Dossier on transition pathways towards 100% RE for cities and regions

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About

ICLEI Local Governments for sustainability (www.iclei.org) is a global network of more than 1,750 local and regional governments committed to sustainable urban development. Active in 100+ countries, we influence sustainability policy and drive local action for low emission, nature-based, equitable, resilient and circular development.

The dossier has been developed in the framework of the "100% Renewables Cities and Regions Roadmap" project (https://renewablesroadmap.iclei.org/).
The 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.

By working with local and regional governments from Argentina, Indonesia and Kenya, the project will foster multilevel governance, and put that collaboration at the heart of the sustainable energy transition.

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Disclaimer

Dossier package on 100% transition pathways

The present document should be considered part of a package of Dossiers (and Annex) assessing existing pathways towards climate neutrality in order to pursue the objectives of the 100% Renewables Cities and Regions Roadmap project, as well as support Local Governments (LG) wanting to set a 100% Renewable energy target.
The "Dossier on transition pathways towards 100% RE for cities and regions" (Badino 2020a) and its Annex includes pathways to 100% Renewable Energy and give policy recommendations, on top of clarifications needed for the LG to pursue successfully their vision.
The "Dossier on the applicability of existing transition pathways towards 100% RE for cities and regions" (Badino 2020b) assesses the pathways according to replicability criteria in order to reach a climate neutral future.
Finally, the specific context of the deep-dive cities and regions supported by the project are considered in the "Dossier on the applicability of transition pathways towards 100% RE for each deep-dive city and region of the "100% Renewables Cities and Regions Roadmap" Project" (Badino 2020c), where strategic considerations and suggestions can be found for each of them.

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Executive summary

Renewable energy systems are a great way to reach carbon neutrality of entire communities, fostering green economy and supporting almost all the Sustainable Development Goals (SDGs). The sustainability of the global economies in a world of limited resources can only pass through a stringent reduction of energy needs, followed by energy efficiency and 100% renewable energy (100%RE) systems for all sectors consuming energy. Local governments are a key actor to implement and foster the energy transformation worldwide, as they can set policy and regulations that can steer both market and personal behavior of their community. This energy system transformation in a complex interconnected global environment must be accompanied by a choral very ambitious and transparent leadership. The thorough understanding of the different types of targets, the technical aspects linked to each technology and application, as well as the tradeoffs derived by the impact of each technology are fundamental knowledge for the policy makers. A multi-sectoral integrated approach is needed when setting a vision and a strategy to reach it, as well as a lean step-by-step approach.

The key policy recommendations to achieve a global 100%RE goal in the community are:

1. Be visionary and ambitious
2. Sustainable energy for all
3. Connect at all levels
4. Develop a holistic, lean strategy and integrated policies.
5. Reduce consumption first, then go renewable and diversify
6. Be the local role model, invest, divest
7. Institutionalise the strategy
8. Define comprehensive legal and regulatory frameworks
9. Communicate transparently and broadly
10. Monitor and value interim achievements and adjustments
11. Promote training, capacity building and cultural change.

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Imagine fuel without fear. No climate change. No oil spills, dead coal miners, dirty air, devastated lands, lost wildlife. No energy poverty. No oil-fed wars, tyrannies, or terrorists. Nothing to run out. Nothing to cut off. Nothing to worry about. Just energy abundance, benign and affordable, for all, for ever. (Amory Lovins, Reinventing fire (Lovins et al.2011))

1. Introduction

As society and economy are still developing in a non-sustainable way while human welfare and health improve, demand for energy and associated services increases. As the Intergovernmental Panel on Climate Change (IPCC) reports (IPCC 2011), the energy supply has been dominated by fossil fuels since 1850, leading to a rapid growth of greenhouse gas emissions to unprecedented levels in the history of the planet.

Energy transition towards sustainable alternatives is needed: it is now acknowledged that the development model heavily based on fossil fuel on which industrialisation and progress were based is no more an option and a strong shift towards climate neutral and sustainable alternatives must happen as soon as possible.

Considering also that population grows and heavily moves to densely populated urban areas, strongly lowering our human growth and per-capita consumption is the only rapid option available to live in a World of limited resources, together with the adoption of energy efficient solutions for the remaining consumption and Renewable Energy (RE) sources to cover the demand. If implemented properly, Renewable Energy solutions contribute to mitigate climate change and increase adaptation and resilience to climate changes effect. At the same time, they ensure social and economic development, the well-being of ecosystems, energy security, rapid energy access to all and, consequently, social benefits for the whole community.

In order to stay below the 1,5°C climate temperature increase, research points out that a minimum of 95% emission reduction should take place by 2050. Renewable Energy Sources (RES) play a big role in covering the energy consumption that is left after the implementation of energy efficiency and consumption reduction measures. While covering the entire global consumption with RE (100% RE) by 2050 is the global target advocated for by the “2015 Energy Revolution Scenario of Greenpeace” (Greenpeace 2015), the World Wildlife Fund (WWF) calls for the urgent need of an intermediate step of more than 40% coverage by 2030 in order to be on track (WWF 2011). And before any percentage is calculated, a strong reduction of the overall consumption is needed. Obviously, these objectives are not to be considered reachable via isolated renewable energy projects, but they require coordinated implementation strategies that integrate all the social, economic and environmental planning goals and priorities the Local Government (LG) needs to address (Go100RE 2017). Tailor-made solutions considering a multi-level governance, multi-stakeholder and multi-sectoral approach are the key to success and, according to the IRENA Coalition for Action, the same can be developed for every country, state, region, city or company in the world (IRENA 2019).

A literature review on researches, policy papers and current best practices of pathways to reach 100% renewable energy supply for the community was performed: this dossier presents the outcome of this exercise, with a focus on the replicability potential, in order to increase the efficacy and the speed of the measures to be adopted worldwide.

Please not that, in the present work, the terms **"goal" and "target"** are used interchangeably as part of the climate change mitigation and adaptation strategy, referred to as **"strategy"** only assuming the same could (and should) include any other aspects of the community development. Moreover, the term **"Local Governments" (LG)** includes any level of government and administration (city, town, region, state), below the national government, which manages a community and its physical living space. Finally, the terms "roadmap" and "pathway" have been used as synonym, despite the first with a slight stronger accent on the context of a specific LG and the second as more general way to achieve the set goal.

Chapter 2 summarises the 100% RE roadmaps in place undertaken by LGs in various parts of the world, which are listed in the Annex. In the same chapter, the assessment of the existing pathways leads to the acknowledgment of the lessons to be learnt from local governments.
Based on these assumptions, the following two chapters (chapter 3 and chapter 4) cover more technical aspects behind such ambitious strategies. Finally, the dossier presents policy recommendations to LG leaders and policy makers (chapter 5) to learn from others' experiences and successfully set and implement 100%RE policies for their communities. The dossier draws final conclusions that can be found in chapter 6. A small glossary and the list of references follow. The Annex (Badino 2020d) to the present document, containing the overview and list of all the LGs assessed, can be found as separate document on the project website (https://renewablesroadmap.iclei.org/).

Figure 1-1 (Image by Larisa Koshkina from Pixabay)

2. Energy transition pathways towards 100% renewable energy

A number of the existing energy transition pathways towards 100% Renewable Energy (RE) of local governments (LGs) (towns, cities, regions, states) was collected (Badino 2020d) and summarised in this chapter.

Selection criteria for choosing the examples of LGs aiming to 100% RE roadmap:

1. **Clear commitment**: the LG in the list have a clear binding commitment towards reaching a complete supply for at least one sector (electricity, heating/cooling or transportation) with Renewable Energy Sources (RES). When the analysis of the available resources showed inconsistency or unclear binding commitment on certain aspects of the LG strategy, that piece of information has either not been reported or reported partially, focusing exclusively on certain and verifiable data in order not to leverage on altered commitments. Differently, whether the strategy contained technical or substantial mistakes, a "note" has been added.
2. **Applicability**: the experience presents policy elements that may be useful for policy makers in other regions;
3. **Geographic representativeness**: local governments have been selected from different parts of the world and grouped into Africa, Asia, Central America, Eastern Europe, European Union, North America, Oceania, South America and Caribbean;
4. **Integrated strategies**: when available, priority has been given to local governments with strategies including all energy sectors for the entire community (100% RE) or, at least, more than one sector;
5. **Levels of Government**: the selection has included different levels of governments: towns, cities, state or regional governments, national governments, as well as island regions.

It is not meant to be a comprehensive list of all commitments, but to provide inspiration and examples to local leaders, to share the lessons learnt and to improve and inform policy recommendations.

Challenges differ from developed countries, where the integration of increasing shares of variable RES are pressing issues, to developing countries, where technology and financial resources are rather the focus. Similarly, while energy access and social and economic development have been the primary drivers in most developing countries, secure energy supply and environmental concerns have been most important in developed countries (IPCC 2011).

As literature reports (Jacobson and Delucchi 2010, Delucchi and Jacobson 2010, Jacobson et al. 2019, Pacala 2004) and the assessment in this chapter confirms, the main hindrances to achieving such a wide cultural change to a global 100% RE are political,

managerial and social rather than technological or economic. The following subchapters provide the main results of the assessment of this Dossier.

Too timid commitments towards 100% Renewable Energy

The Global Status Report 2020 for Renewable Energy (GSR 2020) shows that renewable energy sources have still a big development potential in all the regions of the world, as shown in Figure 2.1 below.

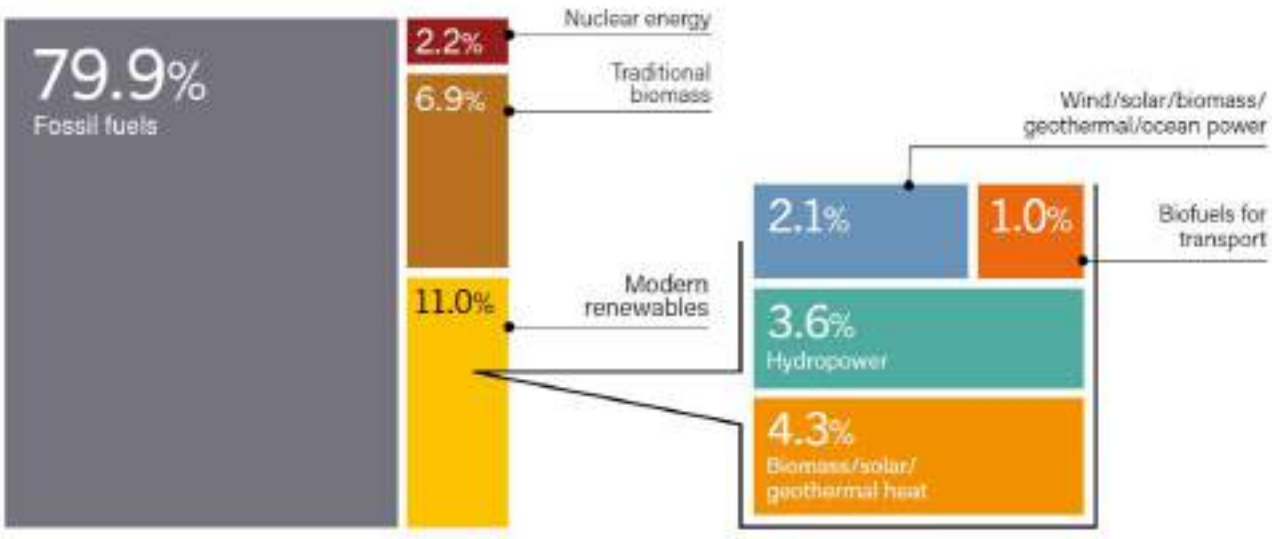

Figure 2-1 Estimated Renewable Share of Total Final Energy Consumption (IEA 2018 in GSR 2020)

Also from the assessment of the existing 100% RE roadmaps reported in Annex (Badino 2020d), the most outstanding output shows that many cities and regions around the world are already stepping into a 100% RE roadmap and leading the way for others to follow, but the **movement is still extremely timid**.

- A scant number of local governments took very strong commitments to reach a community-wide coverage with renewable energy for all sectors.
- Moreover, a limited number of cases implement a 100% RE strategy together with a climate neutral strategy (such as Frankfurt, Germany).
- Very few pathways include drastic reduction of energy use associated to renewable energy exploitation.

No pathway considers any policy on strong reduction of energy needs and demand before including the use of renewable energy, such as questioning and stepping out of the current pro-capita resource consumption patterns, lowering the population growth or introducing ambitious measures to save resources; the only energy reduction involved by a few

examples includes energy efficiency measures to be applied to the existing energy use and needs.

> This variety of ambitions can offer hope, as it still "*provides a tremendous potential for knowledge sharing and collaboration, and for identifying transferable policy lessons that may be applicable in other contexts*". System integration solutions in industrialised countries could inspire and support developing countries to make a leapfrog development establishing a climate neutral, fully renewable infrastructure from the start (World Future Council 2014).

As noted also in the Global Status Report above mentioned (GSR 2020, Figure 2.2), by IRENA (IRENA 2019) and other studies referenced here, the assessment of the pathways shows that the majority of the 100% RE commitments, strategies and policies address exclusively one sector (typically electricity). Very few cases (such as Sydney – Australia) consider also heating and cooling as a priority, while even fewer include also a transition to renewable energy in the transport sector.

This is also reflected in Figure 2.2, an infographic developed in the Global Status Report of Renewable Energy (GSR 2020, which shows the same trend in the previous years.

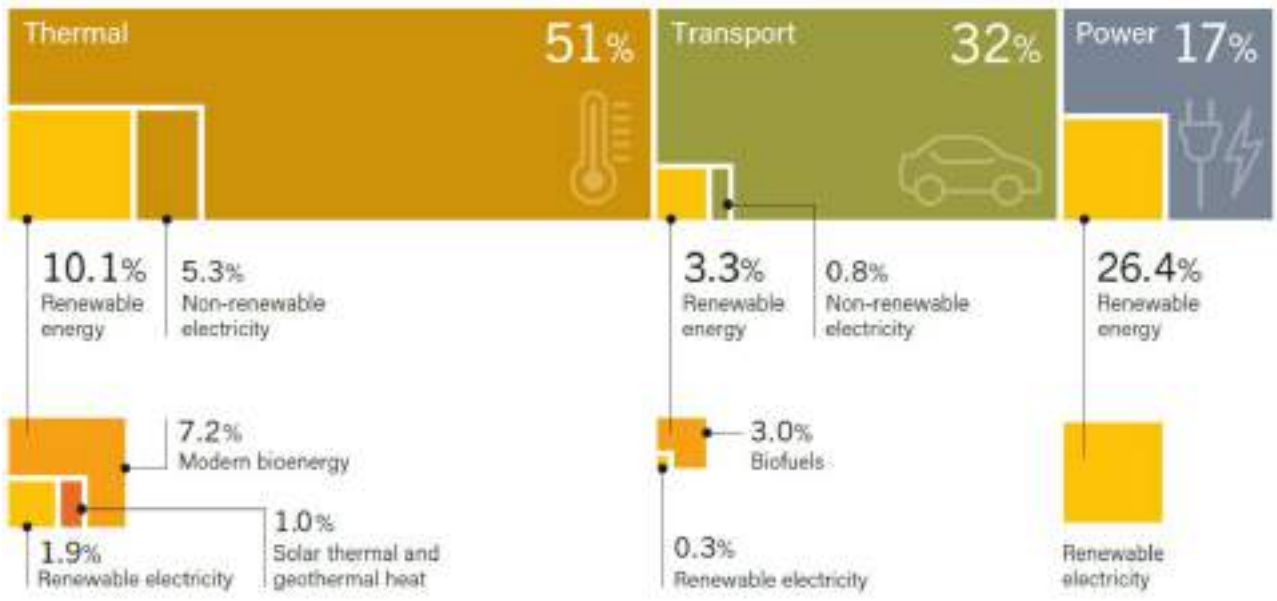

Figure 2-2 Renewable Share of Total Final Energy Consumption, by Final Energy Use (IEA 2017 in GRS 2020)

As noted by Greenpeace (Greenpeace 2015) too, policies supporting RE technologies and development in these sectors still lag far behind. Other local governments aim at carbon neutral and sustainable municipal operations as a mean to support transition to 100% clean energy. While these can certainly be a starting point, they would hopefully represent a first, initial step to explore 100% RE application in the framework of a more ambitious long-term commitment; unfortunately, they happen to be the only 100% RE commitment of the local government. On the other hand, a conspicuous number of local governments have simply pledged a generic wish to employ 100% clean energy but didn't engage in action yet. Finally, the distribution of the 100% RE visions is not yet global, but it is rather concentrated in a few countries (Greenpeace 2015).

Renewable Energy as driver for green economy

Urgent is the need for **increasing ambition and speed of the energy transition**, which present an unprecedented opportunity for development.

Research shows (Hansen et al. 2019) that 100% RE systems are technically feasible and economically viable, in particular when different energy sectors (such as electricity, heat, transport or industry) are integrated and a holistic planning approach is taken. Furthermore, studies state that it would be technically and economically feasible to produce all new energy systems with wind-, solar- and hydropower by 2030, while replacing existing energy supply systems with renewables by 2050. The transition is more energy efficient, cheaper and creates more jobs than the current energy.

Since 2009, the module prices for solar photovoltaics (PV) have fallen by around 80%, while wind turbine prices have declined by 30-40%, making the business case for renewable energy stronger than ever (IRENA 2019). Furthermore, clean energy solutions create more jobs per unit of energy than any other energy source (World Future Council 2018).

Figure 2-3 (Image by eko pramono from Pixabay)

Long term integrated approach to energy transition

A strong political effort is needed in order to reach a worldwide integrated approach to the energy transition, including **heating/cooling and transport** sectors with the same level of commitment as the other sectors, to holistically approach long-term strategies and to have concrete, quick actions to pave the way to 100% RE supply of all energy needs.

A stronger integration of storage systems for homes and businesses, as well as off-grid solutions to access remote areas are likely to be needed to achieve 100% RE worldwide, nevertheless, the analysis shows that they are not yet part of the many strategies currently developed. Information and communication technology (ICT) can be applied for power management and end-user services, integrating renewable energy in mini-grid systems (Greenpeace 2015).

Local governments as driver for change

Another important result that can be derived from the assessment of the existing pathways and achievements is that **local governments (LGs) can act as drivers for change and support the development of local businesses and jobs in line with the vision**, developing the existing track record of ambitious environmental policies or beginning one, creating momentum for a sustainable and green economy. In several cases, LGs support private strategies serving the community, acting as incubators for a new renewable energy

industry sector or supporting local businesses that aim at reforming the city economic profile.

In the most successful cases, such as Denmark, Sydney (Australia) or small towns in Italy, the vision of the LG shaped the development of the entire community feeling following the most ambitious of the strategies. Countries such as Germany, with the vision called "Energiewende" (="energy transition") or Denmark helped to build momentum around the RE sector, triggered innovation and inspired many countries. Also in the USA, despite the current political leadership at the national level is not supportive, local governments are showing their strong commitment and paving the way for energy transformation.

Barriers that should be addressed to exploit this potential are for example language knowledge or technical expertise, and intermediaries such as city networks and global associations can support greatly in this exercise.

Figure 2-4 (Image by AquilaSol from Pixabay)

Clear 100% strategy and implementation approach

Strong political commitment together with setting a binding and achievable long-term target is the first, necessary, step towards achieving a 100% RE goal. A **clear and transparent strategy together with a concrete step-by-step implementation approach** and integrated policies to support the transition across all sectors are key and

important components, as no tangible change can occur without the commitment of political institutions. The analysis of the existing roadmaps show that ambitious strategies are more effective when they are conceived with an holistic approach, both in terms of policies, sectors and stakeholders' integration.
Strong community engagement in all the phases of the roadmap development and implementation, as well as innovative business models, are often to be found in successful examples, since a clear vision supports stakeholders and citizens' engagement and allows for investments in the sector.

The call for forward-looking leadership is strong, considering that continuous exploitation of fossil fuel and the maintenance of the current economic status quo will rise the demand for increasingly scarce resources, likely to lead to economic, social and political instability, enhancing international conflicts (Jacobson et al. 2019).

Communication and miscommunication

An ambitious strategy such as reaching 100% RE supply for the community, requiring everybody to engage strongly and urgently, must be accompanied by the fairest and clearest communication.
Unluckily, one of the most striking results in the assessment of the pathways is that too frequently the targets and goals are **miscommunicated** or completely misunderstood. This can be found in the news on the press, but also, which is more concerning, in official documents and publications of local governments, as well as reflected in global organisations and networks' official assessments.
Following the considerations in this chapter, the present dossier intentionally avoided developing a graphic overview of commitments, as well as including the several graphs and figures available in the literature reporting the total numbers of "100%RE committed cities and regions" globally. While such data can be accessed in several reported resources (for example, IRENA 2019, Brot für die Welt and World Future Council 2018), the same need to be interpreted bearing in mind the complexity of grouping considerably different visions or the same can be misleading. Somehow, the information they give can be considered as representative of the intentions of local governments, rather than analogous commitments.

Figure 2-5 (Image by Pete Linforth from Pixabay)

Among the most common examples, miscommunication presents as a “100% RE” goal or achievement, implicitly referring to a community-wide and multi-sector coverage, an objective or result which is, actually, covering only a part of the total energy consumption. Simply omitting important pieces of information in the title or in the summary, such as “in electricity sector”, “in local government operation” can lead to false expectations. Other examples display as a commitment a mere wish of the mayor to be involved in a green energy transition, with no concrete strategy to actually reach a 100% RE or carbon neutrality vision nor plan to have one.

Other examples, furthermore, show more technical mistakes such as confusion on the different types of targets and goals (see chapter 4), which drastically change the meaning of the roadmap itself: depending on the type and characteristics of the target and what the 100% is total of (refer to chapter 4), the vision could be very little ambitious whilst still called “100% RE”. Against the agreed definition of 100% RE (see chapter 3), some examples fail to consider the “installed capacity” instead of the energy consumption or include nuclear, non-renewable biomass or even “natural” gas in the count of RES.

It seems there is a lot of confusion when setting targets and strategy, concerning:

- definition of renewable energy and type of sources;
- the differences among various types of energy efficiency strategies or 100% RE targets and goals and what the reduction or the percentage refers to;

- difference between energy consumed or generated and power installed or, else, between peak consumption and average yearly consumption;
- commitment scope - community-wide or some sectors- or other characteristics of the target itself;
- the role of sharing a binding commitment rather than a generic management vision, announcement or advocacy with no actual plan or strategy.

In order to understand what the LG is actually committed to and in order to find the real level of GHG emission reduction and/or 100% RE target, it is necessary to compare several sources, possibly knowing different languages, and to read each word accurately.

The assumption made in the present paper is that the above-mentioned miscommunication is not due to express intent. It is probably the result of a genuine willingness of political leaders to show their strong ambition and wishes for their community, however, visions and goals should leverage on clear and transparent strategies to be shared with the community. Miscommunication could also derive from a lack of understanding of the technical jargons or from the lack of expertise at various levels that could prevent the understanding of the differences among the various types of targets, levels of ambition and achievements.

In the framework of the present dossier, these findings lead to the need for inclusion of some technical definitions in chapter 3, such as related to energy and power, as well as to specifically renewable energy, its sources and what does "100% renewable energy" mean. On the other hand, chapter 4 explains the types of targets and goals that can be chosen within an energy efficiency or 100% renewable energy strategy.

Technical details of an ambitious strategy

The issue of **miscommunication and lack of technical awareness** is very concerning, even more when a local government sets such an ambitious and clear vision for its development, as the same can result into the failure of the strategy, leading to a lack of engagement and investments at all levels.

In order to make sure that there is no misleading communication, local governments leaders, as well as technicians and communicators (and whoever has some responsibility related to the strategy implementation) should have the most complete understanding of the vision, of the steps to be implemented to reach the goals as well as of the barriers and possible difficulties. When internal capacity is not available, external experts or support from peer local governments, other levels of government, available literature and formal training courses should be employed.

Official announcements and documents should be transparent and clear, including any variation to the initial plan and to the vision that were previously communicated. Among the implications of a non-transparent communication, on a global level, is the

impossibility to compare results and group achievements without a huge and meticulous effort. Bad quality aggregations of 100% renewable commitments, therefore, bring to a lack of transparency of the global vision itself. Moreover, international funds would not invest in an unclear space, where the strategy does not leverage on step-by-step transparent goals.

On a local level, one of the main reasons that could doom the strategy to fail is the lack of trust and engagement that citizens and businesses can develop towards a straightforward and clear strategic plan.

On a more ethical level, finally, raising the degree of ambition implies a leap towards a community vision which requires effort both at the social and the technical level: the bases of trust and relationship should, therefore, be strongly placed. Politicians should set themselves in a new collaborative space with the community: recent leadership models are evolving from the old management concept of strong hierarchy demands, to new models in which the group of followers is engaged on a same vision. Experiences such as positive leadership or teal management show that more personal aspects of the human being are stronger drivers of motivation to engage rather than obligation or monetary compensation. This is true for businesses as well as for local governments, who can reach their strategic objectives together with citizens, businesses and stakeholders in a participative atmosphere. The local government should be example and enabler of the transition and transparent communication and collaboration are the only possible alternatives.

Figure 2-6 (Image by hanneslindblom from Pixabay)

"There is no greater waste of resources in ordinary organisations than the energy expended every day to hide our weaknesses and manage others' favourable impressions of us" (Kegan et al. 2016)

3. Renewable energy, carbon neutrality and 100%RE definitions

Renewable Energy (RE) and Renewable Energy Sources (RES)

Renewable Energy (RE) is defined as "*energy that is produced by natural resources—such as sunlight, wind, rain, waves, tides, and geothermal heat—that are naturally replenished within a time span of a few years*" (Lund 2010), therefore produced in a sustainable manner.

According to IRENA (IRENA 2019, IRENA 2020), the following can be considered **Renewable Energy Sources (RES)** *inter alia/including*:

- Solar energy;
- Wind energy;
- Hydropower;
- Geothermal energy;
- Bioenergy*;
- Ocean energy (including inter alia tidal, wave and ocean thermal energy).

Many of the RES can supply electricity, thermal energy and mechanical energy, as well as they can be used to produce fuels to meet other energy service needs. Some RE technologies can be part of decentralised systems in urban and rural areas, directly deployed at the point of use, whereas others are primarily deployed within large (centralised) energy networks (IPCC 2011).

Non-renewable energy and RES impact

The fact that the lists of RES are often presented as "examples", leaves the inclusion of other sources quite open (with terms such as "including" or "inter alia") and it happens to find nuclear energy, biofuel from non-renewable sources or even "natural" gas included erroneously among the RES. Also, despite "renewable" to a certain extent in certain conditions, the allowance of biomass among RES can have (and often has) very dangerous implications (see in-depth analysis below) and should be avoided whenever possible.
While it is important to leave some extent of freedom to adapt the definition to the local context, it should be clear that, in order to be defined "renewable" the sources should necessarily be included in the framework of the above-mentioned RES, and that the way in which the same resources are designed, installed and run play a key role in the assessment of their benefits.

Non-combustion RE technologies (like solar, wind or hydropower) can offer benefits with respect to air pollution and related health concerns.

Water availability could influence the choice of RE technologies, as some are particularly vulnerable to conditions of water scarcity and climate change, moreover, others providing similar services without stress on water resources are available. In the same way RE-specific impacts on biodiversity may be positive or negative and it is the specific context that determines the degree of impact on biodiversity. Therefore, many impacts can be mitigated by siting considerations and by integrated planning (IPCC 2011).

Policy makers should pay particular attention to those RES which require special consideration, as they might have implications for sustainability, environmental pollution, food security or social justice. Despite being preferable to avoid, low-impact, small hydro and some forms of biomass may be included after being evaluated for the above-mentioned concerns (Sierra Club 2020), while new, large-hydro power systems should be abstained from use whenever possible.

A brief description of the different RES is given below, with an overview of the most common applications and challenges for their deployment (WWF 2011, IPCC 2011). Before that, few further clarifications are required concerning nuclear energy, hydrogen and electrification.

- **Nuclear is not a RES.** Nuclear power is seen by some parties as part of the roadmap to a fossil free world, as it produces large-scale electricity with low carbon emissions. Adding concerns to the high energy intensity of the mining and enriching process of uranium, nuclear fission produces dangerous waste with high toxicity for thousands of years and with no place to be safely stored. On top of these environmental issues, material and technologies for nuclear energy can be used to produce nuclear weapons. Political instability, extremely high costs of the nuclear option and the high technical expertise needed to guarantee the safety of its technology are additional concerns that, with the above-mentioned points, lead to the conclusion that investing in other sustainable energy technologies should be preferred (WWF 2011).
- **Hydrogen is not a RES.** Whilst often erroneously listed among the RES, **hydrogen** is not an energy source, but rather a “vector” of energy – which was previously produced using an energy source. The transformation processes from primary energy to hydrogen and to energy to be used present some energy loss, but, when producing hydrogen from a renewable source of energy, these losses are considered acceptable and hydrogen technologies are welcome.
- **Electricity is not a RES.** Similarly, when advocating for the **electrification** of certain sectors or activities, it should be clear that the GHG emissions associated to electrification depend on the source with which the electricity was produced in the first place. Whilst this is useful to avoid emissions of local pollutants even when fossil fuels are used, the vision is to produce electricity from RES. Also this

transformation process presents energy losses, but whether electricity is derived from a a renewable energy source, electrification of entire sectors is welcome.

In order for the extreme valuable role that renewables can play to support us in our future is not spoiled, it is key to understand pros and cons of each technology, how and when it should be used, and which kind of trade-offs require a necessary selection.

Renewable energy sources and considerations

Renewable energy sources should not be seen as the saviour of our society as such, but a tool that can allow us to stop our dependence to fossil fuels while reinventing the way we consume and grow.

Solar

Solar energy technologies harness the energy of solar irradiance providing electricity, thermal energy and light.

Photovoltaic (PV) systems produce electricity and can be integrated in devices, buildings or installed on exposed areas (such as industrial sites rooftops or parking areas). Concentrating solar power (CSP) focuses the solar rays into a small area through mirror or lenses, collecting the generated heat for other purposes (for example, heating water to generate electricity via a steam turbine or direct heat). On a small scale, the same process can be used for cooking purposes.

Solar thermal systems heat water, which can be used for sanitary purposes or in the building sector and can also be easily integrated. With appropriate technologies, they can also be used to cool buildings during the hot seasons.

Figure 3-1 (Image by teresa cotrim from Pixabay)

Wind

Wind energy harnesses the kinetic energy of moving air and nowadays it is mainly used to produce electricity from large wind turbines located on land (onshore) or at sea- or in freshwater basins (offshore). Despite the high visible effect on landscape, the environmental impact of wind technologies is minimal, provided that the same are well planned - for example, they can coexist with farmlands (grazing or crops). Both on- and offshore applications require sensitive planning in order to minimise the impact on aquatic, terrestrial and aerial fauna.

Figure 3-2 (Image by Free-Photos from Pixabay)

Hydropower

Hydropower harnesses the energy of water moving from high to lower elevations, primarily to generate electricity. Systems span from large dam projects with reservoirs to run-of-river and in-stream projects. The operation of hydropower reservoirs can offer multiple uses in addition to energy supply, such as providing irrigation, drinking water, flood and drought control, navigation.

Hydropower systems can have severe environmental and social impacts: they can threaten freshwater ecosystems and the livelihood of people depending on the water

flowing downstream. Such systems fragment habitats and can cause the displacement of entire communities. New hydropower schemes should meet stringent environmental sustainability and human rights criteria, minimizing any negative impact on river flows and freshwater habitats, too.

Figure 3-3 (Image by David Mark from Pixabay)

Ocean

Ocean energy derives from the potential, kinetic, thermal and chemical energy of seawater, which can be transformed to provide electricity, thermal energy or potable water. The potential of this technology is high but significant challenges are still in place and further research and development are needed. A wide range of technologies are possible, such as barrages for tidal range, submarine turbines for tidal and ocean currents, heat exchangers for ocean thermal energy conversion and a variety of devices to harness the energy of waves and salinity gradients. Counting still for a small percentage of global development, it is likely to become significant only in specific suitable areas, like America's Pacific Northwest and the British Isles. Because of their potential impact on the marine environment, coastal communities and maritime industries (such as fishing and shipping), it is critical that appropriate sites and technologies are selected and applied with a careful planning process that minimises any negative impact.

Figure 3-4 (Image by Dimitris Vetsikas from Pixabay)

Geothermal

As one of the most ancient technologies to be used, geothermal energy utilizes the accessible thermal energy within the Earth to provide heat. Geothermal reservoirs are accessed using wells or other means (such as pipe grids) and the extracted fluids at various temperatures can be used. When the temperature is high enough, the fluid can be used to generate electricity or, more directly, for applications that require thermal energy, including district heating and high-temperature heat for industrial processes. The first layers of the earth can also provide constant thermal energy that can be exploited with various technologies, such as geothermal heat pumps used in heating or cooling applications. Whilst extracted fluids can contain toxic components, closed loop systems can prevent them from escaping. Similarly to other sources, a careful design and planning of the technology in the area and context is required.

According to WWF (WWF 2011), geothermal energy can provide central heating for buildings in almost all parts of the world. Differently from other RES, geothermal sources provide a constant supply of energy output.

Figure 3-5 (Image by WikiImages from Pixabay)

Biomass energy

Materials derived from living or recently living organisms can be used to develop bioenergy – either to produce electricity or heat directly, or to create gaseous, liquid or solid fuels. Biomass energy sources (also described as biofuels) are used through combustion and can include biomass feedstocks (including forest, agricultural and livestock residues), wood from short-rotation forest plantations or energy crops and the organic part of waste production.

Biomass is listed among the RES based on the concept that the plant material used can be replaced through re-growth and the carbon dioxide that is emitted from burning the harvested biomass can be absorbed by the new plant growth. Though, this are over-simplified assumptions and additional arguments should be considered about the sustainability of using biomass as a fuel source (GMI 2013). Its sustainability strongly depends on land and biomass resource management practices. Policy and mandatory certifications play a key role to ensure the highest standards, as well as a thorough understanding by local leaders and policy makers about the complexity of the various interactions linked to biomass use.

Several concerns are posed regarding biomass energy:

- Under the same term, many very different alternatives are listed, ranging from more sustainable practices to highly unsustainable plants;
- Literature is non unanimous about the sustainability impact of biomass exploitation, thought a general choral concern is present the larger the biomass plants are and the more they exploit a resource grown on purpose to be burnt.
- Fossil fuels are often used in biomass production (for example, in order to cultivate and harvest biomass crops);
- Biomass is transformed into thermal or electrical energy via combustion processes, which release a variety of pollutants as well as GHG gases in the atmosphere – the latter partly compensated provided that plant regrowth is sufficient to absorb the carbon dioxide released and that good management practices are applied;
- Other substances, comprising fossil based material, might be added to facilitate the combustion of biomass (in particular for wet materials) and allowed by many regulations - thus worsening the environmental impact of the biomass utilization and the social acceptance of renewable energy sources in general;
- Biomass exploitation is one of the main causes of deforestation and unsustainable land use, impacting also on human rights and social justice themes, on top of representing a threat to biodiversity, and to the availability of land for food and water supply to people's needs.

Considering all these concerns and the complex interaction between management practices, policies, human rights and social justice, costs and economy, in a context of global capitalistic culture, the overview of biomass exploitation is highly alarming. It seems that misunderstandings, mismanagement and consequent miscommunication can be a very easy trap for any local leader wishing their community to go renewable. Though, when biomass production is not sustainable, the environmental and social impacts can be enormous, as well as policy backlash and lack of trust from citizens and stakeholders on renewable energy in general.

Considering the unclear debate, the suggestion for local governments (LGs) would be to prefer other types of RES and consider biomass as a final resort, making sure all the highest sustainability standards are met in all phases of biomass use. This could be the case when it is the only suitable replacement for fossil fuels- typical applications in this sense are aviation, shipping and long-haul trucking or specific industrial processes, or else as a possibility to derive energy from organic products that would otherwise be wasted (such as agriculture and food processing, manure or organic municipal waste), leading to avoided waste in landfills and co-products. The design of the plant should take into consideration the amount of this kind of waste production, in order to avoid the need of lacking material to meet the system demands.

Small scale biogas digesters can provide cooking and lighting to households. Local and indoor air pollution (alongside GHG emissions, deforestation and forest degradation) can be improved by substituting local biomass for cooking and heating purposes with less

polluting RES such as solar, as well as its use could positively impact on the associated health repercussions, particularly for women and children in developing countries.

Figure 3-6 (Image by Free-Photos from Pixabay)

Carbon neutrality

According to the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2019), **carbon neutrality (or reaching "net zero emissions")** refers to balancing the amount of anthropogenic emissions of greenhouse gases (GHG) released in the atmosphere over a specified period with an equivalent amount that can be either sequestered or offset or by buying enough carbon credits in the market.

Carbon sequestration or carbon dioxide removal (CDR) is "*the long-term removal, capture or sequestration of carbon dioxide from the atmosphere to slow or reverse atmospheric CO_2 pollution and to mitigate or reverse global warming*" (Wiki 2020). Naturally, this happens through biological, chemical and physical processes at a certain rate and it can be accelerated (or slowed down) through changes in land use, agricultural practices and forestry management. Artificial methods and technologies have recently been developed to enhance the effects of sequestration, as they are seen as part of the solution to address climate change mitigation.

A **carbon offset** is "a reduction in emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere" (Wiki 2020). Carbon offsets can be made in the so-called "carbon markets" briefly presented below:

- obligatory schemes: companies, governments or other entities can buy carbon offsets to comply with certain regulations (such as the United Nations Framework Convention on Climate Change - UNFCCCs' Paris Agreement) which allow them to emit GHG up to a certain threshold. The EU trading scheme is an example;
- voluntary schemes: individuals, companies or governments can purchase carbon offsets to mitigate their emissions. A direct experience can be made when buying a flight ticket, where the option to pay an increased fare to allow the company to "compensate the CO_2" emitted during the trip is offered.

Despite using fossil fuels for its energy consumption, an entity can be declared as "carbon neutral" by planting trees to balance the emissions, funding local or global programs and projects aimed at reducing GHG emissions or purchasing carbon offsets in the market. On the other hand, when using RES locally to meet the energy demand, the above-mentioned practices are not needed and the various benefits for the community previously described can be enjoyed, too.

In line with what suggested in chapter 5 of this Dossier, ICLEI – Local Governments for sustainability (ICLEI 2020b) suggests 4 steps for local governments to achieve climate neutrality, reported in the infographic below (Figure 3.7). It is important to note that step 1 "Go low-to-no" is particularly important in order to reach 100% RE coverage: the energy demand should be first of all severely reduced, in order to apply energy efficiency measures on the remaining consumption, and be able to tackle the final energy consumption after all these interventions with a total coverage through a variety of RES.

A local government should also divest from fossil fuels and unsustainable practices, and rather invest this budget in activities and actions that are aligned with the 100% RE vision. If there is any emission that cannot be reduced nor covered with RES, as mentioned above, offsetting is an option.

Figure 3-7 Steps suggested by ICLEI in order to achieve climate neutrality (ICLEI 2020b)

The meaning of reaching "100% Renewable energy (100% RE)"

When defining a "100% RE target" it is crucial to understand what this entails.

In 2020, the IRENA Coalition for Action agreed on the following definition for **100% renewable energy (100% RE)** (IRENA 2020):

"One hundred percent renewable energy means that all sources of energy to meet all end-use energy needs in a certain location, region or country are derived from renewable energy resources 24 hours per day, every day of the year. Renewable energy can either be produced locally to meet all local end-use energy needs (power, heating and cooling, and transport) or can be imported from outside of the region using supportive technologies and installations such as electrical grids, hydrogen or heated water. Any storage facilities to help balance the energy supply must also use energy derived only from renewable resources".

This is in line with the definition from "The Global 100% Renewable Energy Platform" (Go100RE 2017): a 100% RE goal is "*fully achieved when the amount of renewable energy generated within or imported into the defined area equals or exceeds the annual energy consumed*".

The underlined expressions in the definition should be further reinforced, as they don't seem to be homogeneously applied in the assessed pathways in Annex (Badino 2020d): the totality (100%) refers to the energy consumption and not the power installation and the same should be calculated on the yearly consumption, not on the peak production of a specific RE system.

In order to avoid confusion or miscommunication, the 100%RE definition proposed in the present dossier and the related documents (Badino 2020b, Badino 2020c, Badino 2020d), if not else specified, is the following.

100% RE is the ideal energy transition of a community-wide coverage of the energy consumption in all sectors, strictly with renewable energy resources only:

- Bioenergy,
- Geothermal energy,
- Hydropower,
- Ocean energy,
- Solar energy or
- Wind energy

with potential offset used as last resource.

In short, "100% RE" is defined as equivalent of carbon neutrality achieved via the sole deployment of renewable energy in the whole community.

Some clarification of technical jargon related to RES

Without approaching excessively technical details, a few clarifications of the technical jargon appear to be useful.

When talking about **power**, it is referred to the rate of doing work or transferring heat and it is measured in Watt [W] or Joules per second [J/s] and their multiples. When talking about **power installed**, the same makes reference to any system (such as a photovoltaic plant or a wind turbine) and the total production capacity embedded in the system: multiplying the available power for the working hours, it is possible to calculate the **energy production** of the system. Usually, the power of a system is defined with its value of peak power and designers need to evaluate the average effective power to be considered in the calculation of the total annual production of the system.

When talking about **energy consumption**, be it for a certain sector, for the entire community or for anything which requires energy to work, such expression refers

"Energy is considered a prerequisite for development and for a life with dignity, essential to overall human progress, social welfare, technological advancement and essential to human rights." (World Future Council 2018, UN SDG 2015).

to all the energy used to perform an action. When talking about a complex system such as a city, this often refers to an **"energy mix"** coming from different sources. The typical energy units in this type of context are the Joule [J] or the Watt-hour [Wh], which is equivalent to 3600 Joules [J] and corresponds to the work done by a power of one Watt operating for one hour. Usually, multiples of Wh are preferred: kilowatt-hour [kWh] which is 1000 times bigger than a Wh; megawatt-hours [MWh] which is 1000 times a kWh and gigawatt-hour [GWh], which is 1000 times a MWh. The amount of energy consumed by a complex system varies in time and it can present peaks and variations on a short scale (i.e. hours or days), medium scale (i.e. month or seasons) or long scale (i.e. years or decades). When aiming at covering the energy consumption of a community, it is meant to refer to the average yearly consumption and not to temporary peaks.

Against the definition of 100% RE mentioned above, it happens to find targets set in terms of installed capacity instead of final energy consumption. This is a key difference and very important aspect to consider in order to avoid misleading communication. A 100% RE target should always be set on the final actual energy production and consumption: simply focusing on installed RE capacity, there could still be shares of energy consumed that has been produced with fossil fuels, and that would not be monitored together with the target results. Setting targets in terms of capacity has little significance and should not occur (Brot für Welt and World Future Council 2018).

Setting 100% RE target does not necessarily mean energy independence or self-sufficiency. Interconnected transregional/transnational systems, multi-level cooperation and local grid integrations are key to achieve a 100% RE future globally.

RES and Sustainable Development Goals

While directly linked with "access to sustainable, secure and affordable energy to all", one of the three pillars of the Global Covenant of Mayors for Climate & Energy initiative (GCoM 2020), similarly described as Sustainable Development Goal (SDG) 7, 100% RE strategies support the implementation of all the 17 SDGs (UN SDG 2015, World Future Council 2018), as shown in Figure 3.1 below. To mention only a few examples reported in literature (World Future Council 2014 and 2018, UN SDG 2015) and evident from various experiences worldwide, the development of renewable energy based economies reduces the inequalities suffered by vulnerable parts of society living in slums or remote or rural areas, not served by existing infrastructures, and it ensures equal opportunities to economic resources and education. The pathway towards 100 % RE can generate significant cost savings, the bigger the nearer is the target. Ranging from reduced fossil fuel imports to improved energy and economic security, from reduced externalities due to biodiversity losses to health issues, economic benefits for citizens, businesses and governments are clear.
In addition to cost savings, the creation of new economic activities, green jobs and new

business models can be triggered, generating new sources of domestic revenues and improving the quality of life of the entire community.

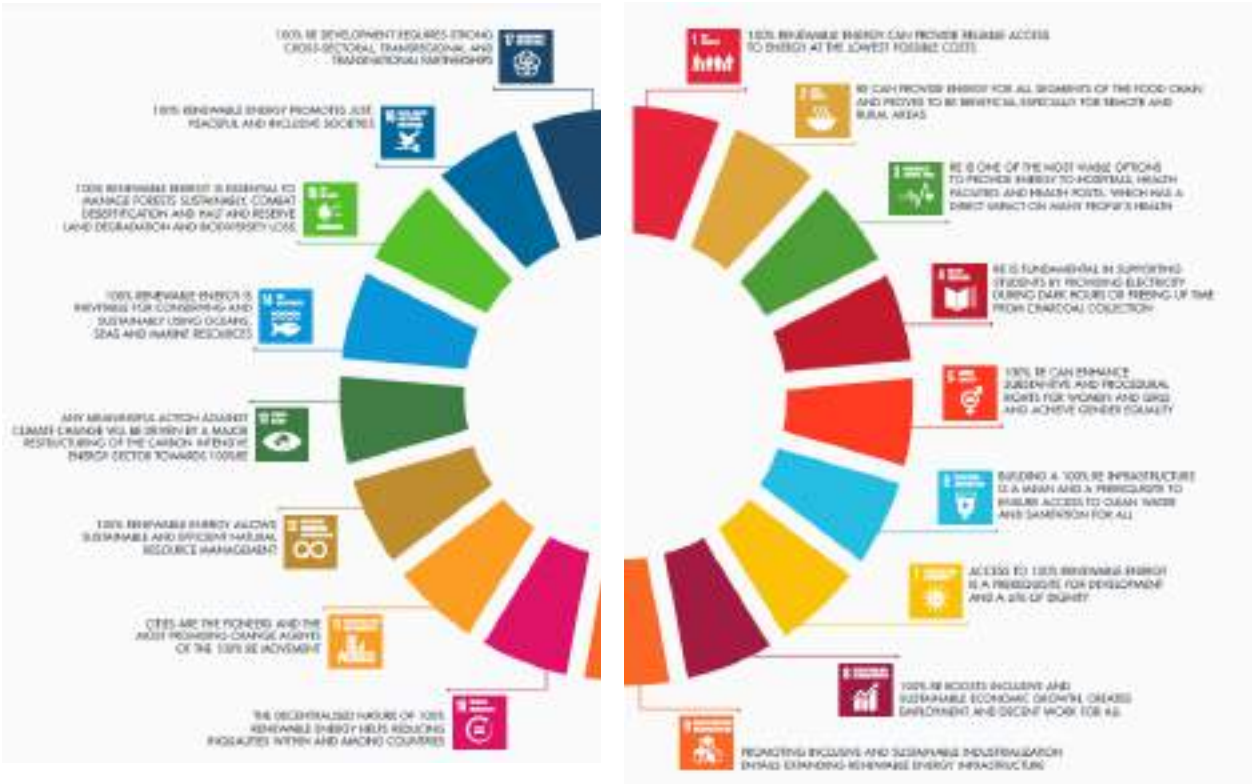

Figure 3-8 Renewable energy relationship with Sustainable Development Goals (SDGs) (World Future Council 2018)

Additionally, transitioning to 100% RE can mitigate risks and help countries to become more resilient. From an economic point of view it reduces the exposure of local governments to external economic and political factors. Moreover, renewable energy sources ensure access to water and sanitation for all thanks to resilient and low cost renewable options for water treatment and pumps. A fossil fuel free economy improves environmental quality thanks to avoided pollutants both in the different phases of the extraction and the transportation of fossil fuels as well as in their exploitation. 100 % RE strategies are not just for the wealthiest countries. Development benefits provided by RE technologies, as well as access to sustainable, secure and affordable energy to all, are applicable worldwide and can ensure good livelihood for all.

4. Targets and goals: 100% of what?

The successful implementation of a comprehensive and coherent 100% RE strategy starts with the definition of politically binding targets and of goals to be reached. A target should be time-bound, measurable and clear from the beginning: the scope of application, the sectors and the boundaries should be well-defined. Before setting any commitment, a local government should unequivocally clarify the characteristics of the target itself, which establish the direction of the roadmap and the level of ambition, while informing the strategy to be adopted. Moreover, a clear understanding helps to communicate in a transparent, open, accessible and comprehensible manner what does the 100%, the totality refer to.

Figure 4-1 (Image by Ana Carolina Franco Pixabay)

"It is important to "make the invisible visible" by encouraging debate on the unaddressed topics of the energy transition and highlighting where renewable energy makes, and can make, a major difference" (REN21 2020)

While the technical definition of "100% RE" can be found in chapter 3, some clarifications on the nature of "setting a 100% RE target" are given below, avoiding to be excessively technical but rather aiming at clarifying part of the confusion arisen from the assessment of the existing 100% RE pathways. Specific reference to targets and goals aiming at the reduction of GHG emissions or at 100% RE supply of energy consumption were considered and the discussion is left sufficiently broad to clarify the concept to policy makers, without presenting unnecessary technical differences.

The strategy to reach 100% RE can combine different types of targets, including more ambitious long-term goals with more limited short- and middle-term stages.

Once the local government understands which type of target wants to adopt (see the following chapter "Types of target"), it is important to define which scope they want to include and which sectors should be considered in the climate strategy. Finally, they should make sure that the plan and the vision is well institutionalised when adopting it, and set policy and resources allowing the plan to be implemented (See infographic below – Figure 4.2 in ICLEI 2020b and chapter 5 for reference).

Figure 4-2 ICLEI's suggested steps in order to plan and implement climate mitigation and adaptation actions (ICLEI 2020b)

Baseline assessments

A very good exercise that informs and helps in the definition of the best strategy to reach a 100%RE target for the specific context, and the type of target itself to be selected is to develop an assessment of the baseline of the local government (LG) area.

The term **baseline** is generally used to describe an overview of a certain situation at a specific point in time (**baseline year**). In this particular context, it generally implies the development of a **"greenhouse gas emissions inventory"** - showing both the amount of energy consumed in the community and the greenhouse gas emitted by certain sectors or activities, as well as of a "**climate risk and vulnerability assessment**" - disclosing the consequences of climate change that are already affecting the city and the possible social and economic risks.

Such overviews offer precious information to the management and technical experts of the LG, such as the low-hanging fruits, the sectors to include in the strategy (being either the most energy consuming or the most vulnerable), the initiatives creating synergistic response as well as the potential integrations with other goals of the city. Once the baseline is known, scenarios can be developed, modelling the possible developments that take into consideration economic, social, climate, technology and any other changes happening (or foreseen to happen) between the baseline year and the year selected as "**target year**". Despite this modelling exercise is subject to assumptions, the different scenarios developed, taking into account the various hypothesis, present the policy makers with an idea of what to expect in the target year, what to plan to reach the sought changes and how to assess the feasibility of the measures foreseen in the strategy.
Independently from the type of target the local government selects, therefore, a 100% RE strategy should be built on a baseline assessment.

Figure 4-3 (Image by TheDigitalWay from Pixabay)

Scope and boundary

The first distinction to be made when setting a target is the **scope** and **boundary** of its application. The local government needs to define whether the GHG emissions reduction or the 100% RE target refers to the LG administration exclusively or to the entire

community. In the first case, the target could address what is owned or managed by the LG or, rather, the LG operations. Differently, in the second case, it is important to specify which type of stakeholders' activities are addressed, for example whether the target includes the business sector or the industrial sites in the local government area or if it considers energy sources that are outside the city boundaries but serve the community within as well.

In turn, this will define a certain physical boundary, but most importantly, it will affect the measures to implement in order to reach the target, as well as the communication material and strategy to be developed.

In the framework of the 100% RE, the ideal target combines both GHG emissions reduction and 100% RE for the energy consumption of the whole community and it includes business and industrial sectors, to be influenced thanks to innovative policies and financing schemes inserted in the strategy. Though, while this is obviously the ideal and most ambitious option that a LG can possibly choose, smaller targets can be considered as first steps to undertake in order to explore the reaction and engagement of the community. More modest objectives can be valuable for setting the vision and image of the LG administration as a role model as well as to inspire citizens, stakeholders and the business sector to follow the strategy, mobilizing local resources and supporting a cultural change.

Energy consumption sectors

The target can include the consumption derived from all the **types of energy use** of the community: **electricity, transport and mobility, heating & cooling** are the most commonly included, though **cooking and industrial sectors** should be also taken into consideration when aiming at a 100% RE global target.

As previously mentioned, in the framework of realising a 100% RE ambition, it is important to choose a long-term target considering all the sectors and energy types, while selecting a few sectors on 100% RE for the short- and medium-term steps. The feasibility of the target relies greatly on the policies and measures implemented by the local government, which, in turn, pave the way for community and investors' engagement. Consequently, as a matter of principle, no target should be considered infeasible.

Figure 4-4 (Image by Albrecht Fietz from Pixabay)

Types of target

The most technical distinction to be understood is the **type of target**. Following the categorisation of the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC 2014) and broadening the discussion to include 100% RE targets examples, clarification Figures (4.5, 4.6 and 4.7) together with the description of the most common types of goals are briefly described with their application to the 100% RE scene for a LG.

Base year goals.

When opting for a base year goal, the percentage of the selected indicator to be changed (in the illustrated framework, the reduction in GHG emissions or the supply of energy production) is given in relation to its value in a given base year. Typically, the base year is selected as one in which reliable data on emissions are available.

The target year is a year in the future in which the change is expected to be achieved. This type of goal actually translates in a fixed amount to be addressed. As an example, in case the local government aims at supplying the 100% energy consumption for the year 2005 with renewable energy sources, this amount of consumption is a fixed number given by the baseline in 2005, which should be covered with renewable energy projects until the projected production is reached within the target year. Even when this is given community-wide, what happens in terms of energy supply in the community between the base year and the target year is not part of the commitment nor is it controlled by the measures which lead to the actual achievement of the 100% RE base year goal defined. Figure 4.5 shows graphically the achievements of two imaginary scenarios in which both cases (1) and (2) can define the goal as achieved within the target year. Though, the two cases reach very different conclusions: in case (1) remaining energy consumption which is not covered by RES endures and it is bigger than the total consumption in the base year; while in case (2) there is total coverage of energy consumption with 100% RE. Similarly, when GHG emissions are considered, setting a base year target does not guarantee that the total level of emissions in the community does not increase between the base year and the target year, nor it entails a strategy that plans to control it.

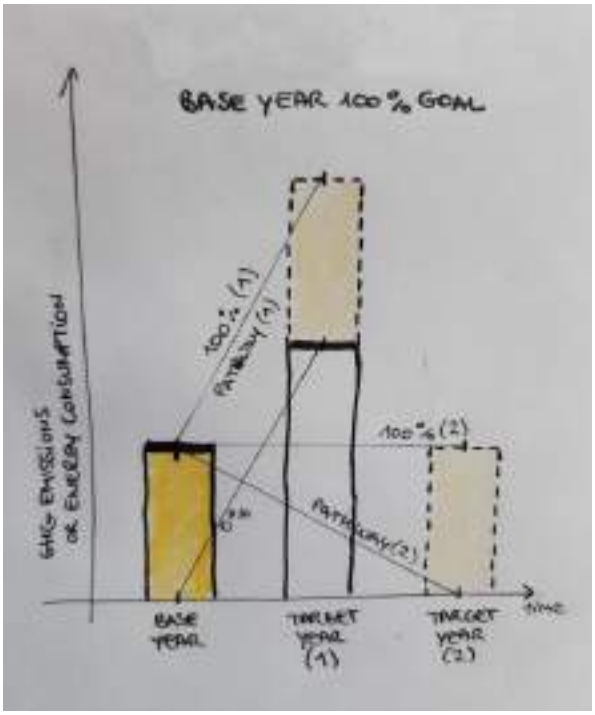

Figure 4-5 Base year 100% goal (developed by Miriam Badino)

From a communication point of view, it is easily confused with a target of reaching X percent GHG emissions/ energy consumption <u>of</u> the base year value, which is instead in a "fixed level goal" (see following subchapter).

Despite being a very common type of goal due to its technical and management ease, as it shows a percentage of the total consumption or emissions in the target year, it should be avoided in case of 100% RE or carbon neutrality targets, as it is very easily miscommunicated.

Fixed-level goals.

Fixed level targets and goals represent a change in the indicator in order to reach a fixed, predetermined, amount by the target year, without making reference to any base year in the past. When talking about 100% (either RE supply of GHG emissions reduction) commitments, the entire value of the target year is addressed (Figure 4.6). If a local government sets a fixed-level goal of reaching zero net emissions by a certain date, the emissions to be considered are all the emissions at the present moment, plus (or minus) any emission that will occur beyond the LG control (e.g. technological evolutions, climate, economy, population changes) until the target year. It is a very ambitious goal, as it requires a lean and flexible strategy and constant monitoring, in order to update calculations on the actual reduction of emissions (or energy production from RES), taking into account the changes in the framework (for example, the construction of an entirely new district of the city), as well as the measures and policies needed to reach the goal. In any case, this would be the type of strategy required beyond a certain (low) level of ambition, furthermore, the effort behind this exercise can support a very transparent and impactful communication of the vision itself.

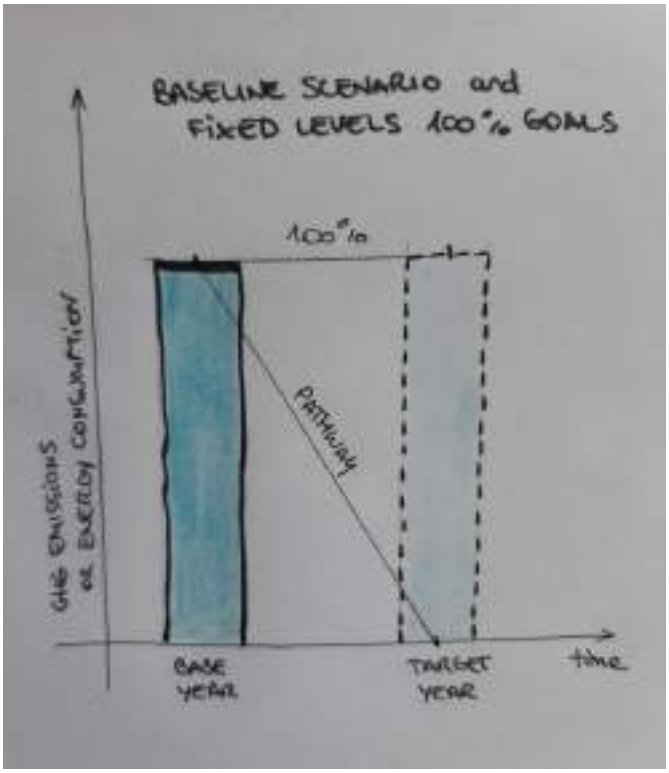

Figure 4-6 Baseline scenario and fixed level 100% goals (developed by Miriam Badino)

Baseline (or business-as-usual) scenario goals.

This type of target entails a commitment to reach a certain change within the target year, compared to the levels that would have (most likely) occurred within that year without the implementation of any measures. When talking about 100% commitments, this type of target is actually the same as the fixed-level goal described above, which explains the reason why the two objectives are both represented in Figure 4.6.

Base year intensity goals.

When defining a target of this type, the local government commits to reach a certain intensity of the value (e.g. the value per unit of output) by a certain target year, which is referred to and compared with the intensity of a base year in the past. In this framework, this goal is typically translated into, for example, the GHG emissions per gross domestic product (GDP) procapita or per energy unit. Despite this goal might appear more similar to the base year goal type of target, it is highly ambitious compared to the other two goals described. This occurs since in the example above the total emissions to be avoided depend on the changing conditions and the commitment foresees a change even in case of increase in the output. Despite being less common among the 100% RE targets, the RES supply could be referred to the totality of the energy consumption of unity of output and it would be equivalent to the previous two cases: Figure 4.7 differs exclusively in the indicator on the y-axis.

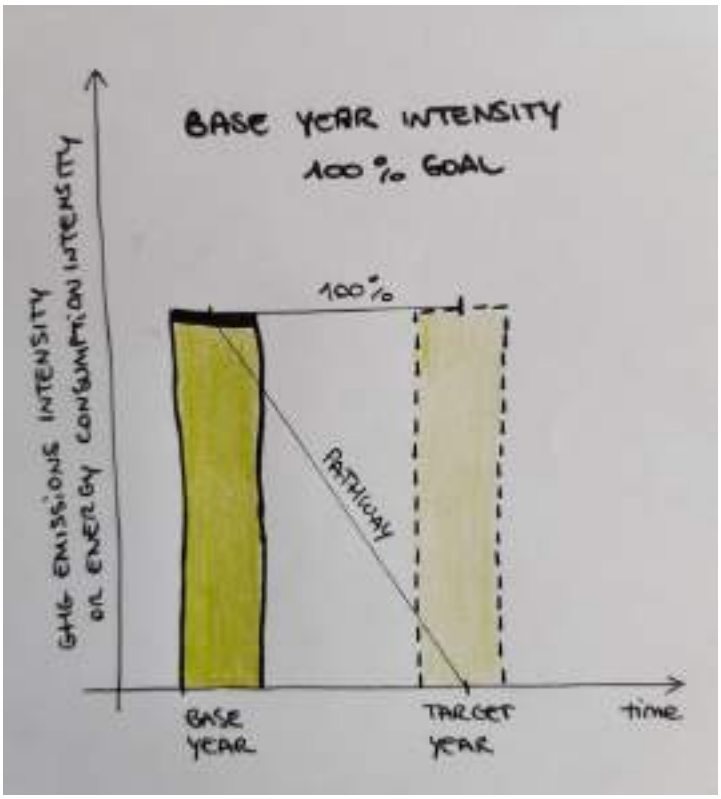

Figure 4-7 Base year intensity 100% goal (developed by Miriam Badino)

In the same way, local governments need to plan a very careful and flexible strategy, with constant measurements and assessments of the changes occurring in the context.

The target and its communication

Once the characteristics of the 100% RE target and therefore of the 100% RE roadmap are clear, it is fundamental that the local government communicates the same with outstanding transparency and simplicity, yet maintaining consistency with its commitments. 100%RE coverage of the consumption of the entire community for all energy sectors requires several middle step achievements, various adjustments in the strategy and the plans can be foreseen before the long-term target year is reached. The local government should be aware of this process and of its complexity, being ready to celebrate each small achievement with its community, as well as any new development and insight that help improving the direction to actually reach the most ambitious goal. Also from a psychological point of view, it is proven (for example, Louis 2017, Badino et al. 2020) that step-by-step engagement on middle-term goals is essential, as well as rewarding those who take the first steps drive people to engage more and, therefore, it is a

more valuable approach for a leader, rather than limiting to merely present an ambitious end goal.

A better understanding of the soft skills to be developed within the local government, as well as the psychological and social barriers that hinder strong community participation should be addressed together with the measures to employ in order to overcome any difficulty or barrier that could arise during the process.

Figure 4-8 (Image by Alexas_Fotos from Pixabay)

5. Strategic and policy recommendations

Committed leaders, cooperation, creative solutions and transparent communication are key to successfully achieve a 100%RE powered community.

Local governments have a key role in supporting the roll-out of renewable energy in the community. A list of policy recommendations have been compiled based on literature review and from the outcomes of the analysis of case studies and current 100%RE roadmaps. Together with the vast guidelines available and research on the field, local leaders can find them useful when setting and implementing a 100%RE roadmap (Energy Cities 2017, Go100RE 2017, Greenpeace 2015, GSR 2020, IPCC 2011, IRENA and ICLEI 2013, IRENA 2018, IRENA 2019, ISEP 2020, REN21 2020, Wiseman et al. 2013, World Future Council 2014 and 2018).

Be visionary and ambitious.

Set a binding commitment to reach 100% RE coverage for all energy sectors (electricity, transport and mobility, heating & cooling, cooking and any other energy use) for the entire community, carefully valorising its potential and features. Set a long-term strategy of green integrated development, with a well-defined roadmap including intermediate goals and achievements and using 100% RE as a driver for a holistic change of local culture, economy and education.
Besides demonstrating political commitment, setting an ambitious target provides citizens and stakeholders with a clearer view of the long-term vision for the region and catalyses changes by providing an official mandate for action. It can support a more efficient deployment of resources, give confidence to make higher investments and attract domestic and international investors – bolstering the achievement of the goal itself.
Setting the target, though, is not sufficient: in order to ensure its effective implementation, the same should be credible, achievable and supported by a stable policy and regulatory framework, together with a step-by-step roadmap with indicators and regular progress reports.

• • •

"A goal is not always meant to be reached; it often serves simply as something to aim at."
Bruce Lee

• • •

Sustainable energy for all.

The community needs to be reassured that the ambitious strategy elaborated for the community does not entail more efficient and sustainable energy consumption and long-term protection of the ecosystem exclusively, but it aims at tackling inequalities and improving social wellbeing as well.

Prioritize a decentralised, community-based approach to the energy transition to renewable energy sources. Support the participation of the civil society, as well as of local stakeholders and businesses, involving the whole community in the decision-making processes that lead to the 100%RE roadmap definition, development and implementation. Co-development of the local government's vision with local entrepreneurs and the establishment of local clusters[1] are key to successfully walk the pathway to 100%RE, as it builds positive synergies across the region and further momentum.

Set policies that ensure access to sustainable energy for the entire community and promote inclusive communication and outreach. Citizens' participation through "energy democracy" is strengthened and their engagement is enhanced, since people can benefit from energy as a common good, while supporting the development of effective, accountable and transparent institutions.

• • •

"If we can make a difference in the life of one person in a community, it is a small yet significant step to empower a whole community"
Loshini Naidoo - University of Western Sydney, Australia (TNLC 2014)

• • •

[1] The term "cluster" refers to geographic concentration of interconnected economic and innovative activities in a particular field (industry, academia and government institution) *(University of Amsterdam and ICLEI 2012)*

Connect at all levels.

Promote and facilitate multi-level governance, cross-sectoral collaboration and peer-to-peer cooperation at all levels of government, thanks to LG institutional bodies. Local governments can be a local hub for implementing broader (i.e. national) policy frameworks, with the potential of including bottom-up (i.e. citizens) mobilization as part of the solution to improve the framework itself.
Follow the indication of the SDG 17, "partnership for the goals" and build new, while strengthening old, cross-sectoral renewable energy partnerships to exchange solutions, lessons learnt and best practices.
Use the strength developing from the collaboration and partnership with similar and different levels of government, also through local, regional and international networks.

• • •

"It is the long history of humankind (and animal kind, too) that those who learned to collaborate and improvise most effectively have prevailed"
Charles Darwin

• • •

Develop a holistic, lean strategy and integrated policies.

A key requirement for the development of a 100 % RE strategy is the integration of the same across policy areas such as fiscal, energy, economic and infrastructures, as well as across all the local governments' goals, strategies and plans (energy efficiency and conservation, environment, urban development, building sector, transport, public lighting, socio-economic, …).
Set RE policies that consider all the aspects of their potential: electricity, heating & cooling, transportation and cooking alternatives, as well as both on-grid and off-grid options. Together with the supply side of RE development, local demand and private investments need to increase as well, requiring the local capacity to be built.
The strategy is required to be sufficiently lean in order to adapt to the changing environment and context both in the present and in the long- or middle- term target years, yet keeping its ambition. The flexibility to learn from experience is critical to achieve cost-effective and high penetration of RES into the development pathway.
A collaborative space with many levels of government, different local stakeholders,

businesses and citizens interacting is the best place where to be adaptive and fast to change, aiming at a common (green) development goal.
As commonly acknowledged, there is no one-size-fits-all approach to achieve 100% renewable energy and target, as well as measures and enabling frameworks are subject to and must be adapted to local circumstances.

• • •

"The future is already here - it's just not evenly distributed"
William Gibson

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Reduce consumption first, then go renewable and diversify.

Lowering energy consumption and enacting energy efficiency and behavioural changes (for example with energy and information labels, mandatory minimum energy performance standards and voluntary efficiency agreements) should be the top priority of any strategy, before considering covering the (remaining) energy needs with RES solution. A more energy efficient infrastructure encourages the development, financing and integration of the required efforts to meet the community energy needs with locally available energy resources.
Explore local assets and characteristics (socioeconomic structure, climate, geography, topography…) to plan RE development in the specific context of the LG.
Integrate multiple renewable energy sources as part of the solution to successfully cover 100% of energy consumption. All the types of sources should be taken into consideration as potential sources while doing the assessment of the same, yet being extremely cautious that no option hides a human right violation or entails environmental degradation. When considering biomass, biofuels and large hydro solutions, in particular, a careful assessment is needed in relation to their potential interference with food security and water resources.
Specifically, when some parts of the community are located in remote areas or not yet connected to the electricity grid, it is important to consider off-grid and mini-grid solutions in addition to the infrastructural changes involving grid expansion. Mini-grid systems can be very valuable for district energy and cooling, in particular when associated with hot by-product waters of local businesses.
The electrification of heating/cooling and of the transport sector, together with integrated systems interconnecting them with the electricity sector, increase the reliability of the system and the potential of success in achieving 100% RE.

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"You cannot escape the responsibility of tomorrow by evading it today" Abraham Lincoln

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Be the local role model, invest, divest.

Be the first to walk an ambitious pathway of energy transformation, increasing energy efficiency and installing RE systems to cover the consumption of local government properties and controlled systems.
Invest in the energy transformation to happen. Allocate a percentage of the annual fiscal revenue to solar energy industry investments, infrastructures and energy efficiency measures and support private sector engagement as an additional funding source. RE can be the leading sector for a sustainable and diversified urban development.
Divest for the energy transformation to happen**.** Divest from fossil fuels, redirect fossil subsidies to fund renewable energy projects. Implement new mechanisms to internalise externalities, such as locally-based fee systems (carbon tax, waste tax, pollution tax) and other financial mechanisms to favour sustainable and clean alternatives.

The role model played by the LG is key to acknowledge the need to raise ambition, to perform all the due steps and achievements each small-big-intermediate goal on the path entails. A long term strategy is bound to be a living entity which requires adaptation to the evolving context, in order to keep (or increase) the ambition. Be transparent in your role: make achievements, failures, decisions, data and knowledge accessible to the community, in order to allow people to follow with renewed trust.

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"Step out of the history that is holding you back. Step into the new story you are willing to create"
Oprah Winfrey.

Promote training, capacity building and cultural change.

Create opportunities for capacity building and professional development to make sure the strategy can be successful. This include, inter alia:

- specific technical and professional knowledge required in the community on the RE sector (such as system design and installation);
- technical knowledge and capacity building for LG officials - technical, political and communication staff;
- management skills to develop projects and initiatives (for privates, businesses as well as within the LG officials);
- awareness raising campaigns;
- development of soft skills for LG officials and the community;
- development of non-RE-related expertise to be built in order to exploit existing knowledge at best (for example, language courses for LG officials, businesses and citizens so that the community can access to existing best practices, resources and technical education).

The local government can be a key actor to make these opportunities happen, through lending spaces, funds, connections and capacities, as well as by developing a vision. A broad aim of promoting a culture of sustainability within the community and of increasing the level of community engagement can positively impact on non-technological measures of energy consumption, thanks to behavioural change.

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"Our society relies on the power that comes from technology. It is this power that has reshaped the world and continues to do so. It is this power that holds the promise for great benefit - and unprecedented destruction. It is this power that drives wealth creation and the economic incentives for research and development. And it is this power that preserves a status quo that undermines human development in ways that few of us see. No matter how exciting a more integral science might be, little is likely to change until we understand the forces that have led to our dependence on modern technology and the part we all play in maintaining those forces. It is not just the desire for power that drives modern technology It is the fear that we cannot live without it"

(Senge et al. 2004)

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Figure 5-1 (Image by Steve Buissinne from Pixabay)

Institutionalise the strategy.

(Re)Organize the internal structure if needed, establishing formal bodies or organisations in the LG to be responsible for designing, implementing and monitoring the transition. Make sure that the vision is well communicated, understood and shared in each department of the local government, as well as the responsibilities and roles are clear for each step.
The creation of an internal committee can facilitate the development of an ambitious strategy and its implementation, when it is composed by political and technical LG officers from relevant departments (research and development, urban planning, finance and new technologies) and when the same interacts with utilities, local representatives from business, academia, stakeholders and citizens' groups, experts in urban planning, law, finance and technologies.

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"Knowledge is of no value unless you put it into practice"
Anton Chekhov

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Define comprehensive legal and regulatory frameworks.

Implementation of RE projects and initiatives needs to be enabled by specific laws, whether not already in place, supporting a decentralised, people-centred and participatory transition, as well as by financial tools to make the same begin.
The local government can attract direct investments by implementing stable, long-term support schemes and supportive policies on land-usage, tax-return and financing in order to overcome challenges such as the small size of the local solar energy industry, the lack of well-developed financing mechanisms for growing industrial companies and the shortage of sector-related skills and expertise.
Other examples of specific policies include policies for research and development, demonstration and deployment of RES technologies, as well as regulations, for instance feed-in-tariffs, quotas, priority grid access, building mandates, biofuel blending requirements and bioenergy sustainability criteria. Fiscal incentives (such as tax policies and direct government payments, for instance, rebates and grants) and public finance mechanisms (such as loans and guarantees) can also be included. Furthermore, RE development can be supported by wider policies aimed at reducing GHG emissions such as carbon pricing mechanisms.
The systematic development of a reliable mix of policy instruments is necessary to guarantee the flexibility and reactivity of the system over the long time frame of the strategy, while reducing risks and attracting investments in the sector. According to IPCC, this is even more important where energy infrastructure is still under development and energy demand is expected to increase in the future.
Examples of specific RE policies can be found on the IRENA website https://www.irena.org/policy

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"Use design as a framework to bring order out of chaos."
Nita Leland

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Communicate transparently and broadly.

Make sure that the communication of goals, vision, strategy and achievements is made in a clear and transparent way and the same reflect fairly and clearly the type of target, its boundaries and exclusions.
As local opposition to energy infrastructure is known to be amongst the biggest hindrances to achieving 100% RE; education, fostering engagement and improving public outreach should be a top priority for policy makers. Encouraging debate on the

unaddressed topics of the energy transition can help in breaking communication silos and in developing a narrative around renewable energy that positively influence its future development.

Make sure the technical, political and communication responsible understand the strategy, the roadmap and their characteristics, supporting each other in order to gather other points of view and clarify any misunderstanding, with the will of avoiding unwanted misleading, incoherent or false communication.
Share the vision, the plans and achievements world-wide: with the community, neighbouring and peer LGs, as well as globally. Taking full ownership and celebrating shared ambition and results together are drivers for improvement, for further increased ambition and for finding new solutions thanks to the potential partnerships that could arise.
Consider taking part into a city network or global sectoral initiative, which could facilitate this process enormously.

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"Never mistake legibility for communication"
David Carson, graphic designer

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Monitor and value interim achievements and adjustments

Reliable, timely and regular updates on renewable energy data and community consumption patterns are essential to define, monitor and adjust plans, targets and policy measures, as well as to attract investments. Developing innovative and collaborative approaches to good quality data collection, processing and validation is very important to guarantee reliability.
Long-term objectives need to leverage on short-term actions offering tangible results. In the communication, middle-steps achievements, unforeseen difficulties and strategy-reshaping needs relating to the 100% RE roadmap should be shared as well, as natural turning points and part of an ambitious, yet complex, pathway. The same is valuable both for supporting the building of trust towards the LG authority and the RE vision and for supporting a stronger community engagement and behavioural changes.

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""Only those who dare to fail greatly can ever achieve greatly."
Robert F. Kennedy

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6. Conclusions

The assessment of existing 100% RE strategies demonstrate that sustainable energy transformation is not only possible, but also affordable with the existing technologies, in different parts of the world and in different contexts.
The energy transition is, nevertheless, at a very early stage, being extremely slow and not happening homogeneously globally. Considering the speed at which climate changes happen, the assessment of the present Dossier shows that there is a strong urgency to act immediately and to accelerate the progress, as well as to raise local governments' ambitions. Heating and cooling, transport, cooking and industrial sectors should be widely included in integrated strategies aiming at 100% RE communities. Stand alone, off-grid solutions should be planned intensively to ensure the access to energy to disadvantaged parts of the society or businesses, located in rural or remote areas, instead of designing expensive and massive infrastructure extensions.

Renewable sources are everywhere in the world and can lead us away from the current fossil fuel based energy system, becoming increasingly expensive and unsustainable. They are local, decentralised, abundant, diverse and inclusive by nature and their economic externalities are negligible. The technical feasibility and economic viability are particularly strong when the strategy foresees the integration of all the possible energy sectors with an holistic approach (Hansen et al. 2019). Continuous innovation and technological improvement can make the transition easier and faster, but communities can already adopt a wide range of RES solutions.

The divestment of LGs from fossil fuels and the investment in renewable energy development is key to avoid locking the present and the future generations into such system.

Ambitious pathways such as reaching 100% RE coverage for the whole community require both great leadership and technical awareness. Energy transition should be driven by a decentralised, participatory and inclusive process in which everyone can engage and benefit fairly. Wide community engagement in the development and implementation of the vision of the local government, as well as the participated celebration of each step, should be seeked through high quality and transparent communication. Environment, climate sustainability, societal and economic policies should be coordinated and synergised, keeping in mind that citizens' health, welfare and happiness in a safe and cared-of nature are the underlying objectives.

The energy transformation means much more than a mere energy supply, but it translates into countless benefits for today and tomorrow communities and concerning economy, health, environment, human rights and gender equality.

7. Glossary

The most relevant acronyms used in the paper is the following:

CO_2: Carbon dioxide

GHG – greenhouse gases

GW: Gigawatt

GWh: Gigawatt hours

IPCC: Intergovernmental Panel on Climate Change

KWh: Kilowatt hours

LG - Local Government

MW: Megawatt

MWh: Megawatt hours

PV - photovoltaic

RE - Renewable Energy

RES - Renewable Energy Source(s)

UNFCCC: United Nations Framework Convention on Climate Change

Please refer also to the IPCC Glossary (IPCC 2019)

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