# TOWARDS 100% RENEWABLE ENERGY:

## UTILITIES IN TRANSITION

ISBN 978-92-9260-189-8

## About the Coalition

The IRENA Coalition for Action is an international network with a vision for its members to work together to advance renewable energy in order to drive the global energy transformation in line with the Sustainable Development Goal on energy.

## About this paper

This white paper has been developed in a joint effort by Members of the Coalition Working Group Towards 100% Renewable Energy. Building on several case studies and first-hand interviews with utilities, the paper outlines a broad variety of experiences and lessons learned from utilities undertaking the transition to 100% renewable energy. The paper also includes updated mapping of 100% renewable energy targets at the national and subnational levels.

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**Further acknowledgements:**
Valuable review and feedback were provided by Rian van Staden (Global 100% RE), Maryke van Staden and Laura Noriega (ICLEI – Local Governments for Sustainability), Mathis Rogner (International Hydropower Association), Roque Pedace (INFORSE), Patrick Bateman (WaterPower Canada), Bharadwaj Kummamuru (World Bioenergy Association), Anna Leidreiter and Anna Skowron (World Future Council), Josephine Pham (YellowDoor Energy), Asami Miketa, Emanuele Bianco, Elena Ocenic, Xavier Casals, Bilal Hussain and Fabian Barrera (IRENA) and Sara Pizzinato (IRENA consultant).

The IRENA Coalition for Action would like to express special thanks and gratitude to senior representatives of utilities interviewed for the case studies in this paper, including Phil Overeynder (City of Aspen), Shannon Tangonan (Hawaiian Electric Company), Anna Lundeen and Christian Schwartz (Mölndal Energi), Magnus Hornø Gottlieb (Ørsted), Bryn Williams (SA Power Networks) and Norbert Zösch (Stadtwerk Haßfurt GmbH).

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# Abbreviations

AEMO: Australian Energy Market Operator

AUD: Australian dollar

B2B: Business-to-business

B2C: Business-to-consumer

°C: Degrees Celsius

$CO_2$: Carbon dioxide

COA: City of Aspen

COP: Conference of the Parties

CVF: Climate Vulnerable Forum

DER: Distributed energy resource

DRES: Distributed renewable energy sources

EEG: Renewable Energy Act (*Erneuerbare-Energien-Gesetz;* Germany)

GHG: Greenhouse gas

GW: Gigawatt

HCEI: Hawaii Clean Energy Initiative (US)

HECO: Hawaiian Electric

HELCO: Hawaii Electric Light

IEA: International Energy Agency

kW: Kilowatt

MECO: Maui Electric

MEAN: Municipal Energy Agency of Nebraska

MW: Megawatt

MWh: Megawatt hour(s)

NDC: Nationally determined contribution

NEM: Net energy metering

NGO: Non-governmental organisation

NREL: National Renewable Energy Laboratory

PPA: Power purchase agreement

PV: Photovoltaic

RPS: Renewable portfolio standard

SG: Synchronous generator

TSO: Transmission system operator

UNFCCC: United Nations Framework Convention on Climate Change

USD: US dollar

UTE: Usinas y Trasmisiones Eléctricas (Uruguay)

VPP: Virtual power plant

VRE: Variable renewable energy

# 1. Introduction

The adoption of the United Nations' 2030 Agenda for Sustainable Development, and in particular Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable and modern energy for all, has led to a global consensus around the need to substantially increase the share of renewable energy in the global energy mix. Renewable energy is key to sustainable development and will play a crucial role in advancing progress on various Sustainable Development Goals as well as the global climate objectives set out in the 2015 Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC; the Paris Agreement; IEA, IRENA, UNSD, WB, WHO, 2019).

The vision of an energy system powered entirely by renewables is more achievable than ever before. Recent years have witnessed steep reductions in the costs of renewable energy technologies as well as technology innovation (IRENA, 2019a). Together with maturing market and policy frameworks and targeted innovations, these developments are allowing for rapidly increasing shares of renewables to meet national and sub-national energy requirements in the power, heating and cooling, and transport sectors (IRENA, 2019b). Target setting has also proved to be a valuable tool to enable increased deployment and guiding policy makers and investors towards a shared goal.

In the coming years, more and more countries and sub-national governments are aiming for very high shares of renewables to meet all end-use energy requirements. The IRENA Coalition for Action's global mapping initiative of 100% renewable energy targets shows that more than 60 countries had implemented various types of 100% targets by the end of 2019. On a sub-national level, the number of cities and regions with a 100% renewable energy target increased to over 300 in 2019. In addition to significant emissions reductions, many governments recognise that a transformation to a 100% renewable energy system could bring wider socio-economic benefits. These include affordable and secure energy, increased employment and economic growth, and a variety of health and environmental benefits.

As of today, the fastest progress in renewable energy implementation has been seen in electricity generation – reaching a renewable share of 24.4% in 2017 (IRENA, 2019c) and an estimated 26% in 2018 (REN21, 2019a). Less headway has been made by renewables in the heating and cooling and transportation sectors, which reached 24.1% and 3.3%, respectively, in 2016 (IEA, IRENA, UNSD, WB, WHO, 2019). This development is consistent with existing renewable energy targets and policies, most of which have focused on the electricity sector (IRENA, IEA and REN21, 2018; REN21, 2019a). These ambitions and implementation levels are far too low to achieve the objectives of the Paris Agreement. Stakeholders from all sides of the energy sector will need to step up their efforts to further accelerate the uptake of renewable energy. This will require increased efforts in the establishment of implementing frameworks to allow for accelerated and broad participation in the transformation.

In its first white paper, launched in January 2019, the Coalition Towards 100% Renewable Energy Working Group analysed the transformation to a 100% renewable energy system from the point of view of national and sub-national governments (IRENA, 2019d). The paper provided insight into why and how policy makers develop and design objectives and enabling policies and measures to promote system adaptations and changes in line with very high shares of renewables.

In addition to providing an updated mapping of 100% renewable energy targets, this white paper focuses on a major implementation piece of the energy transformation: the utility, which can include not only energy generation but also transmission and distribution.

As the entities traditionally responsible for the infrastructure needed to deliver energy to consumers, utilities are significant in enabling further integration of both utility-scale and distributed renewables into the grid. In line with trends such as increased electrification, digitalisation and decentralisation, the roles and responsibilities of utilities will continue to evolve (IRENA, IEA and REN21, 2018; IRENA, 2019e). Through case studies based on first-hand interviews with senior representatives of seven utilities, this white paper examines strategies to realise 100% renewable energy goals at the utility level.

The case studies show that each utility faces its own challenges, but also that all utilities, regardless of their size and geographical location, share many common and recurring themes. The case studies highlight the importance of removing administrative and policy barriers and maintaining or creating favourable frameworks to facilitate the shift towards 100% renewable energy. The Coalition for Action stands ready to work with policy makers, industry and civil society on the road to 100% renewable energy.

Following this introduction, this white paper is organised as follows: Chapter 2 provides an updated overview of (national and sub-national level) 100% renewable energy targets; Chapter 3 elaborates on the role of utilities in the energy transformation and defines the term "utility"; Chapter 4 summarises key takeaways from seven case studies of utilities in transition to 100% renewables; and finally, Chapter 5 presents the seven case studies.

*Box 1. Definition of 100% renewable energy*

The IRENA Coalition for Action has agreed on the following definition for 100% renewable energy:[1]

*Renewable energy encompasses all renewable resources, including bioenergy, geothermal, hydropower, ocean, solar and wind energy. 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.*

[1] Utilities featured in the case studies may apply different definitions when referring to 100% renewable energy.

## 2. Global status and trends

Building on its first global mapping of 100% renewable energy targets in 2018, the IRENA Coalition for Action, in a joint effort with several partners, has continued to identify and evaluate national and sub-national targets. The updated overview of the global status on 100% renewable energy targets includes new targets announced in the past year as well as further details on the type of targets and their legal status. The following section presents the key findings of this exercise.

### 2.1 Mapping of 100% renewable energy targets – national level

In 2019, a total of 61 countries had set a 100% renewable energy target[2] in at least one end-use sector, up from 60 countries in 2018.[3]

Geographically, these 61 countries are distributed as follows: Africa (19), Asia (15), Oceania (10), Central America and the Caribbean (8), Europe (7), and South America (2) (see Figure 1). Of the 61 countries, 14 countries have committed to reaching a 100% renewable energy target in at least one end-use sector by 2030 at the latest, two countries by 2040 and the others by 2050.

*Figure 1. Geographical distribution of national 100% renewable energy targets*


*Note:* The information in the figure is based solely on data reported to one of the data sources as indicated below. Accordingly, the countries committed to a 100% renewable energy target may have changed since the data were reported. Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.
*Source:* Data included in the figure were compiled by the IRENA Coalition for Action with material provided by REN21 and IRENA.

The mapping of targets shows a high commitment from countries in Africa, Asia and Oceania to achieve 100% renewable energy. Many of these targets were announced through the Marrakech Communique at COP22 (the 22nd Conference of the Parties to the UNFCCC) by countries that are most vulnerable to the effects of climate change, particularly least developed countries and small island states.

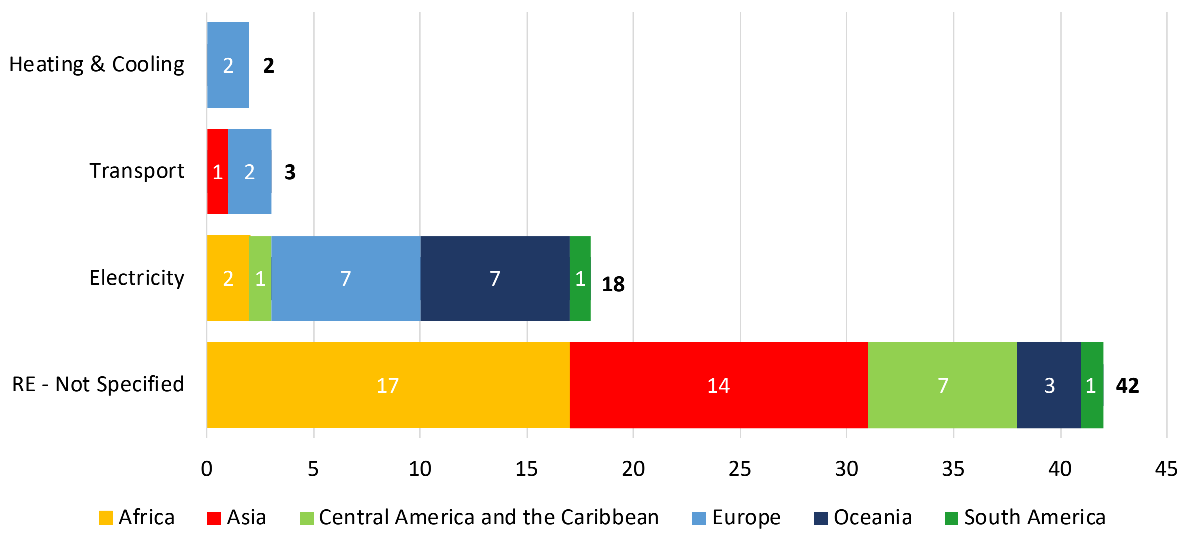
[2] Targets vary in terms of sectoral and geographical scope and boundaries or whether they refer to generation or consumption, direct or indirect energy use, covering only municipal or also other operations. However, for the purpose of this report all announced pledges to reach 100% renewables have been included in the analysis.
[3] This number has been updated since 2018 based on revised data and methodology. It was updated from 53 to 60 to include the 100% renewable energy targets of Djibouti, Guyana, Indonesia, Lithuania, New Zealand, Spain and the State of Palestine.

In 2019, the one country to revise its renewable energy ambitions to include a 100% renewable energy target was Portugal. The country announced a strategy for achieving 100% renewable electricity generation by 2050 in its Roadmap to Carbon Neutrality, adopted by the Portuguese government in July 2019. The transformation is expected to be achieved through large increases in solar photovoltaic (PV) deployment, building on the existing high shares of wind and hydropower, and coupled with improved energy efficiency to reduce overall electricity consumption (Portuguese Environmental Agency, 2019).

## Targets by sector

While some of the renewable energy targets have been clearly defined in terms of end-use sectors, other targets are broader in scope. In cases where the 100% renewable energy target has not been clearly defined, the category "RE – not specified" has been used in the mapping exercise. Of the countries included in the mapping, 42 fall into this category. In the case of targets that are well-specified in terms of end-use sector, most are focused on 100% renewable electricity, with few countries having set targets for more than one sector. In fact, the mapping exercise identified 18 targets aiming for 100% renewable electricity. Two countries with a renewable electricity target (Austria and Denmark) have also adopted targets for 100% renewable energy in the transport sector, whereas two (Denmark and Lithuania) have set a target for 100% renewable energy in heating and cooling as well as electricity. Indonesia has thus far announced a 100% renewable energy target in the transport sector. Denmark remains the only country with a 100% renewable energy target that encompasses all sectors: electricity, heating and cooling, and transport.

*Figure 2. Overview of national 100% renewable energy targets, by end-use sector*



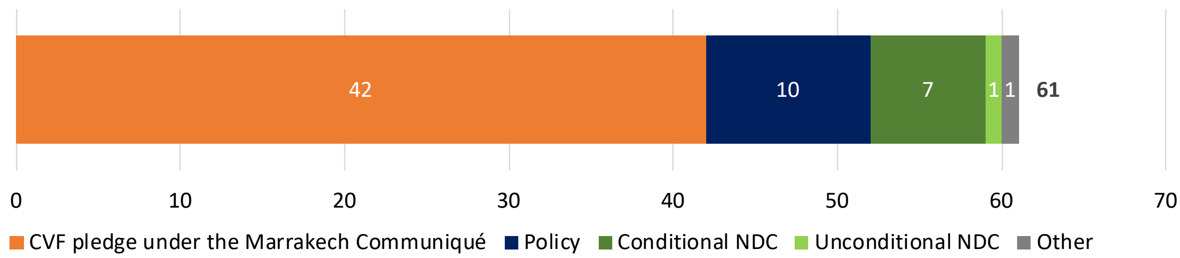

*Note:* The information in the figure is based solely on data reported to one of the data sources as indicated below. The total number of targets in the figure is 65 because several of the 61 countries have targets for multiple sectors. Accordingly, the countries committed to a 100% renewable energy target may have changed since the data were reported.
*Source:* Data included in the figure were compiled by the IRENA Coalition for Action with material provided by REN21 and IRENA.

## Type of target/commitment

The degree to which a country's political leaders and policy makers are held accountable for achieving 100% renewable energy targets depends on the context in which the commitment was made and established. The targets representing the highest level of commitment would usually be those established in national law and are thus legally binding. Other targets may be formally established in policy documents such as nationally adopted energy and climate plans, including the nationally determined contributions (NDCs) under the UNFCCC. Several targets have also taken the form of high-level policy announcements by national governments or pledges under global initiatives (*e.g.*, the Marrakech Communiqué) but have not been fully integrated into national plans or strategies to date.

To provide a comprehensive overview, the mapping in this white paper includes all types of 100% renewable energy targets in its analysis. However, to develop an understanding of the level of commitment, a first attempt has been made in this white paper to distinguish between different target types (see Figure 3).

*Figure 3. Overview of national 100% renewable energy targets, by type of commitment*




*Note 1:* The information in the figure is based solely on data reported to one of the data sources as indicated below. Accordingly, the countries committed to a 100% renewable energy target may have changed since the data were reported. CVF = Climate Vulnerable Forum.
*Note 2:* High-level policy announcements made by national governments are denoted as "Other" in Figure 3.
*Source:* Data included in the figure were compiled by the IRENA Coalition for Action with material provided by REN21 and IRENA.

As Figure 3 illustrates, many of the commitments to 100% renewable energy targets were established by Climate Vulnerable Forum (CVF) countries under the Marrakech Communiqué at COP22. The communiqué states, "We strive to meet 100% domestic renewable energy production as rapidly as possible". Of the 48 CVF countries, 6 (Costa Rica, Fiji, Papua New Guinea, Samoa, Tuvalu and Vanuatu) have taken additional steps to translate this pledge into their NDCs, most of which are conditional upon receiving appropriate international support and funding. Two non-CVF countries (Guyana and Indonesia) have also included 100% renewable energy targets into their NDCs. Of the remaining 11 countries with 100% renewable energy targets, 10 (Austria, Cabo Verde, Denmark, Djibouti, Iceland, Lithuania, Portugal, Solomon Islands, Spain and Sweden) have defined how they intend to achieve their targets in national energy plans or strategies.

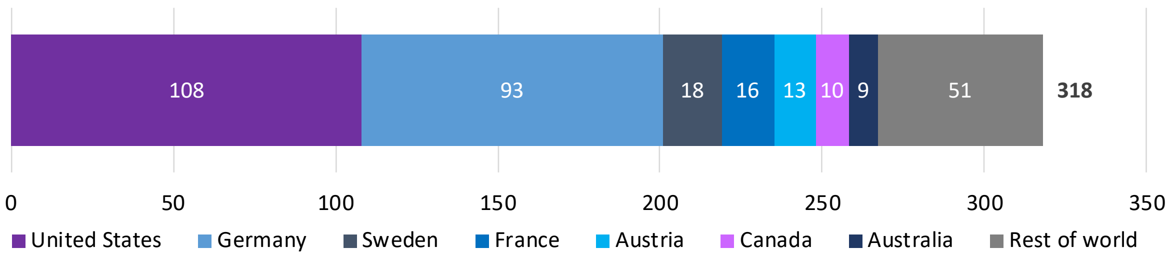
## 2.2 Mapping of 100% renewable energy targets – sub-national level

On the sub-national level, at least 318 cities or regions have committed to some sort of 100% renewable energy target.[4]

Geographically, these sub-national pledges are distributed as follows: Europe (173), North America (118), Oceania (12), Asia (10), Africa (2), Central America and the Caribbean (2), and South America (1). Since the last mapping exercise in 2018, 38 additional cities and regions have reported 100% renewable energy targets, primarily in Europe and North America.

Cities and regions with 100% renewable energy targets continue to be concentrated in a small set of countries including the United States (108), Germany (93), Sweden (18), France (16), Austria (13), Canada (10) and Australia (9) (see Figure 4).

*Figure 4. Overview of sub-national 100% renewable energy targets, by country*



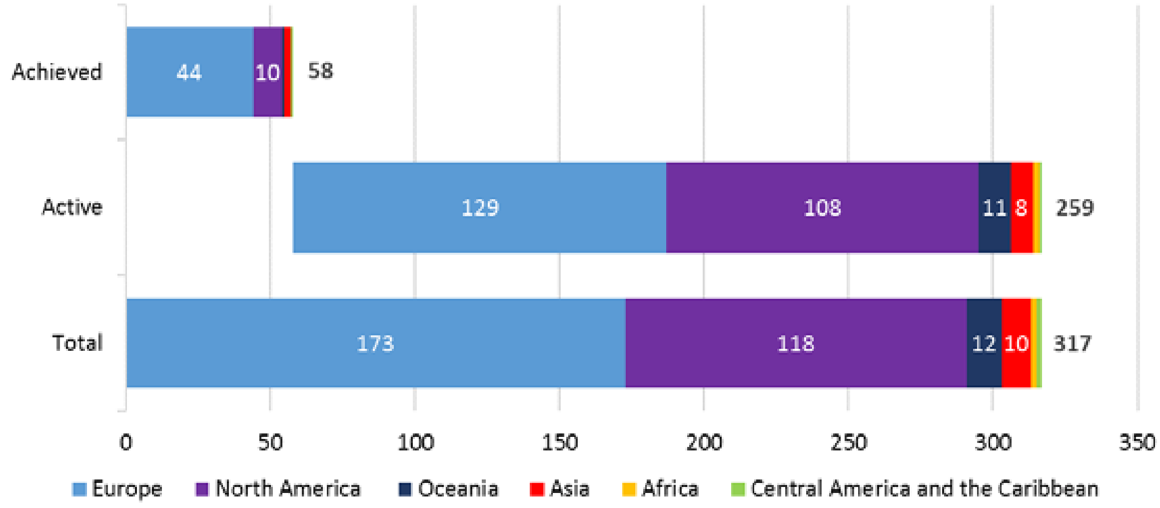

*Note:* The information in the figure is based solely on data reported to one of the data sources as indicated below. Accordingly, the cities and regions committed to a 100% renewable energy target may have changed since the data were reported.
*Source:* Data included in this figure were compiled by ICLEI with material provided by CDP, CAN, C40, Sierra Club, DEnet, DBU, Renewable cities, IRENA and The Global 100% Renewable Energy Platform.

***Since the Coalition for Action's last mapping exercise in 2018, an additional 38 cities and regions have reported 100% renewable energy targets, primarily in Europe and North America.***

[4] Targets vary in terms of sectoral and geographical scope and boundaries or whether they refer to generation or consumption, direct or indirect energy use, covering only municipal or also other operations. However, for the purpose of this report, all reported pledges to reach 100% renewables have been included in the analysis. The completeness and therefore the geographical distribution of the commitments may not be exact due to varying levels of response from different countries in the different regions of the world. Note that data presented in this section may differ from that presented in the Renewables in Cities Global Status Report by REN21 (REN21, 2019b), where only cities are included.

As of end of 2019, 58 cities and regions[5] reported having achieved their 100% renewable energy targets (see Figure 5). Of those 58 jurisdictions, 36 have achieved 100% renewable electricity targets. Additionally, 131 cities and regions with active targets plan to reach their targets by 2030 or earlier, while 114 cities and regions plan to achieve them by 2050 at the latest. Finally, 15 cities and regions have not announced timelines for achieving their targets.

*Figure 5. Sub-national active and achieved 100% renewable energy targets, by geography*

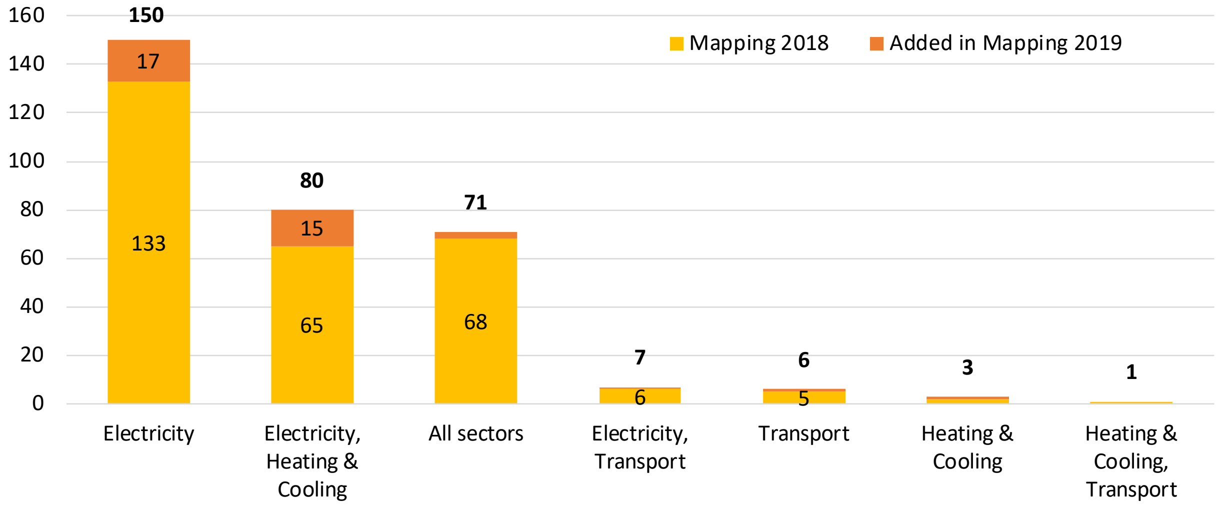



*Note:* The information in the figure is based solely on data reported to one of the data sources as indicated below. Accordingly, the cities and regions committed to a 100% renewable energy target may have changed since the data were reported.
*Source:* Data included in this figure were compiled by ICLEI with material provided by CDP, CAN, C40, Sierra Club, DEnet, DBU, Renewable cities, IRENA and The Global 100% Renewable Energy Platform.

Nearly half (150) of the cities and regions with 100% renewable energy targets have exclusively committed to 100% renewable electricity; most additional cities and regions identified in the 2019 mapping exercise also follow this trend. Of the remaining cities and regions that have made 100% renewable commitments targeting the electricity sector, 87 have set targets for one additional end-use sector while 71 have established targets for all end-uses (see Figure 6).

[5] Since the 2018 Coalition white paper, this number has increased to 58 from 53. However, based on revised data and new reporting, the number of cities and regions achieving the target in 2018 has been revised to 57 from 53.

*Figure 6. Sub-national 100% renewable energy targets, by end-use sector*




*Note:* The information in the table is based solely on data reported to one of the data sources as indicated below. Accordingly, the cities and regions committed to a 100% renewable energy target may have changed since the data were reported.
*Source:* Data included in this table were compiled by ICLEI with material provided by CDP, CAN, C40, Sierra Club, DEnet, DBU, Renewable Cities, IRENA and The Global 100% Renewable Energy Platform.

Most of the targets established at the sub-national level are focused on the electricity sector. Cities and regions that have set targets for all three end-uses are located almost exclusively in Europe (42) and North America (28).

# 3. The role of utilities in the energy transformation

Moving from ambitious renewable energy targets to accelerated implementation will require proactive regulation, new market rules and collaboration between existing as well as new players in the energy market. This is key to making sure that the energy system is fit for renewable energy goals and transitional barriers are removed. In delivering energy to households, businesses and industries, energy utilities have played a crucial role in creating and shaping the current energy system. The ability of utilities to adjust to new demands will partly determine how fast the transformation can happen as well as what their role will be in a future energy system built on very high shares of renewable energy.

## 3.1 Trends accelerating the energy transformation and the changing role of utilities

Utilities have traditionally been state-owned, vertically integrated monopolies responsible for generating, distributing, and selling energy to consumers (Vagliasindi and Besant-Jones, 2013). Since the 1990s, many economies around the world have adopted reforms including unbundling of the energy sector with the objective of creating more competitive markets and lower prices for consumers. In some countries, a liberalisation of the market has carried the implication that consumers can select their preferred power and gas suppliers (European Commission, 2015).

Today, a utility can be broadly defined as an entity engaging in the generation and/or delivery of energy (including, but not limited to, electricity and gas) to consumers in a specific geographical area/jurisdiction. Utilities can be both generators and retailers of energy, which can – under certain conditions – own and operate network infrastructure or make use of infrastructure operated by another entity (MIT Energy Initiative, 2016). Utilities can also be publicly or privately held. In many cases, governments or municipalities still hold/retain a large (or majority) stake in a private utility.

With the ongoing transition to a renewables-based system, the role of utilities will continue to evolve in response to new energy system structures and policies as well as trends in technology innovation and expectations from consumers and investors. In terms of market and technology developments, IRENA identifies three main trends accelerating the ongoing transformation to high shares of renewable energy sources and changing the roles and responsibilities of energy players: decentralisation, digitalisation and electrification of end-use sectors (IRENA, 2019e).

The energy system structures currently in place, both in liberalised and regulated contexts, were developed during the fossil fuel era when structures were configured around centralised generation technologies to meet largely passive or unmanaged demand (IRENA, 2017, 2020). Renewable energy technologies such as solar and wind are inherently more decentralised and distributed than conventional power plants. The past few decades have already seen a significant increase in small-scale residential and commercial renewable energy installations, particularly solar PV, but also solar water heaters, geothermal heating and cooling, biogas, micro-grids, and small wind installations. When managing transmission and distribution grids, utilities will need to deal with higher levels of decentralised generation and active consumers. If managed well through demand-response measures, these decentralised systems can be an important source of flexibility for utilities and the energy system as a whole (IRENA, 2019b).

Emerging digitalisation and innovations for monitoring and control of supply and demand offer important tools for handling higher shares of variable renewable energy (VRE) and a more decentralised system.

These tools enable customers to be more active participants in the electricity market as prosumers through models such as behind-the-meter generation and peer-to-peer electricity trading (Deloitte, 2018). The rise in e-mobility and storage systems will additionally shape how consumers interact with utilities and the energy system (IRENA, 2019f). In addition to the handling of smaller decentralised systems and electric vehicles, new and larger electricity loads will increasingly be connected to the grid as end-use sectors are being electrified. To remain relevant, utilities will need to adapt their operations and business models to respond to and support a new energy market system in which significant portions of demand will be met by customers themselves, and not the utility.

As demonstrated above, utilities can play a key role in shaping the energy landscape of the future by supporting the implementation of ambitious renewable energy targets. Nevertheless, many utilities have been hesitant to embrace the renewable energy transformation, partly because they had and continue to have existing assets to protect, and partly because they were not convinced of the economic viability or technical feasibility of a system based on high shares of VRE. However, as shown in the case studies of this report, some utilities are realising the multitude of opportunities that the changing energy sector will offer in coming years as energy systems are shifted towards 100% renewables. This white paper describes some of the utilities which have committed to some sort of 100% renewable energy pathway.

## 3.2 Overview of utilities in transition to 100% renewable energy

To further illustrate and understand the role that utilities can play in the transformation to 100% renewable energy, this white paper analyses a selected number of companies operating or having previously operated as “utilities” that are moving towards supplying 100% renewable electricity to their customers, either on their own initiative or because of government policies occurring in the jurisdictions they serve. The case studies cover different geographies, technologies, ownership structures and levels of operation including national, regional and local operations. The case studies were selected by members of the Coalition for Action based on first-hand experience from or familiarity with these utilities and build primarily on first-hand data obtained through interviews with senior representatives of the respective utilities.

Table 1 below provides an overview of selected case studies, while detailed case studies are provided in Chapter 5. Key takeaways and lessons learned can be found in Chapter 4.

*Table 1. Overview of utility case studies further detailed in Chapter 5*

| | Utility | Jurisdiction | Target | Achievement reported by utility |
|---|---|---|---|---|
| **National level** | Ørsted | Denmark | >99% renewable energy generation by 2025 | 75% renewable energy generation in 2018 |
| | UTE | Uruguay | 100% renewable electricity generation | 98% renewable electricity generation in 2017 |
| **Regional/ state level** | SA Power Networks | South Australia, Australia | 100% net renewable electricity generation in 2030s[6] | 53% renewable electricity generation in 2018[7] |
| | Hawaiian Electric Companies | Hawaii, United States | 100% renewable electricity generation by 2045 | 27% renewable electricity generation in 2018 |
| **City/ municipal level** | Stadtwerk Haßfurt | Haßfurt, Germany | 100% renewable energy generation by 2030 | 100% renewable electricity generation in 2019<br><br>% of renewable energy generation unknown |
| | Mölndal Energi | Mölndal, Sweden | 100% renewable energy generation | 100% renewable energy generation in 2019 |
| | City of Aspen Utilities Agency | Aspen, CO, United States | 100% renewable electricity supply[8] | 100% renewable electricity supply in 2015 |

*Source:* Data were compiled by the IRENA Coalition for Action based on case studies featured in Chapter 5.

[6] The State of South Australia aspires to meet 100% of its electricity needs through renewable electricity on a net basis. Any electricity consumption met through conventional energy sources will be offset by an equivalent volume of renewable electricity exports.
[7] Refers to targets and achievements by the State of South Australia (SA). SA Power Networks is the sole electricity distribution service provider for the state.
[8] City of Aspen Utilities Agency sources electricity for its customer base through a combination of generation assets owned by the utility and power purchase contracts with a regional power supplier.

## 4. Key takeaways and lessons learned

The growing number of national and sub-national governments committing to 100% renewable energy along with promising implementation strategies by utilities presented in this paper shows broad support and momentum for the creation of a system based on renewable energy.

The following key findings and takeaways may serve as guidance and inspiration for accelerated target setting and the uptake of renewable energy:

- **Commitment to 100% renewable energy is growing at national and sub-national levels.** The 2019 Coalition for Action mapping of 100% renewable energy targets shows growing support for achieving 100% renewable energy with the number of commitments in one or several end-use sectors increasing, particularly at the sub-national level but also at national levels. However, to move from commitment to implementation, the need for further detailing of these targets remains. Allowing for successful implementation of these commitments requires both well-defined targets and direct policy support, as well as a broader enabling framework.
- **The role of utilities in the energy transformation is changing – from hesitation to action.** In many countries, utilities have been hesitant to invest in renewable energy. Reasons include their long-standing commitments to conventional energy assets and their expressed concerns about the economic viability and/or the technical feasibility of high shares of renewables (particularly VRE) in the energy system. The case studies analysed in this white paper demonstrate that some utilities have already achieved 100% renewable electricity and are now refining and improving their business models. A subset of these utilities is also actively implementing strategies to achieve the transformation to a fully renewable energy-based system.

Based on the case studies and additional research, the IRENA Coalition for Action identified major lessons to be learned from utilities in their transition to 100% renewables:

- **Citizen engagement is key for utilities making the transition to renewables.** The first Coalition white paper on this topic – *Towards 100% renewable energy: Status, trends and lessons learned* (IRENA, 2019d), which focused on efforts undertaken by governments and other public actors – showed that the active involvement of citizens at an early stage is a key element for a successful energy transformation. Similarly, utilities interviewed in this white paper such as Hawaiian Electric, Stadtwerk Haßfurt and Aspen Electric, all highlighted the importance of engaging citizens both for consultation on target setting and strategy, and for implementation through their new role as prosumers of energy.

- **While drivers for the renewable energy transformation are multiple and diverse, next to citizen engagement, clear, long-term and reliable government policies and increased energy independence are put forward as key motives by utilities making the transition to 100% renewables.** National and sub-national renewable energy policies, often underpinned by ambitious climate targets, are highlighted as one of the key drivers for several utilities featured in this white paper. While some of these utilities need to comply with mandatory renewable portfolio standards (RPSs), others are adapting their operations to adhere to distinct types of policies. Following recent cost declines of renewable energy technologies, the aim to reduce dependency on costly imported fossil fuels is another key driver highlighted explicitly by utilities including Hawaiian Electric Companies, UTE and Stadtwerk Haßfurt. Other drivers comprise an increasing demand for renewables from the consumers' side – at both residential and commercial scales.

- **Close collaboration between utilities and relevant decision makers is crucial to enabling the renewable energy transformation.** Ambitious targets strengthen the case for utilities to make the transition to 100% renewable energy. In fact, all utilities featured in the case studies operate within jurisdictions that have adopted 100% renewable electricity targets. Close collaboration between utilities and relevant decision makers is highlighted as a key requirement for successfully paving the way for the transformation. This is particularly important when it comes to preventing frequent and sometimes disruptive policy changes, such as sudden cancellation of a support mechanism, retroactive fees and charges, modifications in policy design, or changes to decisions for grid extension.

- **Finding an optimal balance among different renewable energy sources is recognised as a key success factor for utilities in building supply-side flexibility.** Utilities featured in the case studies have undertaken considerable efforts to modernise their generation fleets and establish a mix of VRE, dispatchable renewable energy and utility-scale storage. In addition to the replacement of conventional generation capacity, existing assets have been adjusted towards more flexible supply supported by innovative ancillary services, improved renewable energy forecasting and new enabling technologies. For example, Ørsted relies on interconnections and flexible generation assets (combined heat and power plants) to supplement domestic offshore wind energy generation and is exploring technologies such as batteries and renewable hydrogen production. While considerable advances have been achieved in the power sector in finding the right supply-side balance, accelerated progress is needed to find an optimal balance of renewable energy sources in other end-use sectors.

- **Utilities recognise the need to further increase demand-side flexibility.** Among the utilities in the case studies, a strong focus has been on finding optimal supply-side solutions in the initial phase of their transformation. Moreover, among the utilities with higher shares of VRE as well as those approaching or having achieved 100% renewables, an increased focus on demand-side flexibility is recognised as a crucial factor. Smart meter implementation, household storage programmes and time-dependent tariffs for customers are, or will be, an important way to meet demand-side flexibility needs. Digitalisation of the energy system opens new possibilities for customers to play an active role as buyers and sellers, giving them a choice of various cost and convenience levels.

- **Flexibility solutions to balancing high shares of renewable energy are available, but further innovation is needed.** As variable and distributed renewable energy penetration increases, several utilities regard maintaining grid balance as a key challenge. In response, utilities have identified various solutions for increasing supply- and demand-side flexibility throughout their systems as highlighted above. Utilities at both national and municipal levels also refer to efforts undertaken to expand interconnection with neighbouring grids to support greater flexibility and improve grid stability. Furthermore, utilities recognise that more innovation is required to meet growing flexibility demands. Areas mentioned include battery storage, supra-regional flexibility trade and sophisticated time-use tariffs to further encourage shifting of loads.
- **Utilities recognise the opportunities of distributed renewable energy as key to the transformation.** A major part of successful implementation is to consider customers who install their own solar panels or wind turbines as active actors in the energy system by incorporating bi-directional functionality into these customers' installations. Some utilities are expressing concerns over unregulated situations which may result in an oversupply of renewable energy to the grid at certain times. In the case of SA Power Networks, strong interest among households and businesses in installing solar PV has led to curtailment and over-voltage issues. This case study highlights the importance of establishing early standards and flexibility options such as demand response measures, storage and flexible tariffs so that utilities can directly engage distributed renewable generators and active loads to maintain grid stability. These utilities also recognise that distributed renewable energy resources have the potential to provide valuable ancillary services if new technologies and control algorithms can be deployed to enable the use of such resources similarly to conventional synchronous generators (SGs).
- **Early adoption of high shares of renewables across all sectors may enable synergies and create competitive advantages.** This paper highlights that including all end-use sectors, not just the power sector, in the initial stages of the transformation to 100% renewable energy is crucial to enable sector coupling and to support achieving the target. As energy systems evolve, new economic opportunities and challenges will arise for utilities at different scales. Early phasing out of unsustainable and inflexible energy sources may improve the competitiveness of the utility in the medium to long term. The utility Mölndal Energi in Sweden has shown that achieving a 100% renewable energy target is feasible while keeping grid and electricity tariffs among the lowest in the country. Early adoption of high shares of renewable energy may also offer the possibility of leveraging sector expertise and enable first mover advantage to become pioneers in technology design and development.

# 5. Case studies

## 5.1 National-level utilities

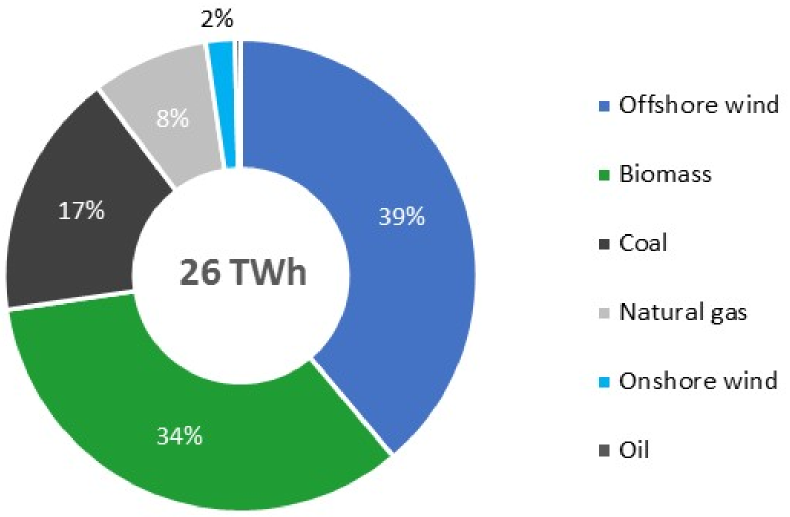
### Ørsted – Denmark

Ørsted is the largest energy company in Denmark, accounting for 50% of electricity generation and 35% of heat generation. Engaged in the generation and distribution of electricity and heat to customers across the entire country, Ørsted develops, constructs and operates onshore and offshore wind farms, bioenergy plants and, to a smaller extent, waste-to-energy plants. In addition to its operations in Denmark, Ørsted is also active as a developer and operator of offshore wind in other parts of the world, with 5.6 gigawatts (GW) in operation in 2019. The Danish government holds a majority stake in Ørsted, owning 50.1% of the company's shares (Ørsted, 2019a).

The company was founded in the early 1970s as a state-owned company primarily focused on developing coal power plants and managing national oil and gas resources. In 2017, the company decided to divest from all its oil and gas operations and changed its name from DONG Energy (short for "Danish Oil and Natural Gas") to Ørsted (Ørsted, 2017).

In 2018, 75% of Ørsted's total power and heat generation was achieved through renewable energy sources (41% wind and 34% biomass), an 11 percentage points increase from 2017. The remaining 25% consisted of fossil fuel generation (17% coal and 8% natural gas), as shown in Figure 7.

*Figure 7. Ørsted total heat and power generation, 2018*




*Source:* Ørsted, 2019b reproduced by IRENA Coalition for Action

Ørsted has committed to achieving at least 99% renewable energy by 2025 and to fully phasing out coal from its generation mix by 2023 – well before the national target of 100% renewable energy by 2050 (Ørsted, 2017). The target is set to be achieved through substantial increases in offshore and onshore wind deployment, as well as through the conversion of coal- and gas-fired power stations to sustainably sourced biomass.

Ørsted was an early investor in offshore wind farms and is now one of the leading players operating and developing offshore wind farms as an independent power producer. In 2018, Ørsted acquired Lincoln Clean Energy, a US-based onshore wind developer, and thus expanded its business to onshore wind and solar PV. The company also invested heavily in converting existing combined heat and power plants from the use of fossil fuels to sustainable biomass.[9]

In addition to converting its generation capacity away from fossil fuels, Ørsted is working with its distribution subsidiary Radius – which supplies about 1.1 million customers in Denmark's Copenhagen area – to modernise the grid with an integrated digital system to monitor, control and analyse grid data. Furthermore, Ørsted has begun investing in commercial battery storage as a means to ensure flexibility and reliability in a renewable-based system (Ørsted, 2019c).

## Interview with Magnus Hornø Gottlieb, Senior Global Public Affairs Advisor, Ørsted

**Q1. What are the key drivers behind the company's/utility's transformation towards 100% renewable energy?**

Ten years ago, Ørsted was one of Europe's most coal-intensive utilities, with a large portfolio within oil and gas. Today, we are the world's leading developer of offshore wind energy, we have divested from oil and gas exploration, and are well underway in phasing out coal completely from our power plants. In 2018, we took one step further in formulating our new vision: We want to help create a world running entirely on renewable energy.

A key driver for this transformation is the acknowledgement that climate change is a defining challenge of our time. Hence, for an energy company, it is both our responsibility to act on this realisation – and it would be bad business not to.

Political and societal calls for climate action have also been important drivers as well. For instance, our decision to rapidly phase out coal was facilitated by heat consumers' demand, carbon pricing and a regulatory framework calling for green energy.

When the offshore wind industry – of which Ørsted is part – has been able to make offshore wind power cheaper than that of new-build coal, gas or nuclear power plants, it is in large part the result of governments. Governments provided the industry with the clarity and confidence to invest and develop the technology.

IRENA, the IEA [International Energy Agency] and the European Commission all assess that to decarbonise our society, Europe alone will need several hundred gigawatts [GW] of offshore wind, towards 2050. This gives Ørsted a good prospect to continue our transition and growth within offshore wind generation.

> ***"Our decision to rapidly phase out coal was facilitated by heat consumers' demand, $CO_2$ pricing and a regulatory framework calling for green energy."***

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

We believe we will be able to reach >99% renewable generation by 2025 within the current framework.

[9] Aside from the standards mandated by the EU Renewable Energy Directive, Danish energy producers have agreed to submit their biomass sourcing to national standards and verification by independent third parties to avoid deforestation and minimise social and environmental risks from biomass sourcing.

The main enablers to Ørsted's green transformation have been ambitious buildout targets for offshore wind, enabling the industry to scale and innovate and bring down costs, together with a stable political and financial framework – *e.g.*, PPAs [power purchase agreements] with a fixed price per kilowatt [kW]-hour based on Contracts for Difference – enabling us to de-risk larger project investments and attract capital.

This buildout must be accelerated to stay within the Paris Agreement. How to best achieve this depends on market maturity and geography. But important factors are creating enough space to install offshore wind, securing adequate transmission capacity, both offshore and onshore, and to secure a pipeline of upcoming projects to enable supply chain investment.

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

Offshore wind energy should be considered an integral and cost-efficient bulk generation technology in geographies with the right conditions in terms of winds, seabed and power infrastructure. Recently, the IEA classified offshore wind as "variable base-load" due to its high capacity factor and low variability, placing offshore wind in a category of its own (IEA, 2019).

***"The Danish power system relies on well-functioning interconnections to our neighbouring markets as well as flexible power plants [to balance the generation from wind]"***

In Denmark, domestic wind energy covers close to half of our power consumption on average. The Danish power system relies on well-functioning interconnections to our neighbouring markets, as well as flexible power plants, some of which Ørsted owns and operates.

This enables the Danish Transmission System Operator to balance the generation from wind.

Historically, while building our offshore wind portfolio, Ørsted has also invested strategically in making our power plants as flexible as possible, and we are exploring technologies such as large batteries and renewable hydrogen production as well.

Ørsted is responsible for any imbalance in the power grid caused by our generation assets. We are able to efficiently respond to fluctuations in the system. Our offshore wind farms can ramp from full generation to zero, or vice versa, within a few minutes – subject of course to the actual wind resource at the time. This in fact enables offshore wind farms to, if allowed and remunerated, help provide some of the ancillary services required to maintain a stable power supply in the system.

**Q4. What are the current challenges with the system operation of the existing share of renewables? And how are you overcoming them?**

In north-western Europe, where the bulk of our generation is located, the main challenge today is the transmission infrastructure. More capacity is needed connecting high-generation to high-consumption regions, *i.e.*, Northern Europe and the North Sea to Central Europe. As renewable generation from offshore wind grows, this leads to bottlenecks and curtailments and to a sub-optimal market outcome.

Currently, we work with policy makers, regulators and TSOs [transmission system operators] to increase the transmission capacity available, and we continue to support the expansion of the European transmission grid and integration of the energy market.

In the future, the grid planning and layout has to be optimised to the geographical distribution of solar and wind generation potential. This is not really different from when the grid was optimised for the locations of gas, coal and nuclear power plants. Getting there will be a process – but a process we will have to accelerate to decarbonise in time.

**Q5. What (other) challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your main country of operations?**

As costs have diminished for offshore wind generation, the question is now: How do we best utilise the immense resource potential? Offshore can in many areas be the backbone of a future carbon-neutral power system and thus enable the green transformation of other sectors. This requires securing the below, all while continuing the societal push for electrification and power-to-X technologies to make full use of the increasing renewable generation.

- Adequate space for the future buildout of several hundred GW of offshore wind towards 2040 – in some areas co-existing with other sea uses in other areas replacing them – all while staying within a defined environmental headroom.
- A well-functioning onshore and offshore transmission grid expansion and cross-border flow of energy.
- An industrial pipeline capable of attracting capital to increase buildout capacity.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

Wherever we locate our activities, we rely on close and constructive dialogue with stakeholders in local communities, *e.g.*, the businesses and suppliers, and on constructing and operating our offshore wind farms, the neighbours to our facilities, local fishing communities, green NGOs [nongovernmental organisations] or other civil societal representatives and citizens' groups. Even as modern offshore wind farms are mainly built far out to sea, they still have a local impact and must be planned accordingly.

While not as much an issue to Ørsted *per se*, as our main focus is offshore, local opposition to onshore infrastructure – *e.g.*, transmission lines – is however a relevant challenge to the continued transformation of Europe's energy system.

We see it as the role of governments and politicians to acknowledge this issue and address it through dialogue with local stakeholders – explaining that infrastructure is necessary to combat climate change.

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

When the initial strategy was developed in 2009, and we announced our new strategy of transforming our business into a green one, we did not immediately have a plan or a timetable for the transition. We committed an increasing part of our effort to developing renewable energy, especially offshore wind energy and efficient bioenergy plants. We succeeded in making a profitable business from renewable energy.

Today, our transformation has been quicker than we dared imagine ten years ago. We believe – and hope – that our journey might inspire others to commit to similar transformations.

**Q8. What recommendations might policy makers derive from this case study?**

The remarkable cost reductions seen in offshore wind energy have been the result of a constructive interplay between policy makers and industry. Policy makers formulated targets for renewable energy, thus creating a demand which allowed for industrial investment and innovation. This brought down the costs, allowing us to set new, more ambitious targets.

> ***"Policy makers must provide the political ambition and a clear pipeline of upcoming projects"***

This dynamic is key to developing a world running entirely on green energy. Industrial players are ready to invest, innovate and industrialise new, renewable solutions – but policy makers must provide the political ambition and a clear pipeline of upcoming projects to speed up the process as well.

## Administración Nacional de Usinas y Trasmisiones Eléctricas (UTE) – Uruguay

Uruguay's National Administration of Power Plants and Electrical Transmissions, commonly referred to as UTE, is Uruguay's state-owned energy utility. UTE is responsible for power generation, as well as for country-wide transmission and distribution. To meet the demand of 1 200 000 customers located in the entire national territory, UTE owns and operates hydroelectric, wind and thermal power plants. The production is complemented by energy from the Salto Grande Hydroelectric Power Plant (a bilateral venture between Argentina and Uruguay) and with energy from generation plants owned by third parties (UTE, 2018).

UTE has managed to reach very high renewable electricity shares in recent years, constituting 98% of total electricity generation in 2017. More than 50% of electricity generated came from large hydropower plants, which have traditionally covered a large portion of Uruguay's energy demand. The remaining share was achieved by wind energy, biomass and, to a lesser extent, solar PV. The small non-renewable portion of generation was constituted by petroleum-fired thermal power plants, which have been traditionally used to provide peak demand power (UTE, 2017). Although these are still a small part of UTE's power generation assets, they have been increasingly substituted by biomass-fired plants, which generated more than 15% of total electricity in 2017. Significant investments in wind power over the last decade have led to an increased share of this technology, which has now surpassed hydropower in terms of installed capacity and constitutes more than half of Uruguay's renewable energy capacity (IRENA, 2019g).

National policy had a strong influence on these developments. In 2008, the Uruguayan government approved a comprehensive, long-term energy plan – the National Energy Policy 2005-2030 – with the overall objective to diversify the energy mix, reduce dependency from fossil fuels, improve energy efficiency and increase the use of local resources (focusing on renewables) (MIEM, 2019). In 2010, the plan was endorsed by all political parties represented in Congress. The plan included a target for 90% of the electricity mix and 50% of the primary energy mix to be composed of renewable energy by 2015. The target was surpassed, with renewables making up more than 93% of Uruguay's electricity generation and 55% of the total primary energy supply in that year (IRENA, 2019g).

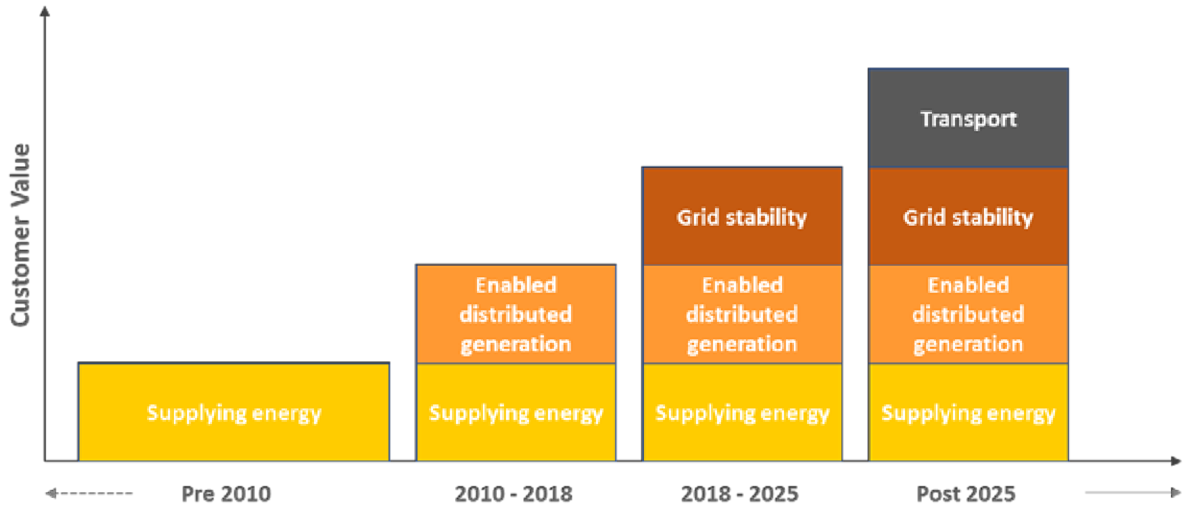
Besides clear government targets and support, the main enablers of this transition have been renewable energy auctions, leading to long-term PPAs between UTE and successful bidders. To encourage small-scale distributed generation, UTE has also provided net metering schemes for small wind power, solar, biomass and small hydro systems since 2010. Under this scheme, UTE is mandated to buy all the excess electricity produced by consumers at retail prices for a period of ten years (IRENA, 2015). Strong government support and well-designed financing schemes, coupled with Uruguay's natural renewable energy endowments, have thus allowed UTE to succeed in 100% renewable energy provision.

## 5.2 Regional/state-level utilities

## SA Power Networks – South Australia

Since the privatisation of the electricity sector in 1999 there has been no vertically integrated electrical utility in South Australia. Currently there are many electricity generating companies and retailers but only one distributor (SA Power Networks) and one transmission line company (Electranet). SA Power Networks is a privately held monopoly regulated by the Australian Energy Regulator. Its primary role is to maintain and operate the state's distribution network, which serves around 860 000 homes and businesses and 1.7 million people (SA Power Networks, 2019a).

*Figure 8. The changing role of SA Power Networks*




*Source*: SA Power Networks (2019b) reproduced by IRENA Coalition for Action

South Australia is at the forefront of the Australian energy transformation, with a target of reaching 100% renewable energy in all end uses by 2050 (AEMO, 2018). For the power sector, with currently committed projects in the pipeline, South Australia is expected to reach 73% VRE in electricity generation by 2021 and effectively 100% by 2025/2026. By the end of 2018, about 53% of South Australia's electricity came from renewables – 35.2% from wind (1 809 megawatts [MW]) and the rest predominantly from rooftop solar (930 MW), with another 135 MW from large-scale solar farms (AEMO, 2018). Natural gas supplied the bulk of the remaining generation with increasingly diminishing supply provided through interconnection with the eastern states. Some emergency local diesel supply also exists. A 500-MW brown coal power station in the state's north closed in 2016. Prior to that, the majority of South Australia's electricity generation was from natural gas and brown coal (AEMO, 2018).

SA Power Networks manages an average electricity demand in the state of about 1 500 MW, with the peak in summer being just under 3 000 MW. AEMO's (the Australian Energy Market Operator's) conservative indications of 700 MW of new committed renewable energy generation will bring installed VRE capacity to 3 574 MW (AEMO, 2019). Regular wind curtailment and negative electricity prices have already occurred, and periods of renewable energy oversupply will clearly become increasingly frequent in the coming years.

Driven by a feed-in tariff and the competitive price of solar PV, there is great interest from both households and businesses to build additional renewable energy capacity in the state. By the end of July 2018, committed and publicly announced additional supply developments in South Australia totalled as much as 8 184 MW across 56 projects. AEMO classifies about 700 MW of this as committed for development (AEMO, 2019). Additionally, the South Australian government has reported that there was about AUD (Australian dollar) 21 billion (USD [US dollar] 14.2 billion) worth of potential investment in large-scale renewable energy and storage in the state, if all projects that registered interest to the state government came about. These included about 4 000 MW of wind, 5 700 MW of utility solar PV, 2 700 MW of battery storage, 1 400 MW of pumped storage, plus 190 MW of other projects, including solar thermal (SA Power Networks, 2019b)

With large amounts of variable and new distributed renewable energy capacity being deployed, SA Power Networks recognises that significant adjustments to the electricity distribution situation in the state are necessary to ensure reliability and security of supply. The company also recognises that its role as distributor will be evolving in the decade to come, as illustrated in Figure 8.

## Interview with Dr Bryn Williams, Future Network Strategy Manager, SA Power Networks

**Q1. What are the key drivers behind the company's/utility's transformation towards 100% renewable energy?**

The State of South Australia is at the forefront of Australia's transition towards renewable energy. As the state's regulated distribution network, SA Power Networks must adapt its business to keep pace with this transformation.

The key drivers of change are South Australian government policy and the strong customer uptake of rooftop solar PV – initially stimulated by generous feed-in tariffs and now sustained by the short payback period customers can achieve from rooftop solar PV – as solar PV prices continue to fall and the price of grid electricity remains high relative to other states.

*"The key drivers of change are South Australian government policy and the strong customer uptake of rooftop solar PV – initially stimulated by generous feed-in tariffs and now sustained by the short payback period customers can achieve"*

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

Under Australia's current National Electricity Rules, all distribution network revenue must be recovered from tariffs on energy imported (consumed) from the grid, and small customers do not pay any network augmentation fees to connect generation.

This leads to a cross-subsidy from non-solar customers to solar customers. It also means that small customers may not always have the right to feed energy into the grid. This consequently presents a regulatory barrier to network operators investing in increasing distributed energy resource [DER] hosting capacity.

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

Until a few years ago the average installed capacity of a residential solar PV system was less than 2.5 kW. Now, with the reduction in solar PV costs, the average size is over 5 kW.

In 2018, we undertook a project to model the DER hosting capacity of our local low-voltage networks. This indicated that the native capacity of our network to accept embedded generation is around 1-3 kW per customer, depending on network construction. Above this level, local over-voltage issues arise in the middle of the day at certain times of year. This tells us that our current connection policy, which is to pre-approve any system with an inverter of 5 kW or less, is not sustainable, and this is becoming apparent in the increase in customer over-voltage enquiries we are seeing in local areas where solar penetration exceeds 30%.

**Q4. What are the current challenges with the system operation of the existing share of renewables? And how are you overcoming them?**

As a distribution network, the most immediate challenge we face is managing the impact of reverse power flows on local residential low-voltage networks. We are pursuing a range of approaches to enable greater penetration of solar PV within the existing network capacity, including new time-of-use tariffs for small customers to encourage shifting of load into solar through improved technical standards for inverters (SA Power Networks, 2019c), shifting domestic water heating loads to the middle of the day and more advanced grid-side voltage management (Australian Energy Regulator, 2019).

We believe the key to enabling significantly higher penetration in the future is to move from today's simple, fixed inverter size limit of 5 kW per customer to a flexible export limit, wherein customer inverters are internet-connected and can download a locational, time-varying export limit that reflects the true capacity of the local network.

SA Power Networks is leading efforts in Australia to advance standards in this area, based on international approaches such as California's Rule 21 (California Public Utilities Commission, 2018).

**Q5. What (other) challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your main country of operations?**

As rooftop solar PV penetration continues to grow, minimum demand continues to fall in the middle of the day. The Australian Energy Market Operator is forecasting that as early as 2024 the state-wide minimum demand may become negative at certain times purely due to rooftop solar PV. The associated reduction in synchronous generation poses unprecedented challenges for system security.

Consequently, the private and public sectors are both taking various measures to address this issue. These include: the commissioning by the South Australian government in 2017 of a 100-MW/129-MWh [megawatt hours] grid-connected battery, the world's largest, which provides frequency support, reserve energy capacity, and energy arbitrage services; an AUD 100 million [USD 67.7 million] government subsidy scheme for home battery storage and a separate 50 000-home virtual power plant [VPP] project; installation of new synchronous condensers; government funding to support new grid-scale storage projects, including pumped hydro; and planning for an additional interconnector to exchange energy with the eastern states.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

In South Australia, although wind currently makes up the largest share of the state's renewable generation capacity (1 809 MW), the most significant factor driving the transformation of the energy sector is customer investment in rooftop solar PV. In 2019, installed capacity of rooftop PV passed 1 000 MW, equivalent to 34% of the total renewable generation capacity in the state.

***"The next significant wave of transformation is likely to be led by customers"***

This gives South Australia the highest ratio of rooftop PV to operational consumption of all regions in the Australian National Energy Market. This trend is expected to continue for the coming ten years. Although the majority of rooftop solar is residential and represents about 33% of the state's homes, business solar PV is currently growing at a considerably faster rate as solar PV prices continue to fall and businesses respond to high retail energy prices.

The next significant wave of transformation is similarly also likely to be led by customers – albeit accelerated by government subsidies – as they begin to adopt small-scale battery storage and enrol in virtual power plants.

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

The transformation to 100% renewable energy is not simply the substitution of one generation source with another; it entails an unprecedented transition from centralised ("top-down") to decentralised ("bottom-up") generation.

In a highly renewables-based energy system, a significant portion of the total energy consumed will be produced by hundreds of thousands of small-scale PV systems connected to the distribution network. Distributed batteries, aggregated in VPPs in the tens of thousands, will become a primary source of frequency control services to maintain overall system stability.

In the future, as more electric vehicles enter the market, vehicle-to-grid electricity transfer may also happen. Therefore, the performance and security of the system will become increasingly dependent on the performance of the distribution network and on the ability of distribution network operators to manage dynamic, two-way energy flows within the technical limits of network assets that were not originally designed for this.

In practical terms, a key lesson from South Australia is that appropriate technical standards and rules must be put in place as early as possible to ensure that customer DERs are "grid-friendly". More importantly, we need to move as soon as possible to devices that can be actively managed.

Today in South Australia we have a large and growing legacy problem: rooftop PV is already "the state's largest generator", but it is completely uncontrolled; unlike other generators, it cannot be turned down by the market operator at times of oversupply, nor by the network operator to manage local capacity constraints.

If we are to reach 100% renewables, all inverters and significant flexible loads such as air conditioners, hot water systems and electric vehicle chargers will need to have standard interfaces that enable them to engage actively with the grid. This will enable network operators to maximise access to local network capacity, increasing the value to customers of their energy resources, while avoiding over-voltage issues and protecting system-wide security of supply.

***"Appropriate technical standards and rules must be put in place as early as possible to ensure that customers' DERs are grid-friendly"***

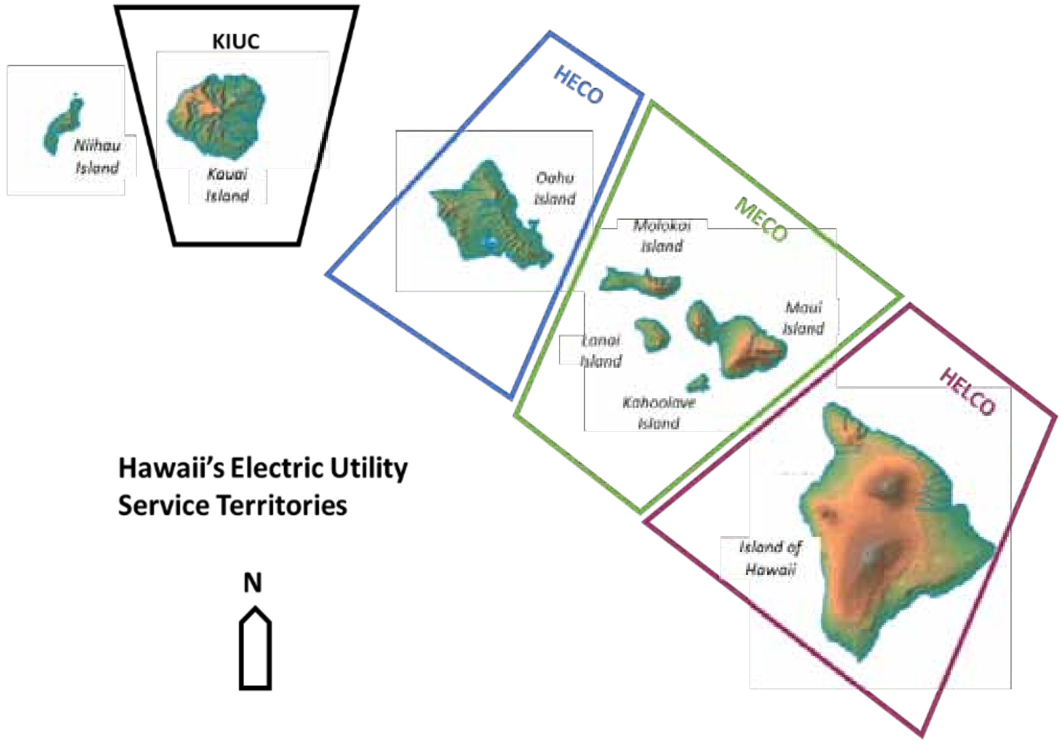
**Q8. What recommendations might policy makers derive from this case study?**

Achieving 100% renewable generation in Australia will ultimately require a change in regulation that recognises the role of the distribution network in connecting and enabling generation as well as supply. Networks need appropriate incentives to invest in network capacity to support higher levels of DER, and this may require changes to network tariffs to ensure that the cost of the network is shared equitably by all users in the future.

## Hawaiian Electric Companies – United States

The Hawaiian Electric Companies – Hawaiian Electric (HECO), Maui Electric (MECO) and Hawaii Electric Light (HELCO) – provide electricity services for the majority of the islands that make up the US state of Hawaii (Figure 9). The companies are all investor-owned utilities and together serve 95% of the state's 1.4 million residents on the islands of Hawaii, Lanai, Maui, Molokai and Oahu (HSEO, 2018). The renewable share of electricity generation reached 26.6% for the three utilities in 2018, up from 23% in 2015.

*Figure 9. Overview of electricity providers in Hawaii*

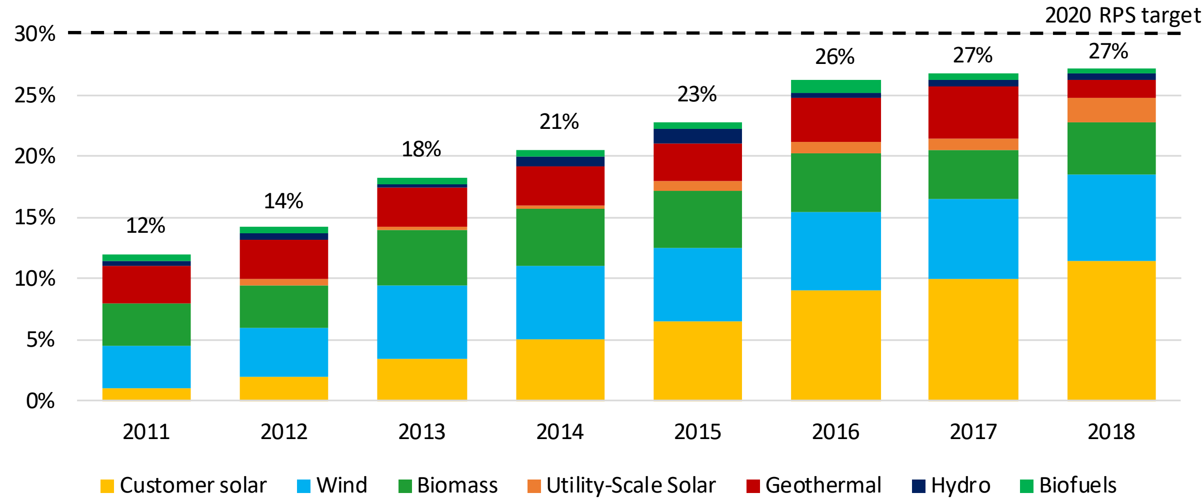



*Source*: HSEO (2018) reproduced by IRENA Coalition for Action
Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

Launched in 2008, the Hawaii Clean Energy Initiative (HCEI) was established in Hawaii as a partnership between the State of Hawaii and the US Department of Energy. This initiative's initial goal was for the state to produce 70% of its electricity from clean and renewable energy by 2030. An RPS of 15% electricity sales by the end of 2015 was also established. The HCEI has since been strengthened and in 2015 the Hawaii State Legislature reinforced the state's commitment to clean energy by increasing the RPS requirement to 100% renewable electricity by 2045, with interim targets of 30% by 2020, 40% by 2030 and 70% by 2040 (NREL, 2018).

Going from 9.5% renewable electricity generation in 2009 to over 25% in the past decade has required extensive efforts from the utilities, and significant work remains to reach 100% (Figure 10).

*Figure 10. Hawaiian Electric Companies' progress towards achieving the 2020 RPS target*




*Source*: Hawaiian Electric (2019b) reproduced by IRENA Coalition for Action

The Hawaiian Electric Companies have incorporated renewables in the forms of residential and commercial rooftop solar, utility-scale solar, battery storage, wind, hydro and geothermal. The companies' combined annual oil use for power generation has declined by 88 million gallons (330 million litres), or about 19%, since 2008, and total carbon emissions have been reduced by about 925 000 metric tonnes between 2010 and 2018 (Hawaiian Electric, 2019b). Recently, contracts have been signed for eight new solar-plus-storage projects for over 275 MW of solar and more than 1 GW of battery storage, all at prices well below the cost of fossil fuel generation (HSEO, 2018). In 2019, the companies issued a second request for proposals seeking about 900 MW of additional renewable electricity capacity.

In the transition towards 100% renewable energy, Hawaiian Electric is also looking for projects to replace the 180-MW coal-fired AES Hawaii plant when its contract with the independent power producer expires in September 2022. For its part, Maui Electric is seeking generation and storage for the planned retirement of the 37.6-MW oil-fired Kahului Power Plant (Hawaiian Electric, 2019b).

The companies' Power Supply Improvement Plan further charts the specific actions needed to accelerate the achievement of 100% renewables, including the pursuit of modernising the grid to accommodate more VRE (Hawaiian Electric, 2016a). While the plan is a guide, the utilities have had to remain flexible and adapt to changing circumstances, always keeping the door open to emerging technologies as highlighted in the plan's Renewable Energy Planning Principles (Hawaiian Electric, 2016b).

## Interview with Shannon Tangonan, Corporate Communications Manager, Hawaiian Electric Company (HECO)

**Q1. What are the key drivers behind the utility's transformation toward 100% renewable energy?**

The most significant driver in the State of Hawaii's transformation to 100% renewable energy is the fact that nearly all of the state's energy requirements have historically been met by high-priced imported oil, causing a drain on the state's economy and a risky dependency on oil imports and fluctuating oil prices. The companies' island grids are not connected, and there is no extension cord to the US mainland, so achieving energy independence is critical.

Hawaii has been addressing this problem for many years and has long recognised the role that renewable energy (especially wind, solar, geothermal, ocean thermal and wave, and biomass, which are all in abundant supply in the islands) can play to mitigate this situation. The Hawaiian Electric Companies are committed to the 100% RPS [renewable portfolio standard] for Hawaii.

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

The key policy enabler to achieve 100% renewables in Hawaii in the power sector is the RPS, established in 2015 under Hawaii's House Bill 623 (HB623) with an ultimate target of 100% renewable electricity by 2045. Other key acts to accelerate the transformation toward 100% renewables in the power sector by 2045 include a community-based renewable energy programme in 2016, and alignment with the Paris Climate Agreement goals in 2017 (NREL, 2018).

In October 2015, the state Public Utilities Commission decided to eliminate net energy metering [NEM] in Hawaii. The NEM has since been replaced with other options for new rooftop solar customers, including: 1) a self-supply option which allows rooftop solar customers to export some excess electricity to the grid without compensation, with the customers having a minimum monthly payment; and 2) a grid-supply option which has a provision for exporting excess energy to the grid for credits against customer bills so long as the exports benefit the electric system.

> ***"The key policy enabler to achieve 100% renewables in Hawaii in the power sector is the RPS, established in 2015... with an ultimate target of 100% renewable electricity by 2045"***

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

The Grid Modernization Strategy (Hawaiian Electric, 2017) addresses a two-pronged strategy: 1) near-term goals of further encouraging customer distributed energy resource [DER] adoption by advancing grid technologies to enable integration and utilisation at the distribution level; and 2) long-term goals of extending the integrated grid platform to accommodate storage and advanced grid technologies (Chong and Asano, 2018).

Additionally, Hawaiian Electric completed the construction of its Schofield 50-MW Generating Station, which came online in 2018 (Wärtsilä, 2018). Schofield's generators, which are fuelled by biofuel and diesel, are capable of quickly starting up, shutting down or changing their output in response to sudden changes in solar and wind energy resources.

With the addition of Schofield and battery energy storage in 2022, Hawaiian Electric will be in a better position to maximise the use of Oahu's variable solar and wind resources by providing grid-stabilising technologies that can manage supply and demand in the sub-second to minute timescales.

**Q4. What are the current challenges with the system operation of the existing share of renewables and the power system as a whole in Hawaii? And how are you overcoming them?**

New technologies in the Hawaiian Electric Companies' Grid Modernization Strategy include information and communication technologies to better manage the generation, distribution and end use of electricity that will allow the utility to better regulate fluctuations in power supply and demand, and deliver power more efficiently, giving the electric grid greater flexibility to integrate renewable energy into the system (Hawaiian Electric, 2017). A key component of these modernisation technologies is the use of advanced meters, which provide real-time data to the utility on both the production and use of electricity by a customer.

One specific initiative is a second round of requests for proposals, where the companies seek grid services that can be provided from aggregated customer resources. One service that is critical to maintaining the reliable operation of the grid is fast frequency response. The companies are seeking this grid service to stabilise the system when frequency deviations occur due to the sudden loss of generation or load.

**Q5. What other challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your state?**

Setting expectations for stakeholders, customers and regulators will become more challenging as the Hawaiian Electric Companies make the transition to 100% renewables.

On islands, the availability of land suitable for renewable energy projects is especially challenging, and there are some conflicting priorities, including agriculture, housing, and conservation.

This gradual transformation will not bring immediate customer savings but will reduce Hawaii's exposure to the sometimes-dramatic fluctuations in oil prices.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

The Hawaii Clean Energy Initiative [HCEI] was the result of the work of local stakeholders representing diverse backgrounds and perspectives, organised into working groups and receiving technical support from the US Department of Energy and its National Renewable Energy Laboratory [NREL].

The companies, especially in relation to the Grid Modernization Strategy, have made transparency and ongoing stakeholder engagement central to all initiatives (Hawaiian Electric, 2017). This has been noted and commended by regulators and activists alike. The utility used a private research polling firm to gain insight as it drafted the strategy.

Significant input from a wide range of stakeholders was also obtained through a public review process that helped to contribute to the final strategy. Stakeholders included both commercial and residential customers, especially customers with solar already installed on their homes and businesses. Although not eliminating disagreement or outright opposition, it was clear that this stakeholder engagement process had an important and positive influence on the formulation of the final strategic plan currently being implemented by the utility.

***"The companies, especially in relation to the Grid Modernization Strategy, have made transparency and ongoing stakeholder engagement central to all initiatives"***

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

The Hawaiian Electric Companies' Grid Modernization Strategy and integrated grid planning initiatives could be practical examples to others (Hawaiian Electric, 2018).

The evolution of the companies' DER processes could also provide guidance to other jurisdictions that are on similar renewable energy paths.

Also, the companies have benefitted from piloting the latest technologies (Dynamic Var Controllers, advanced inverters, etc.) to determine what works and what doesn't as we integrate more renewables into our island grids, and results have been shared thus allowing other utilities to review what might work in their service territories.

**Q8. What recommendations might policy makers derive from this case study?**

Make transparency a key value. Begin stakeholder engagement early. Take advantage of resources like the National Laboratories, the Edison Electric Institute, and the Electric Power Research Institute; vendors and activist organisations like Rocky Mountain Institute or the Interstate Renewable Energy Council; and other leading utilities to find best practices and avoid re-inventing the wheel.

> ***"This gradual transformation will not bring immediate customer savings but will reduce Hawaii's exposure to the sometimes dramatic fluctuations in oil prices"***

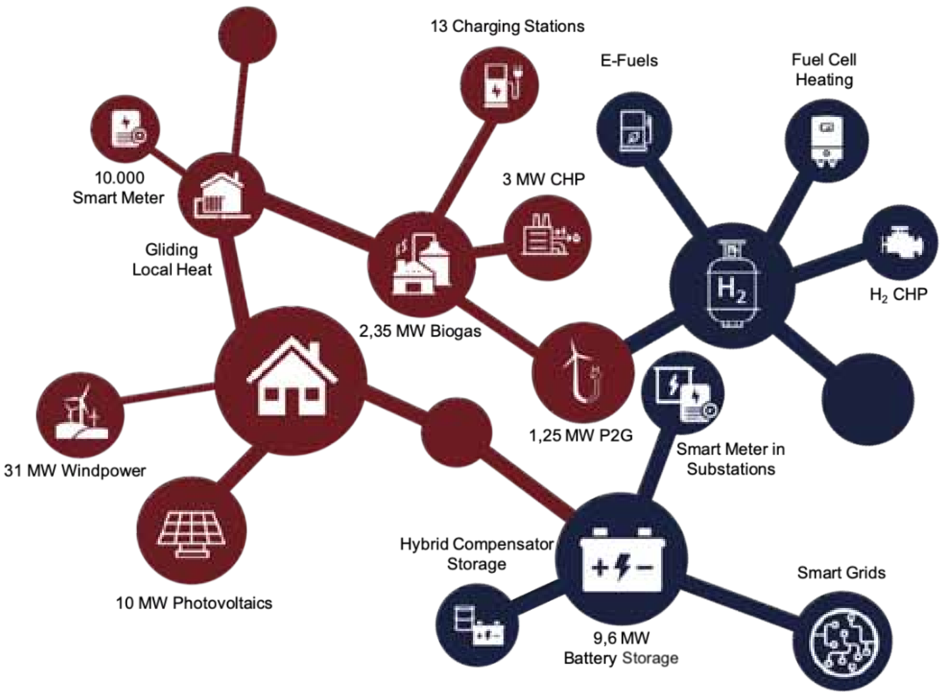
## 5.3 City/municipal-level utilities

## Stadtwerk Haßfurt – Germany

The Stadtwerk Haßfurt GmbH was founded in 1955 and is the municipal multi-utility supplying company of the District of Haßfurt (Federal State Bavaria, Germany). The City of Haßfurt owns more than 80% of the company (shareholders: 82.1 % City of Haßfurt and 17.9 % Bayernwerk AG) (Stadtwerk Haßfurt, 2016). The utility provides electricity, water, gas and local heat supply to more than 9 500 private households, companies and public buildings. Additionally, Stadtwerk Haßfurt offers manifold digital services (Stadtwerk Haßfurt, 2019).

In 2012, in the aftermath of the Fukushima disaster and Germany's decision to completely phase out nuclear energy, Stadtwerk Haßfurt set itself the overarching target of achieving 100% locally produced renewable energies by 2030. The immediate response from Stadtwerk Haßfurt was influenced by the town of Haßfurt's proximity to the Grafenrheinfeld nuclear plant, which was shut down in 2015.

*Figure 11. Renewable energy projects implemented (red) and underway (blue), Stadtwerk Haßfurt*




*Note:* $H_2$ = Hydrogen, CHP = Combined Heat and Power, P2G = Power-to-gas
*Source:* Stadtwerk Haßfurt GmbH internal data

The 2030 target is currently planned to be realised across the following sectors: energy generation and distribution, heating and cooling, and industry and sector coupling.

The company's strategy to reach its 2030 target is based on two cornerstones: 1) building a broad range of DERs and storage systems; and 2) expanding its digital services (B2B [business-to-business] and B2C [business-to-consumer]) to enable ancillary services and forward-looking energy market models (Stadtwerk Haßfurt, 2019).

In 2012, Stadtwerk Haßfurt's electricity mix included 42% of renewable energy sources, complemented by energy externally sourced from coal and nuclear sources. As of 2019, the utility's renewable electricity share had reached twice the electricity consumption of all its customers, with half of this electricity fed into the grid of surrounding districts.[10]

Haßfurt's electricity system relies mainly on four renewable sources: wind (31 MW), solar PV (12 MW), biogas (12 MW) and hydrogen (1.25 MW), with the latter being produced by a power-to-gas plant for industrial and research processes. Moreover, the company has installed 8 MW of battery storage.

Haßfurt foresees a higher overall electrification of end-use sectors in the decade to come. To prepare for this increased renewable electricity demand, the utility has set itself several milestones, including the installation of 50 electric charging stations, an additional 20 MW of storage capacity, the implementation of hydrogen supply infrastructure and the expansion of power-to-gas capacity up to double its current level. Moreover, Stadtwerk Haßfurt plans a 75% increase of PV installations up to 2023. In the attempt to reach the goal of supplying the whole District of Haßfurt with 100% renewable energy (As illustrated in Figure 11), the utility has implemented (red) or is on its way to implementing (blue) several projects, *e.g.*, installing renewable energy capacities, smart meters and fuel cell heating. In accordance with its set 100% renewable energy goals and those already reached, the company is preparing an adjusted strategy on how to further strengthen public communication and engagement as well as to intensify its involvement in pilot and research projects with local, national and international partners. The time horizon for the adjusted strategy is 2020.

### Interview with Norbert Zösch, Executive Director, Stadtwerk Haßfurt GmbH

**Q1. What are the key drivers behind the company's/utility's transformation towards 100% renewable energy?**

Generally speaking, the major driver behind our transformation is a long-term change of strategy for the entire region to achieve the Paris climate goals and thereby do what we can to limit global warming to 1.5°C [degrees Celsius]. On the ground, key drivers behind our transformation are manifold, our way of thinking, our team spirit and of course the trust of our mayor and the city council as well as the municipal utility management.

Another cornerstone of our success is the active involvement of citizens, *e.g.*, through participation in wind farms and electricity grid repurchases or pilot projects with end customers within the framework of research projects.

All those factors accelerate our drive for innovation while intensifying customer loyalty at the same time.

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

In Germany, federal legislation has been an enabling force for the expansion of renewables, mainly due to the introduction of the German Renewable Energy Act (*Erneuerbare-Energien-Gesetz*, or EEG) in 2000 which originally provided a feed-in tariff scheme to encourage the generation of renewable electricity. However, certain changes within the EEG have placed major hurdles for specific forms of renewable energy, due to the law's associated charge to non-privileged final consumers.

[10] The numbers provided have been compiled from internal documents from Stadtwerk Haßfurt and from the utility's website.

This means that these changes within the EEG include insufficient funding and a double burden for storage technologies.

Our newly installed power-to-gas plant, for example, cannot yet run in an economically profitable way, which is why the production of hydrogen lags behind its possibilities. Such hurdles must be addressed for a forward-looking energy supply.

Speaking of the national level, the entire digitalisation sector is stagnating in Germany because of a missing federal guideline for smart meter gateways, due to which no utility company is willing to invest before the market for the gateway is opened. Other European states are already overtaking Germany in this area because they do not have to fight with those hurdles. Moreover, national and federal state legislation (*e.g.*, the "10-H rule"[11] for wind turbines in Bavaria) prevents the necessary expansion of onshore wind plants. Our experience shows that large-scale projects with citizen participation and a transparent flow of information can definitely be implemented successfully.

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

We have applied a broad range of complementing technology from state-of-the-art control technology (IDS-HighLeit), dedicated communication and control networks (partly fibre-optic network) in distribution stations, and decentralised supply facilities.

***"We participate in a supra-regional flexibility market which allows us to balance demand and supply across all relevant timescales"***

Additionally, we offer time- and load-dependent tariffs to our customers (B2B [business-to-business] and B2C [business-to-consumer]) and participate in a (supra-regional) flexibility market which allows us to balance demand and supply across all relevant timescales.

**Q4. What are the current challenges with the system operation of the existing share of renewables? And how are you overcoming them?**

In general, the major problem is the separation of the financial and physical energy flow. Energy produced by renewables is often sold directly to retailers, and their interest is the maximisation of revenue. However, many times those markets do not meet the supply needs of the local energy grid. This is due to the market not operating at the regional, national or even international level. Supply and demand of a local energy grid varies depending on the national and European level.

We try to resolve this matter by partnering with innovative marketer companies that offer more flexible opportunities to trade energy from renewable energy sources. We also take part in research projects dealing with the topic of supra-regional flexibility trade and new market models to real world implementation, *e.g.*, the EASY-RES research project funded within the EU's Horizon 2020 programme (EASY-RES, 2019).

**Q5. What (other) challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your main country of operations?**

The more distributed renewable energy sources [DRES] we get in the medium-voltage and low-voltage grid, the more problems occur regarding grid stability. The stability and security of the traditional electrical power systems are largely based on the inherent properties of synchronous generators [SGs].

[11] The rule, enacted in November 2014, prescribes that the minimum distance between a turbine and the nearest settlement must be ten times the turbine's height.

The increase of SG spinning reserves, grid reinforcement and the use of central electric energy storage systems are some obvious solutions proposed to tackle this problem.

However, due to their centralised approach and high cost, these actions can be undertaken only centrally by the transmission system operators and large-scale distribution system operators.

The transition to 100% renewable energy can only be successful when applying a unified bottom-up approach that determines the development of new control algorithms for all converter-interfaced DRES in order to enable them to operate similarly to conventional SGs and provide new ancillary services to the distribution and transmission grid. These new functionalities have to be transparent at all grid voltage levels.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

Citizens play the most important role. The implementation and integration of 100% renewable energy require a regional strategy that is supported by the city administration, the energy supplier and, most importantly, the people living in the specific region, state or country.

***"In Haßfurt, the regional population has already been involved in several citizen energy forums, thereby participating in and shaping the energy transition to 100% renewable energy"***

It requires a lot of effort to regularly inform and update ordinary consumers, so that the complex (German) system of energy supply can easily be understood by normal consumers in the same way as a mobile phone contract.

The municipality as a whole plays another key role in the conversion of the energy supply locally, in Germany and all over Europe. In Haßfurt, the regional population has already been involved in several citizen energy forums, thereby participating in and shaping the energy transition to 100% renewable energy.

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

- Build, strengthen and expand networks with citizens as well as key stakeholders in politics, business and research.
- Search for business and research partners with a certain affinity to risk, and which are willing to develop and realise prototype projects.
- Always stay open to new ideas and innovation.
- Expand entrepreneurial thinking to convert the energy system to a sustainable future over a long-term period.

**Q8. What recommendations might policy makers derive from this case study?**

- Less legal regulation of the energy market, *e.g.,* via dynamic energy pricing. The *status quo* of renewable technology already allows renewables to outperform fossil and nuclear energy.
- State support for key technologies for a complete conversion of the energy system (*e.g.*, power-to-gas).
- Introduction of a $CO_2$ [carbon dioxide]-pricing mechanism for the use of energy.
- Incentives and information for local politicians and municipal officials to increase acceptance and bolster the courage of local stakeholders to realise the energy transformation.
- An improved flow of information and transparency for citizens to raise awareness, foster understanding and acceptance on the topics of energy generation, energy consumption, electricity pricing and the renewable energy transformation as a whole.

## Mölndal Energi – Sweden

Mölndal municipality owns the energy company Mölndal Energi, providing energy infrastructure in the municipality as well as supplying heating, cooling and electricity. The company sells electricity to around 100 000 customers, many of them living outside the municipality. Of those customers, 22 800 are also connected to the company's distribution grid and 2 240 to the district heating system. In broad agreement between the company and the politically elected board, the vision of the company is "to be leading in the transition to a sustainable society and have the most satisfied customers in the country" (Mölndal Energi AB, 2018).

Sweden's electricity grid is a regulated monopoly, but the country's electricity and heating supplies are open to competition. The inhabitants of the Mölndal municipality may buy electricity from any supplier via the regulated grid, and Mölndal Energi supplies customers outside of the municipality as well. For the district heating supply, the company has a monopoly within the municipality, but with local competition from distributed heat pumps, wood pellet boilers and stoves as well as oil-fuelled boilers.

The company's main asset is a 70-MW (steam power) biomass-fuelled cogeneration plant producing 24 MW of electricity, while supplying district heating from the boiler and from an additional 20-MW smoke stack condenser (Mölndal Energi AB, 2019). An additional heat boiler, which previously used fossil fuel oil, has been refitted to use renewable fuel and ensures heating from 100% renewable energy sources even in very cold peak load hours. Additional electricity is produced in three wind power plants owned by the company, as well as procured based on guarantees of origin to be renewable and in accordance with environmental labelling criteria set by the Swedish Society for Nature Conservation. In 2008, Mölndal Energi was the first company in Sweden to offer its customers both environmentally labelled electricity and district heating (Naturskyddsföreningen, 2008).

The implementation of Mölndal Energi's 100% renewable energy target has been realised while keeping grid tariffs well below the maximum allowed by the regulator – an important requirement from the company's owners/customers. As a result, the company had the fourth-lowest grid tariff and the sixth-lowest electricity tariff among 290 areas in Sweden in 2019 (Nils Holgersson Group, 2019).

Having succeeded with a profitable transformation of its main business, the company continues to make a transition its own operations, including an exchange of traditional vehicles with electric cars, lawn mowers and other machinery, which have been 100% fossil-fuel free since 2018.

Quantitative targets on renewable energy were not publicised. The targets were not meant to be reached at any cost but were rather a signal of the profitable direction in which the company was seeking to go.

## Interview with Christian Schwartz, Chief Executive Officer, Mölndal Energi

**Q1. What are the key drivers behind the company's/utility's transformation towards 100% renewable energy?**

The municipality owning the company and the management have the ambition to provide environmentally sustainable renewable energy at low cost. The municipality is also requiring security of supply and reliability. All these ambitions are in favour of domestic renewable energy.

All investments, from district heating and a biomass-fuelled cogeneration plant to our final steps to 100% renewable in all operations, were based on economic analysis.

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

We have taken all opportunities to benefit from policies supporting renewable energy. The most important was the electricity certificate system that made bio-cogeneration profitable early so that we could start learning how to use bio-residues efficiently.

In front of the board (which consists of representatives from all political parties represented in the local council) I have always described fossil dependence as an economic business risk. This has proven to be a profitable attitude.

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

Our cogeneration plant produces heat and electricity from biomass residues during the time of the year when houses need lots of heat and electricity is most valuable.

In the summer, we buy and distribute environmentally labelled renewable electricity, and we can produce heat from our bio-oil boiler when required.

Our investment in three wind power plants has provided more electricity during the winter months when demand is highest.

We are enthusiastic about our customers installing solar PV panels. They do not compete with our own plants, they contribute during high demand hours in the day, and they produce in the summer months when we rarely run the cogeneration plant. As our customers are often our municipal citizens, and thus owners, we should help them.

Balancing is getting easier with an ensemble of different renewable sources. So many fail to recognise that stable supply always requires a mix of different generators!

**Q4. What are the current challenges with the system operation of the existing share of renewables? And how are you overcoming them?**

We are trying to keep costs down by using our ability to burn biomass waste that is difficult to combust and therefore cheap as it would otherwise be wasted.

Renewable electricity replacing fossil fuels in transport and industry is a wonderful development, but it makes it important that grid operators have a direct interaction with customers, and may use pricing to manage grid congestion also in the distribution grid as power demand increases fast. I just published an opinion article about this with some colleagues in other grid companies.

> ***"We have taken all opportunities to benefit from policies supporting renewable energy. The most important was the electricity certificate system"***

**Q5. What (other) challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your main country of operations?**

None! We are at 100% already. We just see opportunities to reduce costs and have renewable energy replace more fossil fuels among our customers.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

The customers just expect us to succeed. At one point in time, when investing to be able to provide renewable fuel for peak heat, it was important that customers with certified sustainable buildings made us commit to a renewable heat supply. We found our investment in renewable peak heat supply became necessary to manage an extreme-cold winter period with these contracts.

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

Start directly, keep the direction and do not get lost in details. The more you do, the more you learn, and the easier and more profitable it becomes. In the end, when getting rid of the last fossil-fuelled vehicles and lawn mowers, we just did not want to spend the time procuring fossil fuels anymore.

***"Renewable electricity replacing fossil fuels in transport and industry is a wonderful development, but it makes it important that grid operators have a direct interaction with customers"***

**Q8. What recommendations might policy makers derive from this case study?**

Keep the direction! Investors may accept that details in the policy change, but changing the policy target erodes confidence among investors in the energy industry.

## City of Aspen Utilities Agency – Colorado, United States

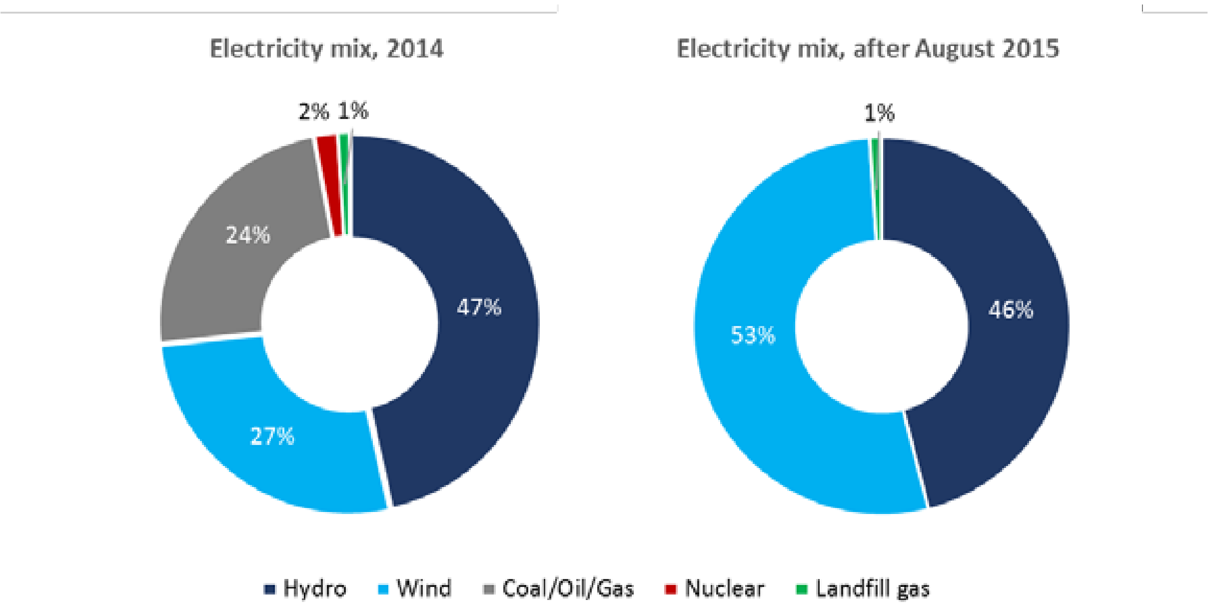
The City of Aspen is a small mountain community located in the US state of Colorado. The city has a population of roughly 7 000 permanent residents, although the total population can vary significantly throughout the year due to the popular ski and mountain tourist attractions in the region. The City of Aspen's electricity demand is supplied by two utilities: Holy Cross Electric (HCE) and the City of Aspen (COA) Utilities Agency. COA-Utilities provides water and electric services to community residents, businesses and visitors to Aspen, Colorado. For this case study, we will refer to the electricity services provided by COA-Utilities as Aspen Electric.

At the time of writing, of the two utilities only Aspen Electric had established a 100% renewable energy portfolio. Notably, however, HCE has also established renewable energy targets. Aspen Electric provides distribution through 40 km (25 miles) of underground primary cable, switching stations and 200 transformers. Aspen Electric owns two hydroelectric facilities: a 5-MW plant and a 0.5-MW plant (City of Aspen, 2019). These hydro facilities, plus renewable energy PPAs, have resulted in Aspen Electric achieving a 100% renewable energy supply to the city.

In 2004, the City of Aspen adopted an ambitious goal to supply 100% of the city's electricity needs from renewable energy resources by 2015. A total of 75% had been achieved by 2014, and by August 2015 the city's electricity supply from renewables through Aspen Electric was 100% (NREL, 2015). Early in the project, it became clear that some critical definitions and assumptions about the 100% renewable goal needed to be clarified before options could be identified. Although the city had clearly stated a goal of 100% renewable energy, the specific technologies and project types that would be considered eligible as "renewable" energy had not been defined. Clarification was needed about other details that impacted the options available to the city, such as whether the purchase of renewable energy certificates needed to be bundled with an energy purchase. Renewables were determined to include solar, wind, and both small and large hydro. Biomass, landfill gas, sewage gas and directed biogas would be considered on an individual project basis dependent on the conditions of each unique project. Wind and landfill gas became the primary technologies to complete the 100% renewable energy goal (NREL, 2015). Aspen Electric and the City of Aspen partnered with NREL in developing a pathway towards achieving a 100% renewable electricity supply through a combination of their own hydroelectric facilities and PPAs with wind and landfill gas suppliers. The results of this transformation are shown in Figure 12.

Given the city's fragile, high-elevation mountain environment and its dependency on tourism – especially the ski industry – in March 2005 the city established the Canary Initiative, an aggressive plan to address global warming through greenhouse gas (GHG) emission reductions (City of Aspen, 2007). The initiative highlights the fact that the region could clearly see the effects of climate change much earlier than many other regions around the world. Thus, the goal to achieve 100% renewable energy by 2015 is part of a much bigger project to reduce carbon emissions by the City of Aspen.

*Figure 12. Aspen's electricity supply transformation, 2014-2015*




*Note: The percentages in this figure may not add up to 100% due to rounding errors.*
*Source:* NREL (2015) reproduced by IRENA Coalition for Action

## Interview with Phil Overeynder, Retired Utility Director, City of Aspen

**Q1. What are the key drivers behind the company's/utility's transformation towards 100% renewable energy?**

The key transformation driver has been the City of Aspen Canary Initiative. The Initiative covers many concrete steps the city chose to undertake due to its unique susceptibility to the impacts of climate change, and the city's electricity supply is just one feature of the initiative.

The Canary Initiative includes the following measures: 1) reduce carbon emissions to address climate change; 2) show that Aspen is a player in state/national/global climate discussions by demonstrating that 100% renewable energy is attainable while maintaining competitive electric energy rates; 3) demonstrate Aspen has a long history of energy independence going back to the 1880s (Aspen had one of the first electric systems in the country);[12] and 4) show how renewable energy is part of the town's identity (or brand) as a result of this history.

**Q2. What are the main policy enablers and barriers the company is facing to achieve 100% renewable energy? What is the impact of national/regional/local legislation or regulatory frameworks?**

The key enablers begin back in 1983, when a long-term goal to address the impacts of climate change first entered into discussion. The city had just established its first hydro project and was also developing the requirements for power purchase agreements [PPAs]. The goal at the time was to use the low-cost energy from hydro to keep electricity rates low and to be able to pay off debts.

In 2005, the city established the Canary Initiative goals, which included $CO_2$ [carbon dioxide] emission reductions.

The city also co-ordinated these climate mitigation goals with its regional power supplier, the Municipal Energy Agency of Nebraska (MEAN), which resulted in flexible power purchase contracts.

[12] Until the 1960s, Aspen met all its energy requirements using 100% renewable energy. The 1983 addition of its first hydroelectric plant was just a continuation of this demonstrated track record.

Thus, MEAN helped assist in meeting the city's goals. The city was seeking a local project that showcased the use of renewable energy.

The city ran into several barriers that related to the different levels of renewables included in the supply. For example, one barrier came up at around 35% wind energy, which resulted in an energy imbalance. Thus, to further increase wind energy penetration, the city would have to buy more wind energy than it actually needed. Around 2014 this barrier was overcome when MEAN agreed to allow Aspen a different method to buy additional wind that eliminated the surplus under most conditions.

A second key barrier was associated with the conventional wisdom that getting to 100% renewable energy would result in many issues including loss of reliability, energy imbalances and excessively high cost/rates. A third barrier was property owner opposition surrounding the local project, which stalled meeting the renewable energy goal.

**Q3. What is the ability of the company's renewable energy system to manage/balance the variability of demand and supply across all relevant timescales (system flexibility)?**

This was a major issue for Aspen Electric back in the 1980s, when it was first decided to build a local hydro plant to meet their electricity demands. For example, the city's peak demands occur in winter, while the hydro resource was highest in the summer. Over time the city applied rigorous analysis to develop the balanced portfolio of hydro/wind/landfill gas that they have today. This portfolio addresses most of their balancing and flexibility issues, except those discussed in the next question.

A key step made by the city was to get the US National Renewable Energy Laboratory [NREL] involved in helping make the portfolio choices. NREL's involvement also helped to give credibility on the portfolio choices. Because of this the transformation to a flexible and well-balanced system operating with 100% renewable energy has been as smooth as can be expected.

Aspen Electric was among the first municipal utilities to include wind in its portfolio. As of summer, 2015, approximately half of Aspen Electric's supply came from this resource. However, since wind is more expensive, the city had to be careful not to buy more than was needed. Nevertheless, since the hydro system was paid off, the city could still justify bringing in more expensive wind and keeping utility rates stable. They were also able to renegotiate their power purchase agreements with MEAN so that they could purchase wind only to keep the utility at 100% renewables, rather than the earlier "take or pay" contracts.

*"The city's peak demands occur in winter, while the hydro resource was highest in the summer. Over time the city applied rigorous analysis to develop the balanced portfolio of hydro, wind, landfill and gas"*

**Q4. What are the current challenges with the system operation of the existing share of renewables? And how are you overcoming them?**

One challenge is that, during drought conditions, which historically last no more than a year (although recent droughts have lasted more than a year) there is reduced hydro output. Because the city owns the hydro facilities, the electricity is provided at fixed costs, regardless of wet or dry periods. Wind energy replaces the hydro shortfall during drought years, but this comes at an increased cost to the utility (as much as USD 1 million to 1.5 million). The city "self-insures" against these increased costs by doubling their financial reserve requirements.

A second challenge occurs during spring (May/June) during high runoff years. During these times, the city's hydro resources exceed power demands. The city's minimum wind energy purchases still have to be satisfied, so this results in excess energy that is sold back to the grid.

Since this is during a time period when energy markets are soft, this results in a financial loss to the utility. On balance, however, Aspen is exceeding its 100% renewable goal (perhaps 101-102%), and these challenges are overcome through their budgeting process.

**Q5. What (other) challenges do you foresee with an increased share of renewables in your operations and the power system as a whole in your state?**

The challenges identified in Question 4 are likely to continue to be the primary challenges in the years to come. However, it should be noted that climate change may make the adaptation to these sources more difficult in the future. For example, a two-year drought, perhaps associated with climate change, had never been experienced in the historical record before 2012-13, and required the city to take special budgeting measures to overcome the low-hydro resource availability.

**Q6. What has been, or what is, the role of local citizens in your transformation towards 100% renewable energy?**

As noted in the Canary Initiative 2007-2009 plan, which is the foundation for the 100% renewable energy transformation, there was extensive collaboration between the Aspen Global Warming Alliance, members of the public, businesses, non-profit organisations, utilities, and city and county staff. The draft plan was released for public comment in April 2006, and copies were distributed to community members and the various entities listed above. The City of Aspen held meetings with community members and the specific sectors, building, transportation and electricity, to present the draft and to invite comments and improvements.

***"Community members and sector representatives were encouraged to engage in conversation with city staff regarding how to address global warming and were invited to submit comments on the plan"***

Community members along with sector representatives were encouraged to engage in conversation with city staff regarding how to address global warming and were invited to submit comments on the plan.

Citizen input in updates to the Canary Plan occurs at five-year intervals. The input reflects continuing support for goals even after goals were met. There was no significant pushback from the community suggesting there are "second thoughts" about getting to the 100% goal.

**Q7. What would this company/utility provide as a lesson for others planning to achieve 100% renewable energy?**

The major lesson is not to believe the naysayers and keep a long-term time frame of reference when approaching these goals. One hundred percent renewable energy is an achievable goal that can continue providing reliable electric supplies at competitive costs. The problems involved with managing a system that is 100% renewable are comparable to issues associated with any energy source. Costs are dropping fast, but major uncertainties are associated with federal policies, such as subsidies. Try to keep utility rates stable during the transformation.

**Q8. What recommendations might policy makers derive from this case study?**

Keep a long-term view of meeting goals and be willing to adapt your programme to satisfy emerging issues, such as opposition to individual renewable energy projects. Keep in mind life cycle differences in technology (*e.g.*, 15-year life for wind turbines vs. 70-year life for hydroelectric plants) when considering decisions on resource mix.

Teamwork is very important; for example, Aspen Electric made MEAN (the wholesale energy provider) as part of their team, and therefore developed a positive collaboration and effective compromises to meet the 100% renewable energy goals.

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# Coalition membership*

The Coalition for Action is facilitated by the International Renewable Energy Agency (IRENA).

ABB

Abengoa Solar

ACCIONA

Access Power

AMEA Power

Association Congolaise pour le Développement Agricole (ACDA)

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Dii Desert Energy

Dulas

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*January 2020

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The Coalition is open to any entity supporting the widespread adoption and sustainable use of all forms of renewable energy.

To become a member and learn more about the Coalition, contact the IRENA Coalition for Action team (coalition@irena.org) and visit our web page **coalition.irena.org**




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