ownership of the actions that are under their jurisdiction. Not allocating responsibility at the strategy-setting stage itself can seriously hamper the implementation of the roadmap and dilute its purpose, hinder efforts to monitor progress, and erode trust in terms of meaningful climate and energy action.

RECOMMENDATION

When formulating the roadmap, a **review of existing policies and regulations** is critical to be able to identify any existing relevant work and how it can be aligned with the roadmap itself in order

to avoid duplicating or undermining efforts. The roadmap can act as a **streamlining** document across existing cross-cutting workstreams. Therefore it is crucial to **consult** or involve multiple local government departments well in advance. Even here, **political will** plays an important role in order to mainstream climate and energy action across various city/regional departments and prioritize the actions outlined in the roadmap. Local and regional governments can also create an oversight office that monitors the roadmap progress should it deem this necessary and if it is feasible. This can also aid in progress monitoring, as responsible departments can all contribute—however, previously outlined data challenges must be taken into account as well.

BARRIER

LACK OF EFFECTIVE WAYS OF MONITORING PROGRESS

⚠ RISKS

The risk here is that if sufficient monitoring mechanisms are not specified in the roadmap to monitor progress, it is difficult to understand how implementation is unfolding on the ground. It is also difficult to then account for and incorporate newer technologies/standards, and to address these gaps and course-correct as needed. Accurate and reliable reporting is also critical to be able to communicate the results to the public. The risk of being locked into insufficient or inappropriate policies can have long-lasting impacts.

✔ RECOMMENDATION

Monitoring progress is particularly important as climate risks are likely to worsen, requiring **continuous improvements** and adjustments in policies. **New departments** or institutions can be created that can help mainstream climate action, and monitor whether the transition is being carried out smoothly across all concerned sectors. **Annual progress reports** can be a useful benchmark, and making such information publicly available and easily accessible can help create accountability and policy certainty, which can help attract investments. **Transparency and accountability** can improve trust between governments and their communities, which can have myriad benefits as community members become more active participants in future energy systems. **Improved data governance** and capabilities can also go a long way in streamlining this process.

Vancouver's tracks its climate progress

The City of Vancouver adopted its Climate Emergency Action Plan in 2020. In addition to sector-specific plans targeting for example its buildings and transport sectors, it publishes annual reports to allow for transparency related to its progress [12].

BARRIER

LACK OF CLARITY ABOUT THE PURPOSE OF A ROADMAP

⚠ RISKS

There may sometimes be a lack of clarity about the purpose of a roadmap, which can create misunderstandings in coordination and the allocation of responsibilities, as well as in communicating the results with the broader public. In the worst case scenario, a roadmap may not add much value for local planning.

RECOMMENDATION

It should be made clear at the start of the process what the **purpose** of the final roadmap is. A roadmap is a **strategy document** that lays out a viable pathway towards a specific end goal, as well as context-specific actions and implementation mechanisms that help realize this goal. It does not substitute for established procedures regarding policies and regulations. It can however guide the development of these across sectors by providing a **common direction** for the target, its milestones and timelines, as well as possible pathways and recommended actions to achieve it. These actions must then follow **established procedures** to be implemented, for example existing public procurement guidelines, processes for updating building codes, or modifying tax rates, and so on. Roadmaps can be accompanied by **recommendations** about which procedures need to be amended or revised in order to realize the end goal. Roadmaps can also feature **varying levels of detail**, which will ultimately affect their utility as well as the amount of consultations, accurate data, and effort that goes into their development.

IN SUMMARY

As is the case with any significant undertaking at the local and regional government level, the challenges encountered in the roadmap development process itself are numerous. They mainly revolve around two main themes, namely the need for thorough **stakeholder consultations**, and robust **data and monitoring capabilities**. Extensive consultations with stakeholders early on in the process can ensure that communities, and especially vulnerable groups, have an opportunity to share their concerns and have them addressed, ensuring a just, inclusive, and sustainable approach. In addition, quality data collection, management, and analysis processes serve to improve planning accuracy and progress monitoring, while contributing to the creation of a more dynamic roadmap. These challenges are not insurmountable, but they do require a forward-looking approach that takes them into account while building partnerships across various external stakeholders.

SECTION 2

IMPLEMENTING A 100% RENEWABLES VISION

Once the roadmap is developed, its goals and milestones must be translated into actionable policies and mechanisms. The implementation phase for any strategy is undoubtedly the most critical phase,—as well as the most challenging—and where a lot of ambitious visions and plans struggle.

Local and regional governments are in a unique position. Cities can be described as problems in 'organized complexity' and feature 'situations in which a half-dozen or even several dozen quantities are all varying simultaneously and in subtly interconnected ways' [13]. There is a balance between what LRGs can do themselves, and where the impetus is on other actors such as the private sector or higher levels of government to act.

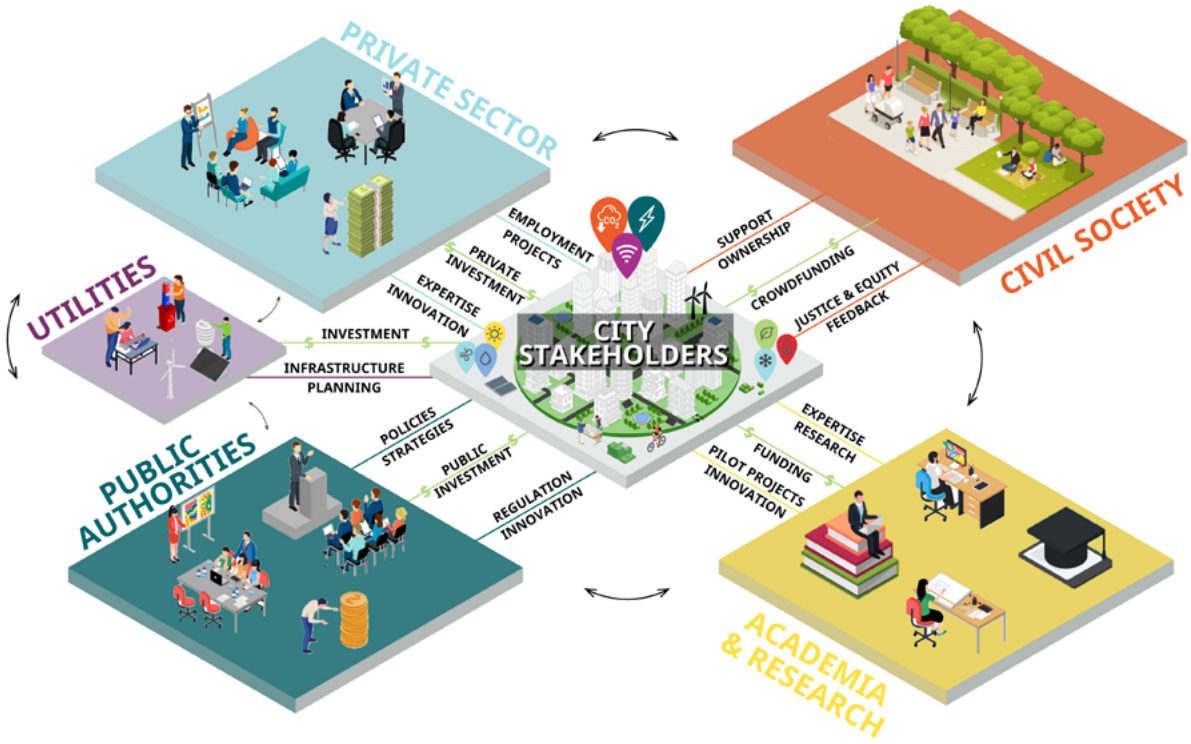


Figure 2. Stakeholders and their interactions in a local energy transition

Given this context and the various stakeholders that are active at any given time in a city or region, the role of an LRG essentially becomes managing or facilitating various interactions in their territories in a way that takes the functioning of the whole system into account [14] [15]. The graphic above illustrates these interactions and highlights the importance for partnerships. Such interactions generally involve information, technologies, policies, people, finance, and materials, and especially for the purpose of creating a sustainable energy system, the flows of energy and emissions as well. A number of stakeholders are responsible for these—**utilities, academia and research, the private sector, communities and civil society organizations (CSOs), financial institutions**—and therefore must be involved in the

decision-making and implementation process [16].

However, these interactions between various stakeholders at the local and regional level are also mediated by frameworks created at the **national level**, and are very context-dependent. Local and regional governments can manage the flow of policy from higher level of governments by **localizing** them in a way that addresses local community priorities. They should also identify areas in which it would be necessary to cooperate with **other regions or sub-national government**s. The movement of goods, people, services, and energy across borders means that a lack of meaningful action in one region can hinder progress elsewhere. It is also for this reason that a **supportive national policy environment** is essential, which LRGs can play a role in creating by pioneering and scaling up creative and successful approaches, or by advocating for such approaches through appropriate channels.

The section below presents a number of general recommendations to aid improved implementation. It provides an indicator based on what is broadly feasible for LRGs to do, and what is better suited for national governments in terms of creating an enabling environment. The recommendations touch upon improving the management of information, technologies, policies, people, finance, and materials for the purpose of creating a sustainable energy system.

FACILITATING THE FLOW OF KNOWLEDGE AND INFORMATION

Given the number of stakeholders that must work in a coordinated manner to undertake an energy transition in a city, generating quality knowledge about the local context and effectively communicating it is a necessary step. Whether this includes data on emissions sources, progress monitoring for a roadmap, or even energy-saving tips for households, having **reliable information** on hand can go a long way in supporting the implementation process.

RECOMMENDATION 1

COMMUNICATION AND AWARENESS-RAISING PROCESSES

PRIMARY RESPONSIBILITY

Local ●●●○○ *National*

A simple lack of awareness can be a major reason for the slow uptake of renewable energy in a city or region, particularly for households and community members. **Physical or even online campaigns** can help engage communities and explain the benefits of renewable energies, energy efficiency, and sustainable development, with the intention of bringing about change in purchasing decisions, choice of mobility options, etc. The benefits of these can be made known in a way that connects to peoples' lived experiences—local languages, contexts, and traditions can be tapped into to increase their relevance. Such campaigns can lead to significant changes, especially when changes are easy to implement and alternatives are readily available. A number of tweaks are possible to maximize effectiveness, including the **tone** of the campaign, the **information** it provides, the scope for **competition/collaboration** with others, and targeting different groups separately depending on the desired impact [17]. While many of these are better suited to LRGs to implement, large-scale measures such as energy efficiency labeling for buildings and appliances are more suited to implementation by national governments, and serve the same purpose.

Energy savings for Dubliners

As an example, awareness-raising campaigns in Dublin (Ireland) provided residents with information regarding their energy use and ways to save energy. Originally, this program aimed to achieve a 5% reduction in energy use—by the end of the project, energy consumption was actually reduced by 13%. Soon after the first phase was completed in 2014, the city developed home energy saving kits to increase awareness and improve home energy use with necessary energy upgrades [18].

RECOMMENDATION 2

IMPROVE DIGITAL INFRASTRUCTURE

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

While many digital and information technology policies might be outside the purview of local and regional governments, they can still take steps to ensure effective policymaking within their jurisdictions to improve service delivery. **Data collection**, **processing**, and **availability** can be facilitated through investments in digital technologies. Particularly for LRGs that control utilities, establishing smart grids can provide a number of benefits including improved fault detection, improved renewables integration, and even demand response services. National governments can facilitate this by providing resources (technical or financial) for any necessary upgrades, developing guidelines and frameworks that LRGs can adopt, and developing regulations that govern data and its fair use at a national level.

RECOMMENDATION 3

INVEST IN RESEARCH AND INNOVATION

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Supportive research and innovation policies can facilitate the development of newer and more efficient technologies. Cost reductions have played an important role in the spread of renewables, especially solar PV and offshore wind, which was made possible through a constructive interplay between industry and policymakers that ultimately enabled industrial innovation and growth [19]. Early-stage support can be crucial as it is where most ideas fail [4-10]. Successful projects can be scaled up across other cities and regions, which can afford greater visibility and attention to pioneering LRGs. Such innovative approaches do not have to involve hard infrastructure, but can include 'soft' infrastructure as well, such as promoting the use of specific transportation or energy consumption patterns. While much of this depends on the broader national innovation framework, LRGs can also contribute by **partnering with academia** to develop local solutions to local challenges, and by implementing **pilot or demonstration projects** that can test the validity of such solutions and better direct future research and implementation efforts.

IMDEA Institutes in Madrid, Spain

The Community of Madrid in Spain set up a network of seven independent institutes in 2006–07 to focus on research and development activities in the sectors of water, food, energy, materials, nanoscience, networks, and software. They operate in close collaboration with other academic, research, and industry organizations, leading to a more effective transfer of technologies and solutions [19].

ENGAGING PEOPLE AND COMMUNITIES

RECOMMENDATION 4

EMPOWER THE WORKFORCE

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Efforts should be made to provide adequate **training and skill development** to keep up with the changing needs of the energy transition and develop a qualified workforce. Such measures are important to ensure a just, inclusive, and equitable approach to the energy transition. Both national and LRGs can contribute, with the former perhaps having a larger share of resources to invest in such programs. There can also be significant sub-national variance within a country, influenced by several local factors. Strengthening technical education in schools and universities can also help. With renewable energy and energy efficiency improvements, many of these 'green jobs' are likely to remain local, providing an incentive for LRGs to spur their local transition.

RECOMMENDATION 5

INCENTIVIZE COMMUNITY ENERGY APPROACHES

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Involving communities in the energy transition can go a long way in improving long-term outcomes. The fact that renewables can generate electricity in **decentralized setups** creates new possibilities for increasing energy access and participation in the energy system, especially for traditionally underserved communities. Community energy generally involves a **community owning or being involved in the operation/decision-making** of an energy project. In places where direct ownership is not feasible, communities can still be engaged to identify their priorities and any obstacles encountered when switching to cleaner fuels, resulting in more responsive and relevant policies and solutions. Such approaches can provide **local socio-economic benefits** and **increase citizen participation and buy-in**, and can be encouraged with the right policy and legal frameworks at the national level. Where communities are unable to afford such projects on their own, funds from various local, regional, national, and international institutions can be sought out. Local and regional governments have a critical role to play in community energy approaches as they are often the first point of contact. Given their responsibility for local regulations and land use, they can play the role of a facilitator and information provider.

RECOMMENDATION 6

MEANINGFULLY RESPOND TO THE INTERESTS OF VULNERABLE GROUPS

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

When undertaking a local sustainable energy transition, LRGs should take special care in ensuring that a diverse set of voices heard and that existing inequalities are not exacerbated. Energy and transport use patterns can differ based on age, gender, race, income, etc. Certain groups may be more vulnerable to energy poverty. Addressing **energy access or poverty** issues should also be a priority, as the alternative is more often than not relying on expensive and polluting fossil fuels. For example, subsidies for rooftop solar may not be sufficient to make the option affordable for low-income households, and may instead worsen the gap between higher- and lower-income households. Alongside these efforts, LRGs can prioritize investments in green technologies for public housing and public spaces, hospitals, schools, etc. so that the benefits are spread out across the community. Moreover, many people across the world work in the i**nformal economy** and live in informal settlements. Their specific concerns should be addressed in socially-sensitive ways, as formal regulations may not cover them and provide the necessary protection. Where local socio-economic concerns clash with the goals of the energy transition, **more dialogue, communication, and an equitable sharing of the benefits** can go a long way in finding a mutually acceptable solution.

IMPROVING POLICYMAKING, GOVERNANCE AND ADMINISTRATION

RECOMMENDATION 7

CLEARLY DEFINE RENEWABLE ENERGY

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Clear **definitions** are important when it comes to target-setting and eligibility criteria for resource allocation. This is also true for what constitutes renewable energy as well as enabling technologies. Such terminology can still leave room for interpretation and misunderstanding. For example, 'energy' and 'electricity' are often used interchangeably in public discourse. However, it should be clear whether such targets and/or eligibility criteria refer only to electricity, or energy more broadly—including solid and liquid fuels used in transportation, heating, as well as storage options, etc. This should also be clearly **communicated** to all relevant stakeholders. Definitions should ideally be linked to supranational frameworks, but **adapted to national contexts** (as well as local/regional contexts if relevant). As an example, the IRENA Coalition for Action's definition of 100% renewable energy accounts for all energy end-uses as well as the sources that are considered renewable [46]. The legal differentiation of renewables from other energy sources can enable policy and financial measures to better target these sources for development, and prevent policy misalignment at various government levels. Local and regional governments should make sure to mainstream any such definitions into their development plans to speed-up their energy transition in a holistic manner.

RECOMMENDATION 8

REGULATORY FLEXIBILITY FOR LOW-CARBON INNOVATION

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

To speed up the deployment of renewable energy, administrative processes should also be reviewed and updated in order to reduce unnecessary delays, particularly in permitting. This can be done by mandating **turnaround times** or even through the establishment of a **single-window clearing system** [20]. Adequate resources and capacities dedicated to this to ensure compliance. By delegating a single point of contact for information, permits and licenses, local and regional governments can speed up the process and encourage greater investments.

In addition, low-carbon projects specifically could also benefit from improved processing times and **prioritization** to help speed up deployment. However, it must be kept it mind that such measures should not come at the detriment of other concerns such as socio-economic development and the environment—for example, weakening environmental protections in order to speed up permitting times.

RECOMMENDATION 9

ROBUST TRANSPARENCY AND FEEDBACK MECHANISMS

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

Given the pace at which the energy transition must be implemented, **robust transparency and feedback mechanisms** can help course-correct when needed. This will need a more dynamic approach to governance, including investing in adequate capacities. Communicating successes (and failures) in the local and regional energy transition can help not only with progress monitoring, but also create trust between governments and their communities. Similarly, better communication with industry and other stakeholders can help identify any blockages in the permitting process or other administrative formalities. **Digitalization and improved digital governance** can also help provide easier access to information for the broader public, and make it easier to communicate results and solicit feedback.

RECOMMENDATION 10

ADDRESS IMPACTS ON NATURE AND BIODIVERSITY

PRIMARY RESPONSIBILITY

Local ○●●○○ *National*

Cities are complex man-made socio-economic systems, but they are all situated within a **broader natural ecosystem**. Accounting for the various interconnections between our communities and their energy consumption, and associated impacts on water, nature, waste etc. can help develop more sustainable, less harmful, and more just pathways to achieve a successful sustainable energy transition. This is an opportunity to consider the negative impacts on nature and biodiversity of our current patterns of consumption [21]. Similarly, given that most resources are finite, adopting **circular approaches** to the problem of waste management, among others, should also be considered. For example, used electric vehicle batteries can be used in stationery energy storage applications, which can reduce the overall use of resources and improve the battery's business case. Pollution on land, air, and water has clear negative impacts, but biodiversity losses are equally impactful, if less overtly visible. Adopting a more **nature-sensitive approach** in planning can go a long way for the overall health of communities and improve resilience and adaptation in the face of climate change and its impacts.

RECOMMENDATION 11

SET AN EXAMPLE THROUGH GOVERNMENT-OWNED ASSETS

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

Local and regional governments can spur the sustainable energy transition in their jurisdictions by assessing their own assets and evaluating how they can be transitioned towards cleaner sources of energy and becoming more energy-efficient. This can include transportation systems, schools, public spaces, etc. **Sustainable procurement practices** can be one such way. When considering long-term investment or procurement decisions, LRGs can opt for prioritize environmentally- or emissions-friendly criteria in addition to socially-sensitive ones, besides simply the financial cost [22]. Electric buses for example may be initially more expensive than diesel-powered buses, however their higher efficiency and lower operations and maintenance costs may result in them being a more cost-effective option in the long run [23]. Similarly, LRGs can also sign power purchase agreements (PPAs) or purchase renewable energy certificates (RECs)—depending on the particular mechanisms available to them—to secure their supply of electricity for their facilities from renewable energy. By setting an example through **publicly-owned assets**, it can help spur the development of a supportive ecosystem (technicians, financiers, etc.) in their city. Similarly, they can undertake energy audits and other energy-efficiency measures in their buildings to not only reduce their energy consumption, but also to help contribute to the local value chain for similar services.

TRANSFORMING ENERGY SYSTEMS

RECOMMENDATION 12

ADDRESS LOCAL ENERGY DEMAND IN MAJOR ENERGY-CONSUMING SECTORS

Given the powers and authorities of local and regional governments are typically centered around buildings, transport, and associated land-use planning, they have great potential to influence energy use in their territories, including electricity and thermal energy for heating/cooling as well as in transportation. There are a number of tools LRGs can deploy to address this challenge:

Urban planning

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

Local governments can take advantage of their **land use planning** powers to design urban areas in a way that maximizes the efficient use and siting of renewable energy [24]. Additionally, the nature of solar photovoltaic panels and wind turbines can allow for their siting in **infill areas** or otherwise unused land close to urban spaces, which can take advantage of existing networks (roads, electricity, water etc.) and reduce overall costs [25]. Local governments can influence energy use patterns, particularly in the transport sector, by promoting **alternative transport modes** that are less energy-intensive, such as walking or cycling. This can be made more convenient through improvements in planning to include pedestrian infrastructure, safety measures such as improved lighting, more efficient public transportation routes, car bans for certain neighborhoods, and so on, ideally depending on **consultations** with local communities. These can be paired with other incentives and programs such as free parking or charging for certain classes of zero-emissions vehicles, or affordable bike share programs. These measures also provide co-benefits such as reduced local air pollution and noise. Green and blue spaces as solutions for increased heat island effects can also be considered, especially for vulnerable groups that may not have access to modern cooling solutions.

Orlando and 'floatovoltaics'

Orlando, United States installed the first grid-connected floating solar array in southeast USA. By situating them on water, any conflicts over land use were largely avoided. The panels provided benefits including reduced evaporation, and their functioning was improved due to reduced shading due to trees as well as the cooling effect from the water [26].

Mandates

PRIMARY RESPONSIBILITY

Local ●●●○○ *National*

Mandates can be used to necessitate the use or installation of certain kinds of technologies. They are straightforward, but their implementation can face some resistance. Therefore they are best done in a way that **reduces uncertainty**, such as by providing a timeline, as well as in coordination with industry actors or developers. They can also be matched with **appropriate incentives** to increase the efficacy of implementation. For example, mandates can require the installation of solar PV systems in new buildings, or require the use of a certain percentage of biofuel in transport. Jämtland in Sweden required newly purchased buses to use between 30% and 50% of renewable fuels [27]. National governments can support by creating guidelines or frameworks that allow LRGs to exercise these powers.

Bans

PRIMARY RESPONSIBILITY

Local ○●●●○ *National*

A ban can be an extreme measure that is best targeted towards sectors where alternative technologies are readily available, such as for transportation or for certain purposes (e.g. heating) in buildings. However, they are likely to be unpopular and face backlash. For example, several national and sub-national governments have announced their intention to ban fossil fuel powered vehicles after a certain date [28]. A **long enough horizon** and **clear communication** of the benefits and available alternatives can help smooth this process by allowing time to switch and adapt. Bans can also be implemented in a **phased manner**. Especially unpopular measures, such as banning gas boilers or gas stoves, can be paired with financial support to enable people to find alternatives, if local resources allow. National governments can contribute by providing timelines as well as through coordinating action across various regions.

Banning natural gas in buildings in New York state

In 2023, New York State adopted legislation that would do away with gas stoves, furnaces and propane heating in most new buildings. By 2026, new buildings less than 7 stories high will be required to comply; larger buildings will have until 2029. Exceptions are in place for large industrial and commercial buildings [29].

Standards and codes

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

Standards and codes are particularly relevant for the building sector. Building codes are predominantly the responsibility of local government bodies. Such measures can ensure the efficient operation of buildings and their energy use, as well as particular design elements. Energy-efficient **building designs** can go a long way in reducing overall local energy demand, and with improved digitalization, buildings can also be a nexus for coupling various energy uses such as energy generation, enabling electric transportation, and providing grid services. Buildings can also be the site of **integration** between energy and nature-based solutions (NBS). For example, green and white roofs can be included in building designs in order to reduce cooling demand in warmer climates, improve water management and use, and improve the overall well-being of users.

Local and regional governments can target new developments easily with clean energy performance or emissions standards, but support for **retrofitting** their existing building stock is also critical. It is often costly, and so financial support and collaboration with regional and national governments may be necessary.

Solar rooftops in Bali, Indonesia

In 2019, Bali, Indonesia, in collaboration with Indonesia Power, a subsidiary of the state-owned utility PLN, established building mandates that required all buildings with a floor area of more than 500 square meters to install solar rooftop PV systems between 2021 to 2024 [30].

RECOMMENDATION 13

OPT FOR COLLECTIVE APPROACHES

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Local and regional governments can consider adopting collective approaches and solutions as they may be more efficient than individual-oriented approaches. For example, **district energy**, which can include heating and cooling, are more efficient and can more readily take advantage of economies of scale, especially for new areas that are under development. Such large-scale interventions can also take advantage of existing renewable sources of energy, such as wastewater heat or geothermal energy, which may not always be feasible at the building-scale. **Nature-based solutions** can also be considered at the city-scale to create cooling blue or green spaces, which can reduce the demand for air conditioning. Improving **public transport** service delivery, connectivity, and convenience can help promote its use. Local governments can also promote **collective energy services** such as 'community choice aggregation' (CCA) that allow LRGs or utilities to aggregate demand for residents and businesses and procure electricity accordingly, which can be more cost-effective. Some cities have also developed group-buying schemes for households to purchase quality solar panels and battery storage systems (BSS) at competitive prices [31]. Increased **digitalization** of the grid allows for developments such as 'virtual power plants', that can allow communities to aggregate their demand and provide services to the grid [32].

RECOMMENDATION 14

STRENGTHEN ENERGY INFRASTRUCTURE

One of the more pressing requirements to ensure a successful shift towards renewable energy is the **expansion of infrastructure**. This primarily includes grid infrastructure at the transmission and distribution level. Not only will new investments be needed to accommodate more dispersed and decentralized renewable energy generation, but the volume of electricity that needs to be transmitted will also grow as our energy demand becomes increasingly electrified. The system will also need to be more dynamic and digitalized in order to handle the more variable and decentralized flows of electricity, while also incorporating storage technologies and bi-directional flows. Moreover, enabling technologies to support such an energy system will also need to be accounted for. The major considerations are detailed below:

Invest in the transmission and distribution grid

PRIMARY RESPONSIBILITY

Local *National*

A high share of renewables creates novel challenges to the reliable functioning of the electricity grid. **Siting** is a challenge, as renewable power plant locations are often dependent on local geographic conditions. Renewables are **variable**, meaning there can be large fluctuations in energy produced from one hour to the next. Renewables also enable grid-connected but decentralized or behind-the-meter generation, which sometimes necessitates a two-way flow of electricity. Moreover, with **increasing electrification** rates, the share of electricity in meeting final energy demand will also rise drastically. As more end uses are electrified and the share of renewables increases, load patterns will continue to shift, meaning the grid must be able to handle larger and more variable loads. All of these require significant **investments** in transmission and distribution capacity, as well as other technologies to allow electricity to reach the end consumer. Governments at all levels should attempt to invest in and prioritize improvements in their grids in terms of reducing losses, increasing capacities and expanding interconnections.

Expand transportation infrastructure for renewable energy carriers

PRIMARY RESPONSIBILITY

Local *National*

The need for renewable fuels and energy carriers such as hydrogen and ammonia is also likely to grow to supplement renewable electricity, necessitating the upgrade of existing networks or the development of new ones. Such energy carriers can allow for sector coupling and facilitate the use of increasing shares of renewable energy. Local governments can contribute by **identifying clusters** of demand and supply for these fuels/carriers and assisting in the **planning of networks**. They can also contribute to generating demand for these carriers through a number of policy measures and financial support. However, national government support is crucial to determine **technical and safety standards**, as well as the feasibility of using existing networks, e.g. using existing gas networks for hydrogen transport.

Adopt sector coupling approaches

PRIMARY RESPONSIBILITY

Local *National*

Sector-coupling, i.e. enabling the uptake of renewable energies by coupling the electricity system with other energy consuming sectors, is likely to play a significant role. Its foundation is an electricity sector based on RE sources, that meets most end-use demand with electrification, and uses coupling technologies to balance any mismatches. For example, using excess electricity in 'power-to-x' applications. At the local level, it can also refer to integrating energy-consuming and -producing sectors for a more efficient system overall, such as waste (including wastewater), transport, water, heating/cooling, etc. and electricity. Local and regional governments can develop **supportive policies** and reduce barriers to enable this, such as through waste management practices.

RECOMMENDATION 15

IMPROVE ENERGY MARKET MECHANISMS TO ENCOURAGE RENEWABLES DEPLOYMENT

In many countries, the functioning of the electricity market can hamper investments in renewables due to excessive financial or technical obstacles. Improving the overall functioning of the electricity market can go a long way in providing the right signals on risks, returns, and investments over a longer time period and can lead to more rapid renewable energy development. There are number of mechanisms that can help, tackling both the supply and demand of electricity:

Supply: Net metering or billing

PRIMARY RESPONSIBILITY

Local *National*

Net-metering allows self-generators of power to be compensated electricity production that is injected into the grid. The amount of electricity injected is adjusted against the amount consumed from the grid. **Net-metering** involves compensation at retail rates, whereas **net-billing** involves compensation at supplier rates. Such cornerstone policies have supported the growth of rooftop solar sector. However, they can threaten the traditional utility business model, which can create resistance. In the case of **virtual net-metering**, power is not generated on-site but at a different location and it is netted virtually, which then accrues credits for the renewable electricity generated [28]. This allows customers without a suitable space, for instance, roof space for PV generation, to use renewables and still be engaged in the schemes.

Supply: Support through tariff systems

PRIMARY RESPONSIBILITY

Local *National*

The rate at which electricity generation is compensated can be used to spur the deployment of certain technologies by provided higher or more stable returns. Administratively-set pricing mechanisms such as **feed-in tariffs (FiTs)** and **feed-in premiums (FiPs)** have been used to provide additional compensation to renewable sources, over-and-above the wholesale electricity market price (where such a market exists). Feed-in tariffs are a fixed compensation that electricity producers receive for each unit of electricity produced and injected into the grid, whereas FiPs are an additional return (fixed or floating) that renewable generators can receive in addition to the prevailing market price, usually with a price cap or floor. Both serve the same purpose—by providing essentially guaranteed returns, they improve the bankability of energy projects. Although FiTs have been implemented mostly at the national level, several cities (particularly those with their own municipal utility) have also designed and implemented them, especially for rooftop solar PV generation [33]. However, setting an appropriate tariff is challenging—they can be too low to incentivize deployment, or too high resulting in a financial burden on the government budget and end consumers [20]. With increasing cost-competitiveness for some RE technologies, countries have resorted to auctions instead to assure cost-reflective prices. Auctions can also be useful **price discovery** mechanisms to set efficient FITs and FIPs [20].

Supply: Quotas and certificates

PRIMARY RESPONSIBILITY

Local  *National*

A renewable portfolio standard or obligation (RPS/RPO) is the most common obligation set by the government on electricity producers to procure predetermined shares of electricity or heat from renewable energy sources. This is most relevant to LRGs that operate utilities. Such obligations can provide **certainty** for the levels of RE deployment in a region. Such standards were set on electricity generation in the past, but recently they have been expanding to renewable heat as well. To ensure the proper functioning of these standards, they should be clear about the **eligibility criteria** of technologies and have a sufficiently long time horizon, with a robust **renewable energy certificate** (REC) system that acts as a guarantee of the renewable origins of the electricity purchased [20] [34]. RECs can be traded and eventually retired when 'consumed' to certify that the energy procured was indeed renewable.

Demand: Power purchase agreements

PRIMARY RESPONSIBILITY

Local  *National*

Some municipalities can opt for power purchase agreements (PPAs) to directly procure renewable electricity from suppliers. These can help indicate a **demand** for renewable electricity, and as such can spur supply. They can serve a dual purpose by helping guarantee **stable returns** for renewable energy projects, as well as more predictable rates for consumers. Such PPAs for wind and landfill projects played a vital role in achieving a 100% renewable electricity target (46% hydroelectric, 53% wind power, 1% landfill gas) in Aspen, United States [35]. **Collective PPAs** may be signed by cities in groups with universities, cultural institutions, local companies, and other smaller municipalities. National governments can support this process by established guidelines and best-practices to allow for such agreements.

Demand: Alternative markets and pricing

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Variable renewable energy tends to fluctuate in terms of production during the day. There is often excess production during the day when demand generally tends to be lower compared to morning or evening peaks. The overall cost of using energy during peak times is considered higher than during non-peak times; however, most electricity markets do not yet reflect this difference. **Time-of-use tariffs**, where prices vary according to the time, can be used to address this. They can help reduce peak loads and encourage patterns of electricity usage that can help the overall stability of the electrical grid, for example by charging vehicles when there is an abundance of solar PV generation. Similarly, markets for other services to the grid such as **demand-response measures**, and **capacity markets** can be developed to enable the reliable operation of the grid. This can serve to reduce overall system costs. However, implementing this can be challenging, especially in highly regulated markets, and would require sophisticated digital systems and engagement with consumers, as well as the cooperation of utilities.

Supply and demand: Carbon taxes

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

While many countries have yet to impose a tax on carbon, they can be very effective by internalizing the cost of carbon dioxide and other greenhouse gases (GHGs) into the cost of energy production. As renewable sources are generally low-to-zero carbon, they are more likely to benefit from this measure compared to fossil fuels. Determining an **appropriate price** of carbon is challenging but not impossible. Such taxes can be **phased in**, exempting certain sectors initially to protect economic competitiveness, as has been done under the European Union's Emissions Trading Scheme (ETS). Currently, there is a risk of leakages across borders and the fact that such taxes can be regressive i.e. place a higher burden on smaller actors/emitters. Carbon taxes are not a silver bullet, but when broadly applied can help more accurately assess the true cost of using certain goods, services and technologies. However, these are often outside the local government's purview, necessitating broader national or international programs.

UNLOCKING FINANCIAL FLOWS

RECOMMENDATION 16

ENCOURAGE INNOVATIVE BUSINESS AND FINANCING MODELS

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Local and regional governments can encourage the private sector in their territories to innovate with more flexible business models that are adapted to the needs of the community. For example, **'as-a-service (aaS)'** models that move away from traditional ownership can provide easily accessible services by removing the upfront cost. Similar models such as **'pay-as-you-go'** (PAYG) are popular for energy access projects as they build on the convenience of existing payment channels such as mobile payments [36]. **Leasing** provides another such opportunity for consumers to use RE systems—consumers pay a fixed lease payment for using the electricity without having to buy the system. Similarly, in terms of financing, LRGs can encourage approaches such as **'crowdfunding'** for their communities. Community members can own a stake in local energy projects for a relatively low rate, increasing their active participation in the transition. This funding can be used for entire projects or to cover financing gaps. However, trustworthy platforms and clear terms and conditions are needed for successful campaigns [37]. Mechanisms such as **green municipal bonds** can be a way for LRGs to raise financing tied to specific 'green' projects that promote renewables or energy efficiency and other environmentally-beneficial outcomes, as cities such as Vancouver have done [38].

RECOMMENDATION 17

PUBLIC FINANCIAL SUPPORT FOR DE-RISKING INVESTMENTS AND REDUCING UPFRONT COSTS

Public funds can be deployed purposefully to complement private finance by reducing risk perceptions, which can hamper the flow of finance, and so local, regional, and national governments can take a number of steps to reduce these. Governments can act strategically by providing debt, equity, or other guarantees in order to catalyze investments, particularly in the early stages of 'risky' energy projects [20] [39]. Development and green banks, often in partnership with local banks, can also provide similar assistance.

This is particularly crucial as the private sector must play a role in RE/EE investment, and is considered more risk-averse. Non-financial de-risking measures such as a **stable, consistent and clear policy environment** over a longer term can go a long way in reducing investor risk perceptions [39]. Several of the policy measures listed above, if implemented effectively, can help reduce risk. Some of the ways governments can deploy public funds are:

Loans

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Where the direct provision of funds is not feasible, LRGs can provide direct loans instead that can help support the implementation of sustainable energy measures[40]. Such loans can be provided at rates and terms that are more favorable than prevailing market conditions. **On-bill financing** is another option, where clean energy upgrades are repaid through utility bills—allowing for the savings and the repayment to be visible on the same bill [41]. The upfront costs could even be covered by third parties. However, loan conditions are still dependent on overall national financial conditions. National governments can support with de-risking measures, credit-enhancing efforts for LRGs, and reducing uncertainties in the overall business environment.

Property Assessed Clean Energy (PACE) mechanisms

Several municipalities in the United States use the Property Assessed Clean Energy (PACE) mechanism to encourage the uptake of energy efficiency measures or renewable energy, whereby residential or commercial property owners can undertake such improvements without an upfront payment, instead paying back the amount as an addition to their tax bills [8]. The debt obligation is also attached to the property, not the owner.

Subsidies, grants, and rebates

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Subsidies, through direct contributions or tax breaks and other mechanisms, can be adopted to promote market growth by reducing initial investment costs. Although direct subsidies have fallen out of favor as the costs of RE technologies have fallen drastically, they can still be deployed to encourage other similar transformations such as switching to electric heating or transportation, or supporting technologies that are under development, particularly in the early stages. Conversely, subsidies for fossil fuels should be reconsidered as they privilege them over renewable sources, while also keeping in mind the needs of vulnerable groups that rely on them. **Grants**, i.e. non-repayable lump sum payments, can be used in tandem with subsidies and also serve to encourage renewable uptake by reducing upfront costs. They are usually provided by governments or even utility companies.

For example, the city of Barcelona currently provides grants and subsidies for building renovations that cover up to 50% of voluntary renovations for PV cells or solar water heating [42]. Another option includes **rebates**, which are retrospective payments to compensate for previously incurred expenses. Rebates are commonly used for energy efficiency measures, including energy-efficient appliances and vehicles and on-site renewable energy systems. The amount of the rebate, payment schedules, and eligibility criteria are predetermined [43]. As with subsidies, rebates can be combined with other financial tools.

Tax benefits

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Local and regional governments can also use their fiscal powers. Taxation can be used to encourage or discourage the use of certain technologies or the adoption of certain behaviors in a city or region. The **revenue** raised can be channeled back into local budgets or earmarked for a specific purpose. Tax-related measures can include, but are not limited to, the imposition of direct taxes as well as tax reductions or exemptions on sales taxes, fuel taxes, or value-added taxes (VAT), and expense-related discounts such as accelerated depreciation. Local and regional governments can also use **'land value capture'** in order to raise tax revenue from developers and property owners and eventually reinvest it into the community [28]. However, taxation policy must be balanced with **socio-economic concerns**, and tax increases are not always politically popular. The balance between national and sub-national governments when it comes to fiscal powers will differ by country.

RECOMMENDATION 18

EXPLORE PUBLIC-PRIVATE PARTNERSHIPS AND FINANCING

PRIMARY RESPONSIBILITY

Local ●●●●● *National*

Public-private partnerships (PPP) can be a powerful tool for LRGs to implement energy projects in their territories. They can allow the realization of infrastructure projects that LRGs may not have been able to undertake on their own. The **allocation of risk** between the public and private partner depends on the PPP contract. Broadly, the functions of designing, building, operating & maintaining, and financing a project can be shared between the two partners, with ownership usually changing hands after a predetermined amount of time. Such partnerships can be deployed for renewable energy projects as well [44]. Following a similar logic, public funds from governments or international institutions can be used to spur the flows of private finance in what is termed **'blended financing'** [45]. In both cases, the public sector's strategic role can work in tandem with the expertise from the private sector to drive implementation. However, given that these are transactions with a higher level of complexity, national governments have a significant role to play in setting guidelines, capacity building, and creating an enabling financial environment.

WORKING WITH THE INTERNATIONAL COMMUNITY

RECOMMENDATION 19

PARTICIPATION IN KNOWLEDGE EXCHANGES

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

By learning from the experiences other cities and regions, local and regional governments can avoid doubling efforts and retreading the same ground. It is important that a **diversity** of experiences is available to learn from, from both Global North and South countries, as different solutions are possible in different contexts. Participating in active knowledge exchange and peer learning through existing city and other networks can provide access to new and creative solutions.

RECOMMENDATION 20

COLLECTIVELY ADVOCATE FOR SUB-NATIONAL GOVERNMENTS

PRIMARY RESPONSIBILITY

Local ●●○○○ *National*

Given that cities are home to over half the world's population and are also responsible for most energy consumption and greenhouse gas emissions, their voice is critical on a global stage. **Advocating collectively** for improvements in national framework, increasing the resources channeled to LRGs, and expanding LRG mandates can help improve overall policy processes. Collective advocacy can also help draw attention to the challenges LRGs face in implementation and accessing finance, providing valuable information that can help partners improve their processes and priorities when it comes to working with cities.

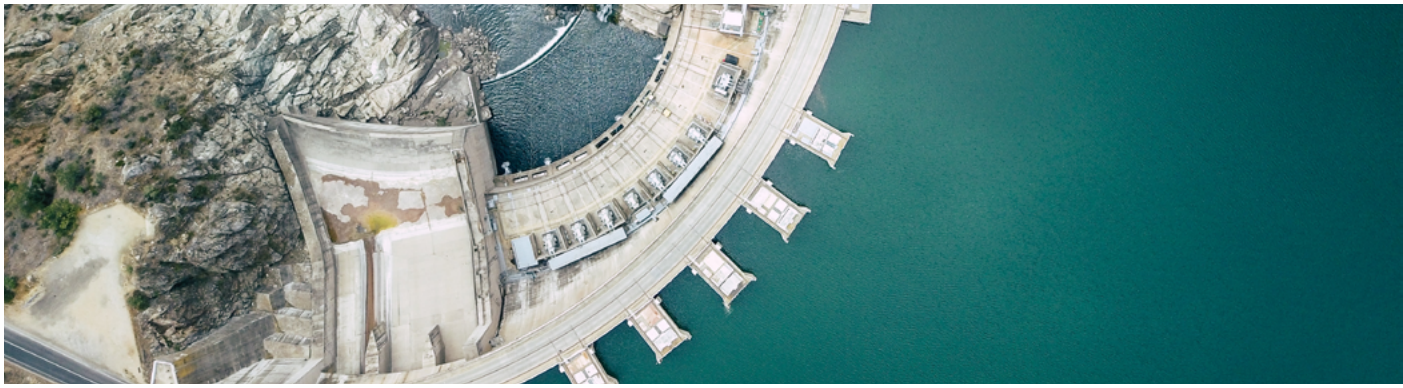
RECOMMENDATION 21

IDENTIFY INTERNATIONAL SUPPORT CHANNELS

PRIMARY RESPONSIBILITY

Local ○○●●● *National*

Collaborating with international organizations and financial institutions can provide an alternate stream of resources for LRGs, as well as access to technical assistance. For example, LRGs can take advantage of **project preparation facilities** to make sure the projects are ready for investment. The development of voluntary and compliance-based **carbon markets** can also allow for the international flow of finance, however care should be taken that projects are legitimate and provide real gains in terms of reduced emissions. However, an enabling national framework is needed to allow for the transfer of funds to local and regional levels.



KEY TAKEAWAYS AND CONCLUSION

In order for the energy transition to be successful, it must rest on certain key pillars, including renewable energy, electrification, and energy efficiency and conservation. Many local and regional governments have committed themselves to these goals and now must move towards concrete action. An **enabling policy framework** with the right incentives and disincentives is key for providing clear direction. Improved processes, such as widespread stakeholder consultation and buy-in, faster flows of information, and channeling resources effectively, are also critical. The following are some key takeaways:

- While local and regional governments may individually share a common goal, e.g. 100% renewable energy use, there are myriad pathways to get there that are highly dependent on the **local and national context**. As such, recommendations for one region may not be applicable to another, or may need to be adapted to the local situation.
- A local energy system cannot be seen in isolation as energy is a core input of virtually all human activity. When undertaking a transition to a **sustainable energy system**, energy sources and transportation routes, usage patterns, cost, etc. should all be considered alongside the interactions with other critical systems in a city or region such as waste, water, transport, health, education, heating/cooling, and so on.
- Local and regional governments are representatives of their **communities** and should seek their guidance wherever possible, particularly when it comes to energy usage patterns. It should also be kept in mind that usage patterns for energy and transport in particular can differ based on age, gender, race, income levels, etc., and the voices of diverse groups should be considered when making decisions.
- Cities are located in broader natural **ecosystems**, and care should be taken to limit pollution and minimize negative impacts on biodiversity. Renewables may be less damaging than fossil fuels, but they can have negative impacts on nature which should be mitigated. Integrating nature-based solutions into local planning efforts can also be beneficial.
- The importance of **data** and monitoring cannot be emphasized enough as it is key for effective implementation in general, as well as in improving linkages and trust with local communities and providing accountability to the overall energy transition process.

Accessing finance is often the biggest hurdle for local and regional governments. However, innovations that can facilitate financial flows, such as strategically de-risking investments, innovative business models, public-private partnerships, etc. can help overcome these challenges.

Local and regional governments do not operate in a vacuum, and so it is important to ensure effective **multilevel governance** and vertical coordination with higher levels of government. National governments should ideally create an enabling framework, with a reasonable level of devolution of powers matched with adequate resources. Continuous learning can allow for effective approaches to be scaled up from the local to the national level.

The transition to sustainable energy systems is as much an **infrastructural** challenge as a financial and political one. It will require massive amounts of investments, not to mention government and regulatory capacities in order to speed up approvals while keeping up with newer technologies and keeping in mind the impacts on the environment. Efforts should be made to expand capacity and streamline processes where possible.

Knowledge creation and learning should be a key part of any LRG's operations, be it through collaboration with academic and research institutions, community participation, or through international exchanges. It can help bring about innovative and responsive solutions to local challenges, building on the experiences of other peer cities and regions.

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100% RENEWABLES CITIES & REGIONS ROADMAP

The 100% Renewables Cities and Regions Roadmap project is implemented by ICLEI – Local Governments for Sustainability and funded by the German Federal Ministry for the Economic Affairs and Climate Action (BMWK) through the International Climate Initiative (IKI).

https://renewablesroadmap.iclei.org/

ICLEI Local Governments for Sustainability

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

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