RLS Energy Network

Regional Renewables Alliance

Roadmap

Joint Research and Innovation Program

Regional Leaders' Summit

Bavaria Georgia Québec Shandong São Paulo Upper Austria Western Cape

Monitoring Report on Renewable Energy in the RLS regions

May 2018

The Regional Leaders' Summit (RLS) of the regions Bavaria (Germany), Georgia (United States of America), Québec (Canada), São Paulo (Brazil), Shandong (People's Republic of China), Upper Austria (Austria) and Western Cape (South Africa) scientific Energy Network seeks to create a unique, dedicated network that secures access to knowledge over four continents, adding real value to its participants, and enabling them to be more competitive in the international scientific community. The objective is to leverage the scientific potential of each region through cooperation in the fields of: ▪ Renewable Energy ▪ Energy Storage and Conversion ▪ Energy Efficiency ▪ Waste-to-Energy. The network seeks to: ▪ Provide privileged access to research activities undertaken by the network partners. ▪ Generate long-term, large-scale, visible projects within the network.

The monitoring report of the RLS Energy Network's describes the renewable energy resources, technologies and key players in industries and universities of the RLS regions. It is organized into three chapters. Chapter 1 offers information on the RLS Energy Network and its roadmap, the Regional Renewable Alliance. Chapter 2 describes the procedures undertaken within the monitoring process. Chapter 3 illustrates data and information on renewable energy with regard to the regulatory framework, status quos, potentials and research and development activities in the RLS regions. With this information, a well-adjusted coverage of potential opportunities for researchers, investors, companies and politicians along the renewable energy supply chain can be provided.

It should be noted that data availability and resources for data collection differ from region to region. Because of this, the report aims to display selected renewable energy developments in RLS regions but does not claim to be exhaustive.

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Summary

RLS Energy Network

The **Energy Network** of the Regional Leaders' Summit (RLS) partner regions Bavaria, Georgia, Québec, São Paulo, Shandong, Upper Austria and the Western Cape established the **Regional Renewables Alliance** in order to research on the combination of vast resources of renewable energy resource with state-of-the-art energy conversion and storage technologies.

The technological leadership of the partner regions in the renewable energy sector offers an opportunity to establish new energy markets. RLS Regions with large areal territories provide enormous resources of wind, water, solar and biomass. Storage and transportation into highly populated regions through newly established markets and logistic structures can impede renewable energy shortages in these regions. Key technologies for these new energy markets are technologies for renewable energy storage in gases and as liquid fuels, e.g. hydrogen, power-to-X or biofuels.

Providing favorable conditions for the future of the world's energy production, transport and storage – with the need for economic, stable and sustainable energy sources – is a major challenge for research in the present as well as in the upcoming years.

Monitoring

The renewable energy monitoring covers data and information on the utilization of renewable energy in the RLS regions. The **key facts** of the RLS Energy Network monitoring report are:

- The regions are very diverse in terms of their population, size and their economic, social and political characteristics and therefore in their energy systems. However, the **regional energy systems face common challenges** as they advance in the deployment of renewable energy and in improving energy efficiency.
- The collection of data and information reveals that the RLS partner regions represent all main renewable energy sources and have already established large capacities at remarkable growth rates in the past. The RLS regions integrate **wind**, **solar**, **biomass**, **hydro** and **geothermal** resources into their regional energy system and utilize them for **electricity**, **heat** and **fuel production**.
- It also provides insights into new and developing technologies, i.e. **advanced storage**, **fuel cells** and **grid systems**.
- Several RLS governments face national regulation for renewable energy and have implemented **regional targets**, **voluntary actions** and designed **incentive programs** for the renewable energy.
- **Research & Development** activities with regard to renewable energy and energy efficiency take a significant part in the transformation of the RLS regions' energy systems.

Conclusion

For the RLS regions, regional energy research cooperation is a mean to address region-specific challenges such as security of supply, energy imports dependence and affordability.

The development of the current status of renewable energy, its storage and its transportation combined with energy efficiency improvements offer a great opportunity to solve the RLS regions' energy challenges.

1 RLS Energy Network

1.1 Background

The Regional Leaders' Summit (RLS) is a forum comprising seven regional governments (state, federal state, or provincial) spanning across four continents, which together represent approximately 177 million people, and a collective gross domestic product of three trillion USD.[1] Since 2002, the heads of government of these regions have biannually met for a political summit. These summits offer the RLS regions an opportunity for political dialogue. The regions are:

- Bavaria (Germany)
- Georgia (United States of America)
- Québec (Canada)
- São Paulo (Brazil)
- Shandong (People's Republic of China)
- Upper Austria (Austria)
- Western Cape (South Africa)

During the 6th summit in São Paulo in 2012, the RLS member states adopted a Final Declaration, which included a commitment (Item 12) to joint research and innovation initiatives in the field of renewable energy:

"In order to increase the proportion of renewable energy in the total energy consumption, as well as contribute to the security of energy supply and to promote renewable energy on a global scale, we invite our universities, research institutes, and industrial clusters to join forces in the formation of a network, centered on renewable energy and energy efficiency, so that innovations and new products will be developed to achieve these goals. This initiative will be led by the Government of the State of São Paulo until 2014. The intensification of the cooperation in research is necessary to implement these technologies in renewable energy sources and energy efficiency broadly and at a reduced cost."

The RLS Energy Network was initiated subsequent to the RLS meeting in São Paulo in 2012. It was agreed among the participants that renewable sources of energy is a crucial issue that requires extensive research. Due to their unique geographical composition over five continents, paired with their research profiles, the partner regions have a strong potential in this field. Together, they cover all aspects of energy, from production, to usage and monitoring, to efficiency strategies. The RLS Energy network is used as a means to bring together complementary strengths in energy research to be shared and further developed in

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[1] in 2016

a joint effort. The objective of the RLS Energy Network is to leverage the geographic and scientific potential of each region through cooperation in the following fields:

- Renewable Energy
- Storage & Conversion
- Energy Efficiency
- Waste-to-Energy

1.2 Roadmap: Regional Renewable Alliance

The RLS Energy Network's roadmap, the Regional Renewable Allowance (RRA), established a permanent scientific group under the umbrella of the RLS. The partner regions of the RRA launched a scientific partnership that combines state-of the-art conversion and storage technologies and substantial resources of wind, hydro, solar and biomass.

1.2.1 Motivation

The transition of the world's energy systems towards a significantly increased share of renewable energy is a global trend with outstanding dynamics. The seven partner regions Bavaria, Georgia, São Paulo, Québec, Shandong, Upper Austria and the Western Cape represent leading protagonists in their countries, regions and continents with unique growth rates and exemplary technical, scientific and, in particular, renewable energy resources. The climate protection targets defined at the climate conference in Paris, COP21, require a share of renewable energy that exceeds current achievements. Regional limitations for the implementation of renewable energy technologies, in particular in highly populated and industrialized areas, are still the main obstacle for further achievements. Global partnerships and synergies are the only solutions to overcome these limitations. Global renewable energy markets are needed to transfer bioenergy, solar photovoltaic, wind and hydro power from regions with an excess of natural resources such as wind and solar energy to regions with limited renewable energy sources.

Key technologies for a successful implementation of these markets are not only the efficient and cost effective conversion of renewable energy resources into electricity or heat. Storage of renewable energy in high density energy carriers such as biofuels, hydrogen and liquid fuels from electricity ("Power-to-X") and high exergetic heat storage are as important as smart integration of these energy carriers into existing grid infrastructures, innovative business concepts and trading platforms. The partner regions have a long tradition of utilizing their renewable energy resource potentials. The consortium members' countries represent all of the relevant energy sources and have already established large capacities at exemplary growth rates in the last years.

1.2.2 Objectives

The roadmap for the Regional Renewables Alliance started with a **preparatory stage**. This first stage will indicate the most promising technologies and implementation strategies in order to prepare an implementation and demonstration phase. The preparatory stage will create and widen networks, personal contacts and promote the exchange of knowledge, technologies and human resources between the partners. Workshops and conferences will bring key players together and will define rules and funding schemes for the roadmaps final **implementation and demonstration phase**.

In order to facilitate the preparation of joint transnational research and innovation projects and to promote the joint development of key technologies for global renewable gas and fuels markets between the partner regions, a first step will

- Investigate the status and potentials of renewable energies (work package 2, "Monitoring report"),
- establish a "Energy systems analysis" and a "Regional Science and Technology map" of the partner regions (work packages 3 and 4) and
- implement a cooperation on the training courses, scholarship and summer schools (work package 5),

in order to finally develop a "Regional Renewables Alliance – Masterplan" with partner-specific target definitions for the partner regions (work package 6). The masterplan will serve as a basis for follow-up projects for the promotion of transnational best practice projects. The master plan will therefore initiate cooperation and demonstration projects from 2019 on.

Table 1: Work packages of the RLS Energy Network's roadmap Regional Renewables Alliance (status as of May 2018)

Work Package	
N° 1 **- in progress -**	**Coordination** 1.1 Establishing back offices 1.2 Coordination of network meetings 1.3 Public relations and Regional Renewable Alliance Website
N° 2 **- in progress -**	**Monitoring report** 2.1 Renewable energy potentials of the partner regions 2.2 Identification of scientific, industrial and administrative key players 2.3 Setup and link of individual databases for each partner region
N° 3	**Energy System Analysis** 3.1 Research papers 3.2 Public consultation and expert workshops 3.3 Development of overall strategy
N° 4	**Regional Science and Technology Map** 4.1 Visualization and publication of the key players database 4.2 Definition of thematic clusters 4.3 SWOT analysis of the partner regions
N° 5 **- in progress -**	**Training courses, Scholarships and Summer Schools** 5.1 Establish a cooperation on the training level 5.2 Identify or establish finding mechanisms for scholarships 5.3 Roll out scholarships
N° 6	**Regional Renewable Alliance - Masterplan** 6.1 Work program for transnational funding scheme 6.2 Database for transnational funding opportunities 6.3 Definition Masterplan

Note: Own representation based on the RLS Energy Network's roadmap Regional Renewables Alliance (pp. 13-20) (status as of May 2018)

2 Monitoring procedure

Technology monitoring is defined as a constant examination of the technology's state, quantifying to cataloging, describing and interpreting the technology's development. Within the framework of the RRA, a monitoring of renewable energy technologies will provide a comprehensive overview of the renewable energy status quo and potentials. Work package 2 develops the monitoring report that describes the renewable energy resources, technologies and key players in industries and universities for each participating region in detail.

The data base provides

- renewable energy status quo and potentials of the partner regions,
- identification of scientific, industrial and administrative key players and
- setup and link of individual databases for each partner region.

The monitoring covers information across all main renewable energy sources, i.e. wind, solar, geothermal, biomass, biofuels and hydro. It also provides insight into new and developing technologies such as advanced storage, fuel cells and grid systems. With this information, a well-adjusted coverage of potential opportunities for researchers, investors, companies and politicians along the renewable energy supply chain can be provided. The outcomes of the monitoring report provide inputs for the planned energy system analysis and the technology mapping undertaken in the working packages 3 and 4.

2.1 Data collection via the RLS Energy Network database

The basis for the monitoring report is the data collection on the status quo and the potentials of renewable energies in the RLS regions. For this purpose, the identical template for data collection was used for each region. In a second step, the filled-in data files were linked in order to enable the presentation of renewable energy's significance at a multiregional level and the comparison between different partner regions. The findings are summarized via this monitoring report (see Annex 1 for the monitoring workflow and timeframes). It should be noted that data availability and resources for data collection differ from region to region. Because of this, the report aims to display selected renewable energy developments in RLS regions but does not claim to be exhaustive. That is why general indicators of a region's energy system and renewable energy technologies were considered in order to give a general, comprehensive overview of the different regions. This report serves as a basis for the other work packages and guarantees a knowledge transfer between the RLS partners and researchers, which will be beneficial for the development of renewable energy technologies in the respective regions.

Figure 2 shows an overview of the template for the RLS Energy Network monitoring database. It includes an energy overview of the region and detailed data of various renewable energy sources, the grid structure, system integration and energy efficiency measures. Each category is divided into four categories: "Data", "Regulatory Framework", "Forecast" and "Research Activities". Together with the geographical, climate, demographic, macroeconomic and national data, they provide a comprehensive picture of the current state, boundaries and opportunities of the energy systems in each region, thus allowing for further analysis and specific research approaches.

Figure 2-1: Overview of the template for the RLS Energy Network monitoring database

RLS ENERGY NETWORK DATABASE

1) ENERGY OVERVIEW	Unit Converter & Exchange Rates
2a) WIND - DATA	8a) HYDROGEN & FUEL CELLS - DATA
2b) WIND - REGULATORY FRAMEWORK	8b) HYDROGEN & FUEL CELLS - REGULATORY FRAMEWORK
2c) WIND - FORECAST	8c) HYDROGEN & FUEL CELLS - FORECAST
2d) WIND - RESEARCH	8d) HYDROGEN & FUEL CELLS - RESEARCH
3a) SOLAR THERMAL - DATA	9a) GEOTHERMAL - DATA
3b) SOLAR THERMAL - REGULATORY FRAMEWORK	9b) GEOTHERMAL - REGULATORY FRAMEWORK
3c) SOLAR THERMAL - FORECAST	9c) GEOTHERMAL - FORECAST
3d) SOLAR THERMAL - RESEARCH	9d) GEOTHERMAL - RESEARCH
4a) PHOTOVOLTAIC - DATA	10a) GRIDS - DATA
4b) PHOTOVOLTAIC - REGULATORY FRAMEWORK	10b) GRIDS - REGULATORY FRAMEWORK
4c) PHOTOVOLTAIC - FORECAST	10c) GRIDS - FORECAST
4d) PHOTOVOLTAIC - RESEARCH	10d) GRIDS - RESEARCH
5a) BIOENERGY - DATA	11a) ENERGY STORAGE & SYSTEM INTEGRATION - DATA
5b) BIOENERGY - REGULATORY FRAMEWORK	11b) ENERGY STORAGE & SYSTEM INTEGRATION - REGULATORY FRAMEWORK
5c) BIOENERGY - FORECAST	11c) ENERGY STORAGE & SYSTEM INTEGRATION - FORECAST
5d) BIOENERGY - RESEARCH	11d) ENERGY STORAGE & SYSTEM INTEGRATION - RESEARCH
6a) BIOFUELS - DATA	12a) ENERGY EFFICIENCY - DATA
6b) BIOFUELS - REGULATORY FRAMEWORK	12b) ENERGY EFFICIENCY - REGULATORY FRAMEWORK
6c) BIOFUELS - FORECAST	12c) ENERGY EFFICIENCY - FORECAST
6d) BIOFUELS - RESEARCH	12d) ENERGY EFFICIENCY - RESEARCH
7a) HYDRO - DATA	12) GEOGRAPHICAL DATA
7b) HYDRO - REGULATORY FRAMEWORK	13) CLIMATE DATA
7c) HYDRO - FORECAST	14) DEMOGRAPHIC DATA
7d) HYDRO - RESEARCH	15) MACROECONOMIC DATA
	16) NATIONAL CONTEXT

Edition: January 2018, ©Energieinstitut an der JKU Linz

Source: screenshot

2.2 Content structure

The template for the data collection guaranteed a consistent structure, simplified the monitoring process for all partners and allows for comparative analysis. In the following, the captured data is described.

2.2.1 Comprehensive regional overview

This introductory part provides a general comprehensive report on the structure of the energy generation and consumption in the respective RLS region. The categories "Gross inland energy consumption", "Final energy consumption" and "Gross electricity generation and consumption" are covered.

2.2.2 Specific renewable energy technologies data

Information on the following renewable technologies are gathered in the monitoring report:

- Wind energy
- Solar thermal energy
- Photovoltaics
- Bioenergy[2]
- Biofuels
- Hydrogen & fuel cells[3]
- Geothermal energy

Depending on the particular technology, different indicators were chosen which together illustrate the state of the technology in the region. In order to allow for a comprehensive data set, historic data as well as forecast data is examined. Furthermore, descriptive information about the regulatory framework concerning the technology is provided, as well as research activities in the particular field. The research activities provide an overview of previous, ongoing as well as future projects and developments concerning the respective technology and thus give an indication about the state of development of the technology (e.g. in form of the technology readiness level).

[2] both heat and power production
[3] from renewable and non-renewable sources

2.2.3 Energy Storage & Grid

The Energy Storage & Grid category provides an overview of the dimensions of existing heating and power grids in the respective region. With regard to energy storage, if there is no data available, descriptive information is provided about the regulatory framework or research activities.

2.2.4 System Integration

The system integration category provides an overview of interfaces between different energy grids, e.g. power-to-gas applications. Furthermore, information about the development of smart grids is provided. If data is not (yet) available, descriptive details with regards to research activities and or existing regulatory framework are given.

2.2.5 Energy efficiency

In addition to the intensive use of renewable energies, energy efficiency is also an important strategy within an energy policy that is geared to the principle of sustainability. Data on energy efficiency provides, next to the data about renewable energy technologies, an overview of measurements taken to cut back on energy demand, e.g. building refurbishments. If data was not available, descriptive details with regards to research activities and or existing regulatory framework are given.

2.2.6 Socioeconomics and climate data and national context

In addition to the above-mentioned data base for the monitoring report on the status quo and the potentials of renewable energies in the RLS partner regions, the following information is considered:

- Geographical data
- Climate data
- Demographic data
- Macroeconomic data
- National context data

These indicators help to categorize the role of renewable energies with geographic, climatic and socio-economic key factors of the RLS partner regions. The approach of social economics analyzes how societies develop because of their local or regional economy, or the global economy. Socio-economic data comprises data sets including principally demographics (e.g.

age, sex, ethnic and marital status, education) and economics (personal incomes, employment, occupations, industry, regional growth) and further specific data classes like e.g. housing, migration, transportation, retailing etc. The major underlying cause of changes in the consumption of energy is human economic activity and demographic alterations. Socio-economic scenarios that project the main driving factors of change are important as they can improve the understanding of the key relationships among factors that drive future energy demand and production and hence, can provide a realistic range of future emissions of greenhouse gases. The main purpose of including a socio-economic data set in the monitoring report of the Regional Renewable Alliance is to characterize the demographic and socio-economic driving forces underlying the energy demand and production within the partner regions for the present and the future. Additionally, socio-economic data will be an essential input for working packages 3 and 4 which deal with energy system and SWOT analyses of the partner regions. The data base also to covers information about the region's role in the national energy and climate context.

2.3 System boundaries

2.3.1 Geographical focus

Data collection was carried out for the regions of Bavaria (Germany), Georgia (United States of America), Québec (Canada), São Paulo (Brazil), Shandong (People's Republic of China), Upper Austria (Austria) and Western Cape (South Africa).

2.3.2 Observation period

For the monitoring database, annual time series data were collected for the period 2005 up to date. In order to determine potentials, data for 2020, 2030 and 2050 were also recorded.

2.3.3 Data sources

The following sections present renewable energy highlights, objectives, trends and research activities of the RLS regions, as well as statistics for all regions compiled during the monitoring process. The data set was generated in cooperation with scientists from different institutions in the RLS regions Bavaria, Georgia, Québec, São Paulo, Shandong, Upper Austria and the Western Cape. The multiple literature and internet sources can be found in Annex 2.

3 Results of renewable energy monitoring in the RLS regions

3.1 Regional key facts

The RLS regions are located on 4 continents and together cover an area of 224,266,1 km^2. The RLS regions are geographically, climatically, demographically and economically diverse. Demographic and economic key facts of the RLS regions are presented below. Detailed information on selected regions is provided in the tables on regional key facts below.

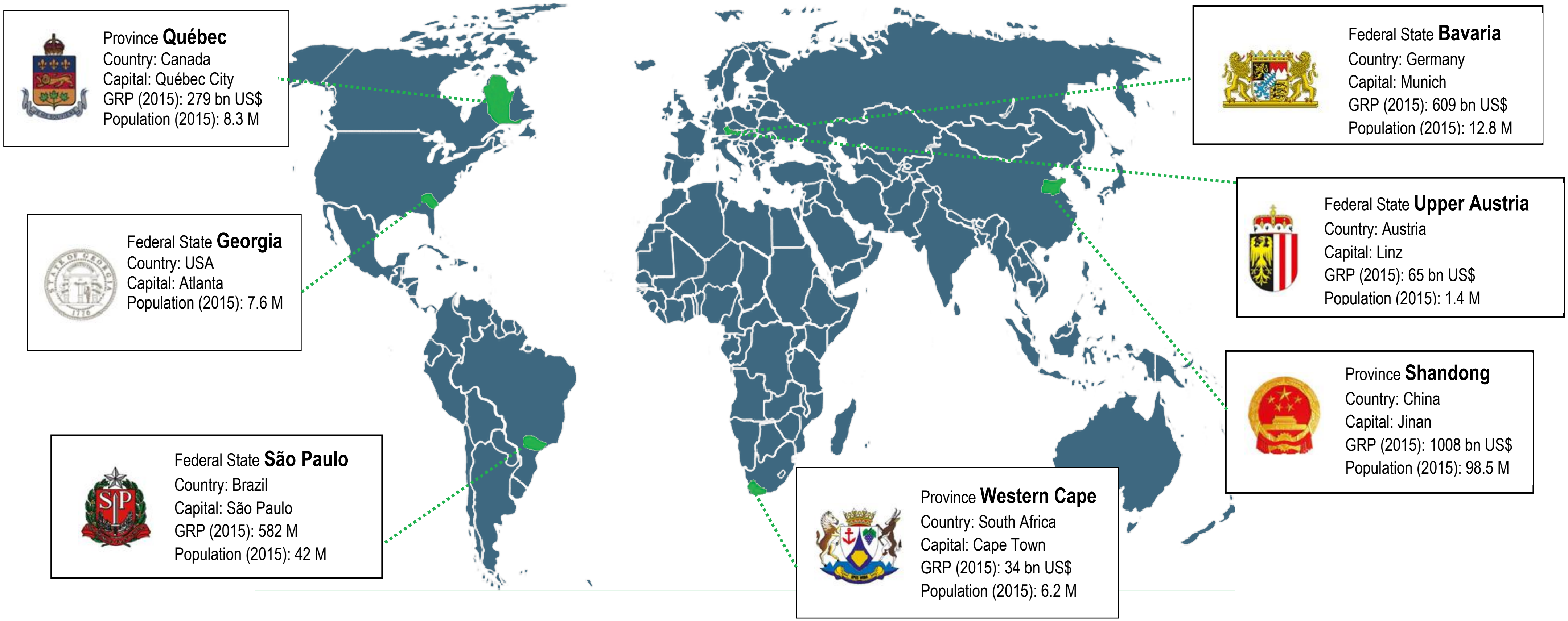


Table 3-1: Regional key facts – Bavaria

Geography		2005	2010	2015	2017	2030
Area	km^2	70,550	70,550	70,550	70,550	-
Inhabitants per area	#	177	178	182	-	-
Climate						
Mean air temperature	°C	8.0	7.3	9.4	9.0	-
Rainfall	l/m^2	957	1,001	744	968	-
Sunshine	hrs	1,729	1,543	1,784	1,749	-
Demography						
Population	persons	12,468,726	12,538,696	12,843,514	12,943,000	13,259,000
Population < 20 years	%	21%	19%	19%	18%	18%
Population ≥ 20 and < 65 years	%	61%	61%	61%	62%	58%
Population ≥ 65 years	%	18%	20%	20%	20%	24%
Private Households	#	5,787	6,065	6,305	-	6,479
Economy						
Gross regional product	M US$	494,162	597,631	608,899	-	-
Inflation rate	%	1.8%	1.1%	0.4%	-	-
Employment	persons	6,418 842	6,776 098	7,273 963	7,537,500	-

Note: '-' : no data available
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-2: Regional key facts – Québec

Demography						
Population	persons	-	-	8,291,320	8,423,220	9,162,379
Population < 20 years	%	-	-	21%	21%	-
Population ≥ 20 and < 65 years	%	-	-	62%	61%	-
Population ≥ 65 years	%	-	-	18%	18%	-
Private Households	#	-	-	3,571,063	3,645,268	3,992,020
Economy						
Gross regional product	M US$	213,625	296,587	278,543	-	-
Inflation rate	%	2.2%	1.8%	1.1%	-	-
Employment	persons	3,705,500	3,937,900	4,097,000	-	-

Note: '-' : no data available
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-3: Regional key facts – Shandong

Geography		**2005**	**2010**	**2015**	**2017**
Area	km^2	157,800	157,900	157,900	-
Inhabitants per area	#	586	607	624	-
Climate					
Mean air temperature	°C	-	13.0	13.0	13.0
Rainfall	l/m^2	810.7	696.3	-	-
Demography					
Population	persons	92,480,000	95,790,000	98,470,000	-
Population < 20 years	%	16%	16%	17%	-
Population ≥ 20 and < 65 years	%	74%	74%	71%	-
Population ≥ 65 years	%	10%	10%	12%	-
Economy					
Employment	persons	58,407,000	64,019,000	66,325,000	-

Note: '-' : no data available
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-4: Regional key facts – Upper Austria

Geography		**2005**	**2010**	**2015**	**2017**	**2030**
Area	km^2	11,982	11,982	11,982	11,982	-
Inhabitants per area	#	116	118	120	122	-
Climate						
Mean air temperature	°C	-	-	-	10.7	-
Rainfall	l/m^2	-	-	-	550	-
Days with rainfall (> 0.1 l/m^2)	#	-	-	-	149	-
Sunshine	hrs	-	-	-	1,929	-
Demography						
Population	persons	1,394,726	1,409,253	1,437,251	1,465,045	1,512,887
Population < 20 years	%	24%	22%	21%	21%	20%
Population ≥ 20 and < 65 years	%	61%	61%	61%	61%	56%
Population ≥ 65 years	%	16%	17%	18%	18%	25%
Private Households	#	560,800	585,500	615,400	-	678,950
Economy					-	
Gross regional product	M US$	49,756	65,807	64,556	67,836	-
Inflation rate	%	1.4%	2.3%	1.0%	-	-
Employment	persons	571,799	594,997	629,100	650,300	-

Note: '-' : no data available; climate data refers to Kremsmünster
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-5: Regional key facts – Western Cape

Geography		2005	2010	2015	2017
Area	km^2	129, 462	129, 462	129, 462	129, 462
Inhabitants per area	#	37	40	48	50
Climate					
Mean air temperature	°C	17	17	17	17
Rainfall (mm)	l/m^2	435	368.5	327.5	153.5
Sunshine	hrs	3102	3102	3102	3102
Demography					
Population	persons	4, 766, 500	5, 223, 908	6, 200, 100	6, 510, 000
Population < 20 years	%	19%	27%	28.9%	25.7%
Population ≥ 20 and < 65 years	%	66%	46%	65%	68.5%
Population ≥ 65 years	%	15%	27%	6.1%	5.8%
Private households	#	-	-	-	1, 768, 694
Economy					
Gross regional product	M US$	229, 150	339, 674	422, 514	-
Inflation rate	%	3.9%	4.3%	5.4%	6.0%
Employment	persons	1, 691, 000	2, 041, 000	2, 263, 000	2, 400, 000

Note: '-' : no data available;
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-6: Regional key facts – São Paulo

Geography		2005	2010	2015	2017	2030
Area	km^2	248,209	248,209	248,209	248,209	-
Inhabitants per area	#	157.94	166.08	173.43	175.95	-
Climate		-	-	-		
Mean air temperature	°C	-	-	-	21	-
Demography						
Population	persons	-	42,486,692	43,046,555	43,674,533	46,825,449
Population < 20 years	%	-	-	27%	27%	-
Population ≥ 20 and < 65 years	%	-	-	64%	64%	-
Population ≥ 65 years	%	-	-	9%	9%	-
Private households	#	-	14,856,875	-	-	-
Economy						
Inflation rate	%	5.7%	5.9%	10.7%	3.0%	-
Employment	persons	-	-	13,697,471	-	-

Note: '-' : no data available;
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

As shown above, demographic characteristics diverge widely across the regions, with implications for economic dynamics, energy demand and job creation needs. Energy and natural resource endowments vary also considerably by region, as does the economic structure and the degree of integration into global supply chains.

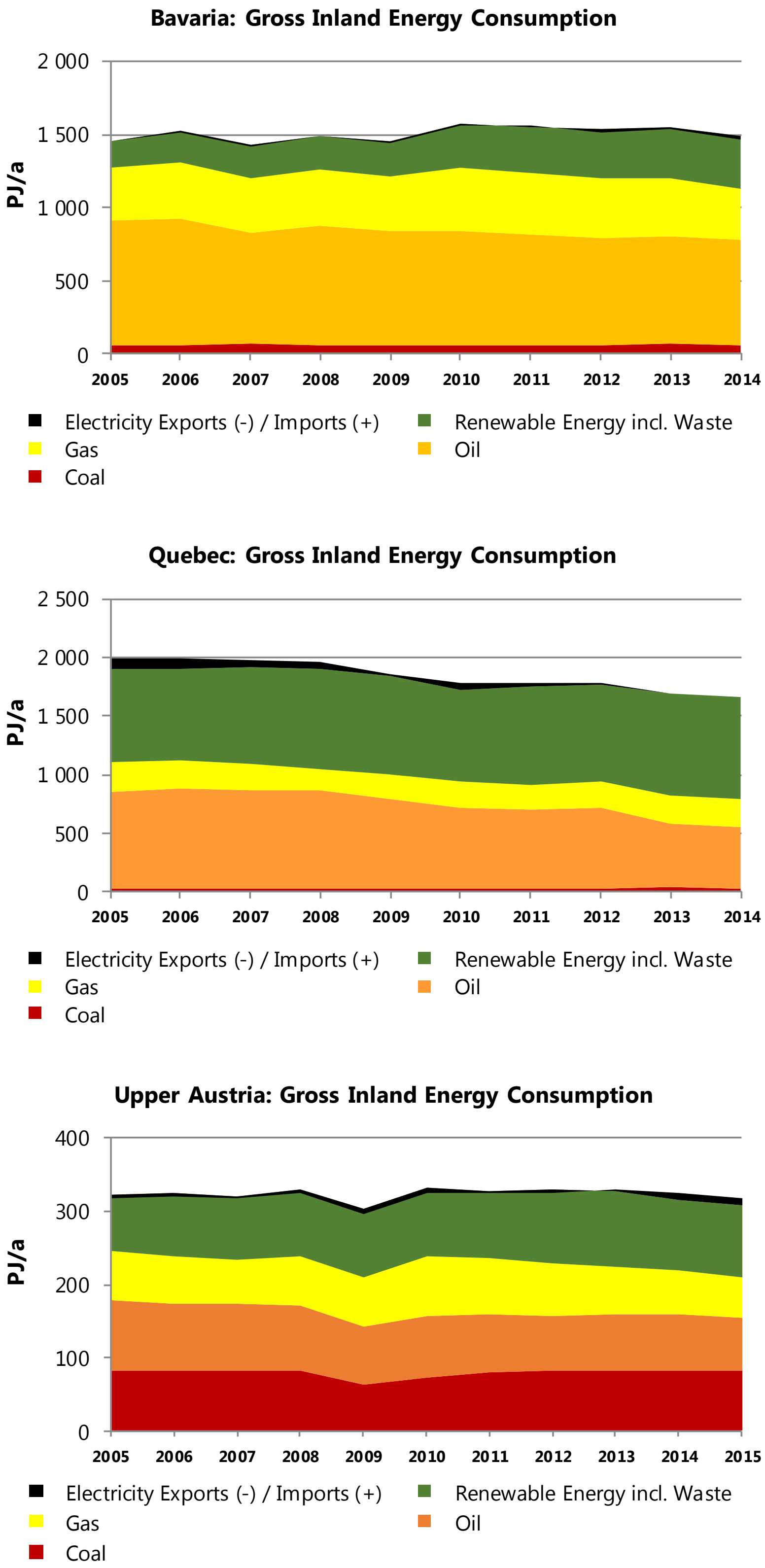
3.2 Renewable energies' status on the regional level

The gross inland energy consumption corresponds to the amount of energy used to cover the domestic demand (boundary is the regional border). It is defined as the sum of the domestic primary energy production, primary energy imports and primary energy stocks minus primary energy exports. The data collection for Bavaria reveals a gross inland energy consumption of 1.919 PJ in 2016. The share of renewable energy incl. waste amounts to 20 % (Coal 3 %, Oil 39 %, Gas 20 %). For Québec, a share of renewable energy incl. waste 52 % (Coal 2 %, Oil 31 %, Gas 15 %) in 2014 can be derived from the collected data. The domestic energy consumption of Upper Austria was in the range of 320 PJ over the last 10 years (except for 2009 based on the economic crises). Renewable energy remains in 2015 the most important energy carrier (31 %), followed by coal (26 %), oil (23 %) and gas (18%). The strong fluctuations of the gross domestic consumption of gas depends on the fluctuating use in power generation plants. Coal is almost exclusively used for the iron and steel sector (see Figure 3-1) .

Energy consumption leads to greenhouse gas emissions. These are displayed below for Bavaria, Shandong and Upper Austria (see Figure 3-2).

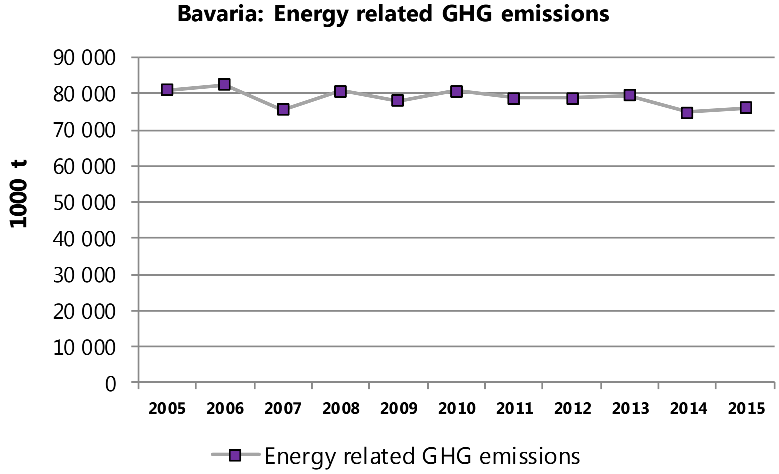
Accounting for non-energy consumption, transformation losses, transport losses and the consumption of the sector energy leads to the final energy consumption. Final energy consumption in 2014 for Bavaria of 1,333 PJ, for Québec of 1,669 PJ and for Upper Austria of 223 PJ was observed (see Figure 3-3).

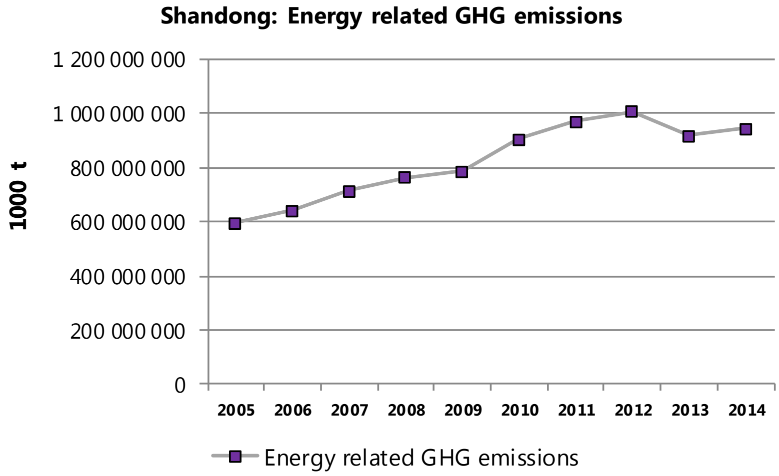
Figure 3-1: Gross inland energy consumption in Bavaria, Québec and Upper Austria

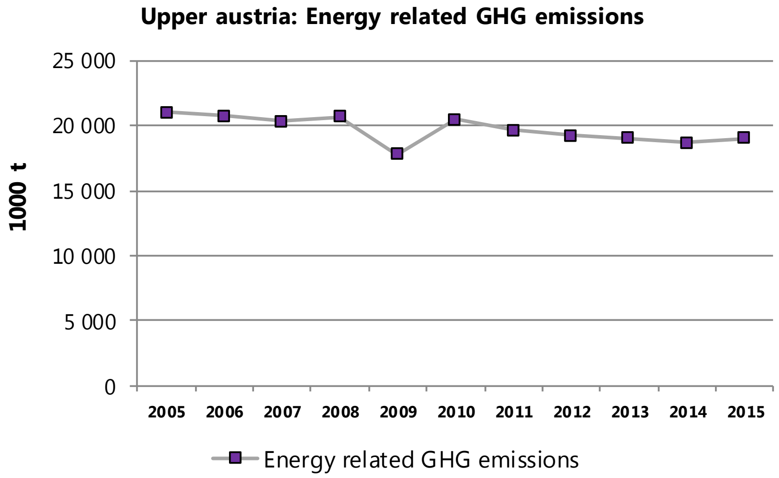


Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Figure 3-2: Energy related greenhouse gas emissions in Bavaria, Shandong and Upper Austria

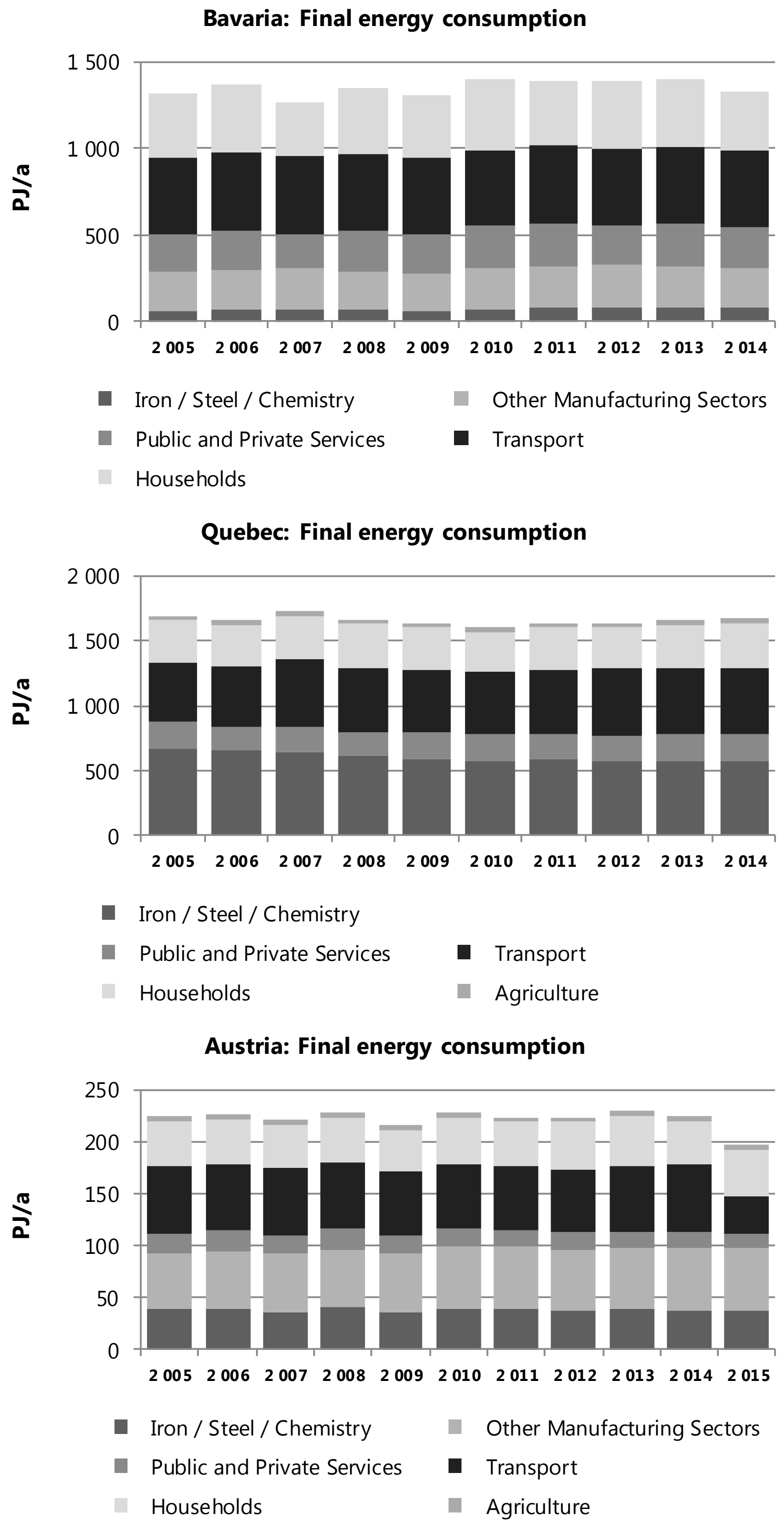






Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Figure 3-3: Final energy consumption by sector in Bavaria, Québec and Upper Austria

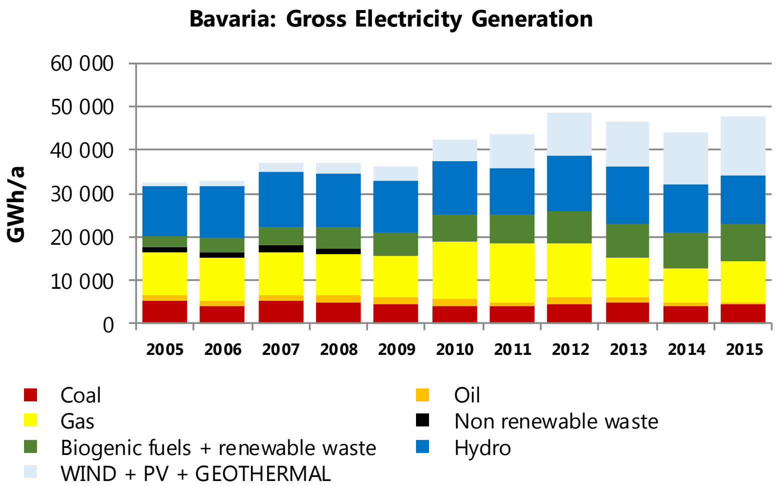


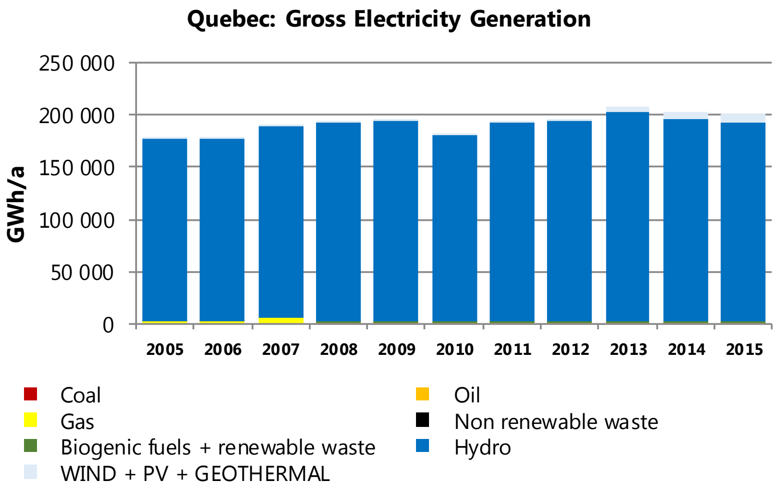
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

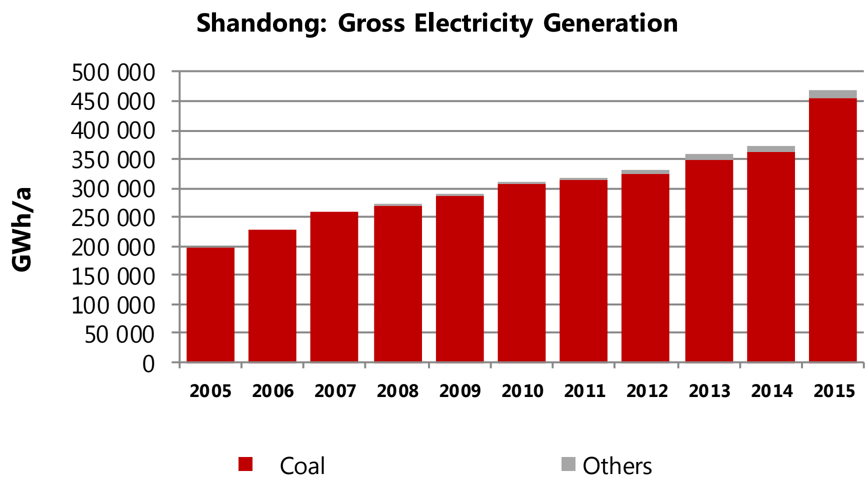
Renewable energy resources are used to generate electricity in several RLS regions (see Sections 3.3 to 3.8 for specific technologies). On the aggregate level, the data collection revealed a gross electricity generation by renewables in 2015 of 33,720 GWh (total electricity generation: 86,242 GWh) in Bavaria, 202,044 GWh (total electricity generation: 203,024 GWh) in Québec, and 10,604 GWh (total electricity generation: 13,956 GWh) in Upper Austria. For Shandong, a strong usage of coal for the electricity generation can be observed (see Figure 3-4).

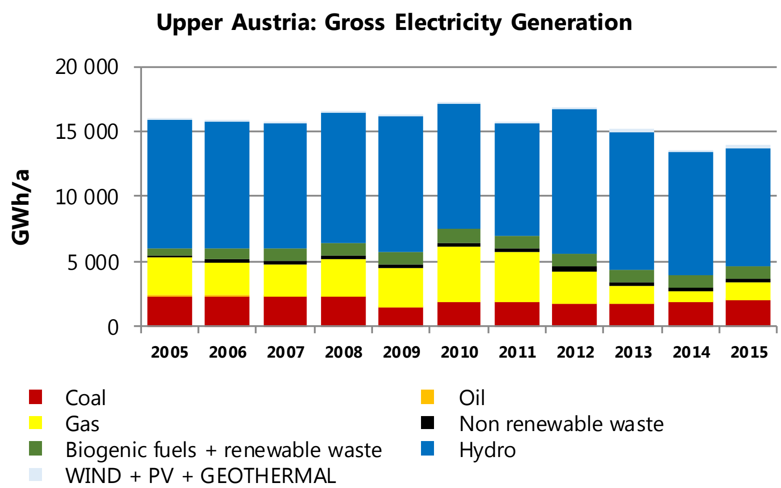
The Western Cape consumed 22,517 GWh electricity in 2016 or 10.1 % of the national total (224,240 GWh), whilst generating a cumulative of 1 976 GWh of renewable energy (2013 – 2017). As a result of the REIPPP programme, the Western Cape has attracted 606MW of capacity, of which 467MW is wind. The Western Cape hosts 14 projects out of the 112, which represents a committed investment of R14.4 billion. Western Cape renewable energy projects has saved an equivalent of 2 Million tonnes of CO2 emissions and 3.2 million kilolitres of water in relation to fossil fuel power generation.

Figure 3-4: Gross electricity generation in Bavaria, Québec and Upper Austria









Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-7: Gross inland energy consumption, energy related GHG emissions, gross electricity generation of Bavaria, Québec, Shandong and Upper Austria

Bavaria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Gross Inland Energy Consumption	PJ	2,008	2,075	1,978	2,040	2,004	2,081	2,038	1,990	2,003	1,932	1,924	1,919
Coal	PJ	62	58	66	65	60	60	62	66	68	61	59	58
Oil	PJ	847	868	767	808	777	785	759	724	742	719	732	747
Gas	PJ	367	385	367	385	375	428	413	409	386	352	365	378
Renewable Energy	PJ	180	209	225	227	243	299	317	342	359	356	376	387
Electricity Exports (-) / Imports (+)	PJ	-8	-2	-7	-1	-18	-7	10	-27	-20	-18	-8	6
Energy related GHG emissions	m t	81	82	76	81	78	81	79	79	79	75	76	78
Gross Electricity Generation	GWh	84,884	84,994	89,022	88,658	90,170	91,969	89,203	93,720	90,852	88,289	86,242	81,527
Coal	GWh	5,118	4,141	5,097	4,936	4,434	4,075	3,943	4,615	4,754	4,177	4,292	4,006
Oil	GWh	1,573	1,128	1,464	1,434	1,665	1,656	795	1,400	1,374	628	697	267
Gas	GWh	9,660	9,751	9,918	9,456	9,299	13,191	13,619	12,390	8,988	7,844	9,211	9,326
Non renewable waste	GWh	1,273	1,360	1,424	1,419	-	-	-	-	-	-	-	-
Biogenic fuels + renewable waste	GWh	2,397	3,362	4,337	4,845	5,657	5,954	6,519	7,334	7,781	8,105	8,704	8,726
Hydro	GWh	11,779	12,031	12,837	12,577	11,987	12,531	10,747	13,112	13,143	11,260	11,206	12,140
WIND + PV + GEOTHERMAL	GWh	799	1,316	1,807	2,355	3,116	5,052	7,890	9,653	10,391	12,185	13,810	14,000
Québec		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Gross Inland Energy Consumption	PJ	2,046	2,042	2,026	1,994	1,901	1,821	1,821	1,823	1,691	1,662	-	-
Coal	PJ	26	26	27	30	21	19	32	32	33	29	-	-
Oil	PJ	826	848	838	840	762	701	663	682	551	515	-	-
Gas	PJ	251	239	224	178	214	214	219	220	232	243	-	-
Renewable Energy	PJ	799	789	824	855	848	790	836	837	879	867	-	-
Electricity Exports (-) / Imports (+)	PJ	96	90	67	52	16	58	33	7	-4	8	-	-

Gross Electricity Generation	GWh	182,425	182,425	194,446	196,937	198,992	186,799	198,450	201,496	207,992	203,024	201,959	-
Coal	GWh	1,378	748	1,254	971	833	629	584	555	508	855	555	-
Oil	GWh	283	1,602	4,438	244	283	243	233	244	160	125	108	-
Gas	GWh	0	0	0	0	0	0	0	0	0	0	0	-
Non renewable waste	GWh	502	463	639	1,540	1,411	1,416	1,302	1,319	1,727	1,845	2,197	-
Biogenic fuels + renewable waste	GWh	175,090	174,313	182,860	189,523	191,510	179,314	191,048	192,325	200,828	193,483	190,501	-
Hydro	GWh	420	427	674	819	1 142	1 433	1 546	2 588	4 768	6 717	8,599	-
Shandong		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Gross Inland Energy Consumption*	PJ	7,555	8,467	9,175	9,446	10,158	10,693	9,180	9,614	10,069	10,401	-	-
Energy related GHG emissions	m t	598	643	716	765	788	906	971	1 007	920	945	-	-
Gross Electricity Generation	GWh	198,968	229,394	259,605	269,923	288,344	309,084	317,245	330,580	359,746	373,776	468,458	-
Coal	GWh	198,968	229,394	259,605	269,700	287,070	306,360	312,904	324,137	350,292	362,944	455,285	-
Others	GWh	0	0	0	223	1,274	2,724	4,341	6,443	9,453	10,833	13,174	-
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Gross Inland Energy Consumption*	PJ	318	320	318	326	296	326	326.2	326	329	324	317	-
Coal	PJ	83	83	83	82	64	74	81	82	82	83	82	-
Oil	PJ	96	91	91	89	79	84	78	76	78	76	72	-
Gas	PJ	68	65	61	68	66	80	77	71	65	60	57	-
Renewable Energy	PJ	76	85	85	92	94	95	91	101	102	96	98	-
Electricity Exports (-) / Imports (+)	PJ	-5	-4	-2	-5	-7	-7	-0.8	-4	2	9	8	-
Energy related GHG emissions	m t	21	21	20	21	18	20	20	19	19	19	19	-
Gross Electricity Generation	GWh	15 910	15 859	15 730	16 451	16 267	17 207	15 659	16 893	15 158	13 573	13 956	-
Coal	GWh	2 352	2 343	2 265	2 255	1 457	1 825	1 821	1 760	1 759	1 899	2 058	-
Oil	GWh	60	55	31	44	22	29	13	13	9	4	5	-
Gas	GWh	2,859	2,536	2,430	2,877	3,022	4,309	3,880	2,429	1,318	786	1,288	-

Non renewable waste	GWh	171	253	276	294	297	280	279	385	338	298	346	-
Biogenic fuels + renewable waste	GWh	576	857	940	914	984	1,019	981	1,012	960	891	967	-
Hydro	GWh	9,865	9,767	9,730	10,018	10,430	9,684	8,594	11,177	10,603	9,472	9,039	-
WIND + PV + GEOTHERMAL	GWh	27	50	57	49	55	61	90	117	171	222	252	-

Note: '-' : no data available; renewable energy for the gross inland energy consumption includes waste
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Regulatory frameworks

Several RLS governments face defined national and regional targets for renewable energy, designed incentive programs, and have designed research and development programs to help reach these targets. The reasons for supporting renewable energy for governments and industry are contributing to national and local energy supply, the creation of additional employment and economic development, building a regional and national industry, mitigating greenhouse gas emissions and other pollutants. Most RLS regions have targets for increasing the amount of renewable energy or low-carbon energy in the electrical generation mix. These targets are based in legislation and appear in roadmap documents. Some regions have specific goals or targets for renewable energy generally and specific technologies in particular.

Renewable energy technology and energy efficiency specific information on the regulatory framework, targets and potentials for RLS regions can be found in Sections 3.3 to 3.13 and Annex 3.

Research & Development activities

Research & Development (R&D) takes a significant part in making renewable energy technology more cost-competitive and consistent. These research programs, in combination with demonstration activities implemented by the industry, support the role of renewable energy utilization as a significant contributor to respond to challenges of growing energy demand and to mitigate climate change. Challenging plans exist to expand renewable energy development. These plans will need specific and continued R&D to be accomplished. Achieving these ambitious objectives will require public and private R&D funding carefully focused on the topics most likely to accelerate renewable energy deployment such as resources, technology, operations, environmental impacts, and social-economic issues.

Within the RLS partner regions, several research and development activities in the field of renewable energy, its conversion, storage and transportation are taking place and can be found in Sections 3.3 to 3.13 and Annex 4.

3.3 Wind power

Technology description[4]

Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which leads to the turn of the blades. The blades are coupled to a drive shaft that turns an electric generator.

3.3.1 Regional policy frameworks and targets

Table 3-8: Regional policy frameworks and targets for wind energy in selected RLS regions

Bavaria
Based on the available space, the economic feasibility and the public acceptance of onshore wind production in Bavaria, the construction of 1,000 to 1,500 new wind turbines by 2021 was considered realistic in the 2011 publication of the **Bavarian Energy Concept**. It states that support for the authorities responsible for the approval of the use of wind power will be given through a clear political commitment to intensified wind power utilization. It aims to revise the general immission related permit procedures and reduce the restrictions in place for new wind power installations, while allowing for increased construction of wind turbines in natural park areas. It also expresses a commitment to strengthening of the use of the potential wind energy in the Bavarian state forests and the encouragement of citizen driven wind power installations. While working together with the federal government in the framework of the **Renewable Energy Sources Act** (EEG, Erneuerbare-Energien-Gesetzes) to maintain investment friendly conditions for the construction of onshore wind turbines, the Bavarian State Government also committed to accelerating the approval of wind turbines through a comprehensive investigation and identification of potential locations for wind energy installations. These measures should lead to an increase of self-produced wind energy accounting for 6%-10% of Bavaria's electricity consumption by 2021.
Québec
In 2017, the Government of Québec released its '2030 Energy Policy'. This strategic plan includes the **development of wind power**, with an emphasis on the prospect of exporting the electricity to the U.S market.
Shandong
In May 2017, the Shandong Provincial Development and Reform Commission published the "**Shandong province electric power development plan in the 13th Five-Year**". This plan prioritizes to develop wind power, speed up the expansion in some regions, as well as actively promote the development of offshore wind power. The plan considers a target of 14 GW installed capacity in 2020 and 23 GW in 2020.
Upper Austria
The **Wind Power Master Plan** of 2017 is a central instrument for regulating wind energy in Upper Austria. A central aim is the protection of existing settlements for possible interference caused by wind power plants. Furthermore, there are regulations that big wind plants have to be concentrated locally on efficient places with a minimum of three plants per site. This regulation prevents a disperse distribution of wind power plants at individual sites in Upper Austria. Besides that, the visual landscapes as well as touristic and ecological aspects have to be considered by siting of wind power plants. In addition, zones with prohibition on building are defined, e.g. it is not allowed to construct wind power plants in alpine scenery above 1,600 m see level or important bird areas. The integration of wind power plants are a component of the energy strategy 2050 of the Upper

[4] based on the definition of U.S. Energy Information Administration

Austrian government, whereby a potential of 30 MW of additional installed capacity implying an additional electricity production of 57 GWh is estimated for the year 2030. Based on the Green Electricity Act 2012 (Ökostromgesetz 2012) the expansion target for wind power in Austria as a whole is 2,000 MW until 2020. Subsidized feed-in tariffs which are higher than the marked tariffs are available to support the achievement of these goals.
Western Cape
In South Africa and the Western Cape, wind energy is promoted by the Renewable Energy Independent Power Producers Procurement Program (REIPPPP). The allocation of MW installed per technology is guided by the Integrated Resource Plan (IRP). The IRP 2010 contains a target of 17.8 GW of renewable energy capacity by 2030, of which 7 GW needs to be operational by 2020 (5 GW by 2019 and a further 2 GW by 2020). At the national level, a total of 6 376 MW has been procured from 112 IPPs under the REIPPPP to date. Of these, 64 IPPs are operational which have an installed capacity of 3 774 MW and generation of 22 165 GWh of electricity since inception. A total installed wind power capacity of about 15,218 MW was made available in 2015 in the RLS regions Bavaria (1,893 MW), Québec (3,262 MW), Shandong (9,580 MW), Upper Austria (47 MW) and the Western Cape (467 MW procured).

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

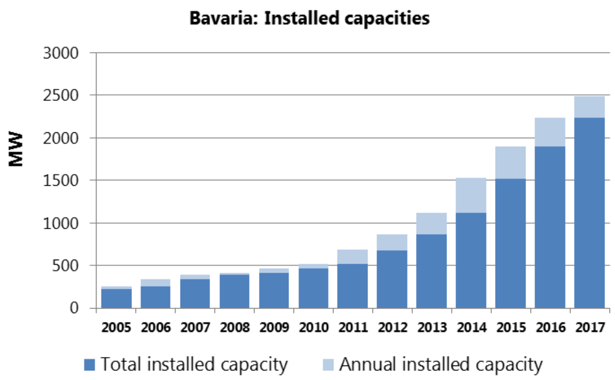
3.3.2 Status quo

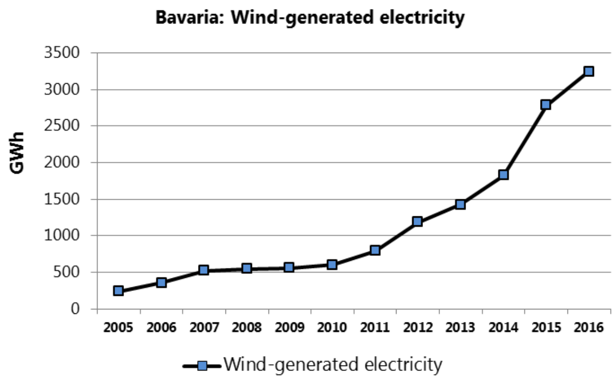
A total installed wind power capacity of about 15,218 MW was made available in 2015 in the RLS regions Bavaria (1,893 MW), Québec (3,262 MW), Shandong (9,580 MW), Upper Austria (47 MW) and the Western Cape (467 MW). For the regions of Georgia and São Paulo, no detailed data was available for wind power or wind energy does not play a decisive role in the domestic energy system so far.

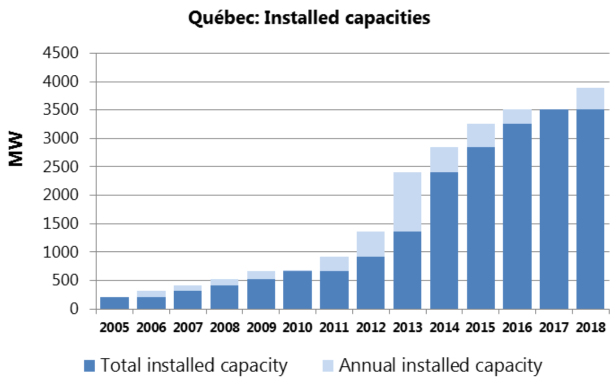
In Bavaria in 2016, the installed capacity of wind power amounted to 2,233 MW and generated 3,426 GWh of electricity. Québec is Canada's second largest market for wind power with 3,882 MW of installed capacity in 2018. Québec's generation fleet includes the 350 MW Rivière-du-Moulin wind farm, the largest project built in Canada so far. Wind power generation in Shandong province is developing at a large scale, and wind power has become the fastest growing renewable energy source. By the end of 2016, the total installed capacity of wind power in the province reached 11.2 GW, growing by 17 % compared to the previous year. The level of wind power technology is continuously improving. The main models have been developed from kW to MW class. Installed turbine capacities of 1.5 MW or more accounted for more than 90% of the province's wind turbines. In Upper Austria, two of Austria's first large plants were put into operation in 1996. At that time, the country was a technological leader. In the later 2000s no further wind power plants were built, and the state is now in the lower middle of the expansion. There is (at the beginning of 2016) a total rated output of around 47 MW and an annual electricity generation of approximately 84 GWh. The Western Cape has a total installed capacity of 467 MW of wind power in 2017.

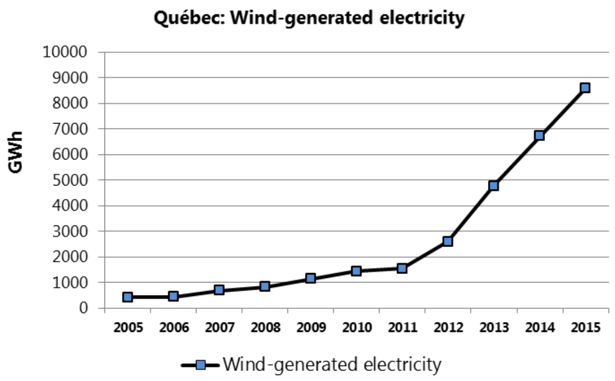
Wind plants, wind farms or wind parks are made up of several single wind turbines and are becoming more productive by several measures. One of these measures is the capacity factor, which is defined as the amount of energy a power plant generates over the year divided by the amount of energy that would have been generated if the plant had been operating at full capacity during that same time interval. For wind turbines, the capacity factor depends on the quality of the wind resource, the ability of the machine to generate when there is sufficient wind, and the size of the generator. The capacity factor is lowered if the utility limits production to accomplish load management requirements. Most wind power plants operate at a capacity factor of 25–40 %. With regard to the capacity factor in the Western Cape, the wind energy data monitoring reveals an average capacity factor of 35 % for the years 2016 and 2017 and a capacity factor of around 12 % in 2013. Due to the increased installation of wind farms and the increase of the average size of the wind turbines from 1.2 MW in 2008 to 2014 to 2.3 MW from 2015 on as well as the higher amount of wind-generated electricity, the capacity factor was intensified. For Upper Austria, an average capacity factor of around 20 % was derived in 2015. Sao Paulo has planned to expanded the usage of wind power. Currently there is one wind farm existing in Soa Paule. By 2020 further wind power plants will be built to increase the total installed capacity to 400 MW and produce 1,332 GWh from it. Until 2030 additional 603 MW shall be implemented. The installed wind power plants with an capacity of 1,003 MW per 2030 will produce about 3,338 GWh.

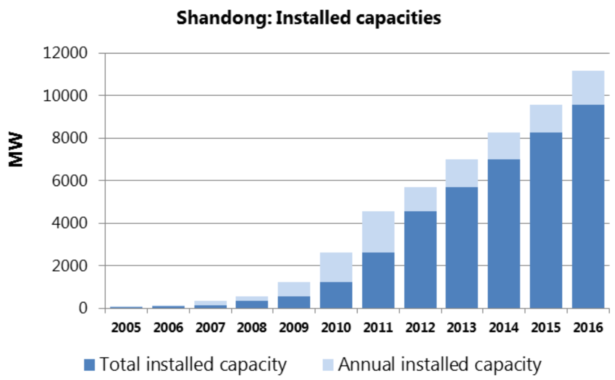
Figure 3-5: Installed wind power capacities and wind-generated electricity in selected RLS regions

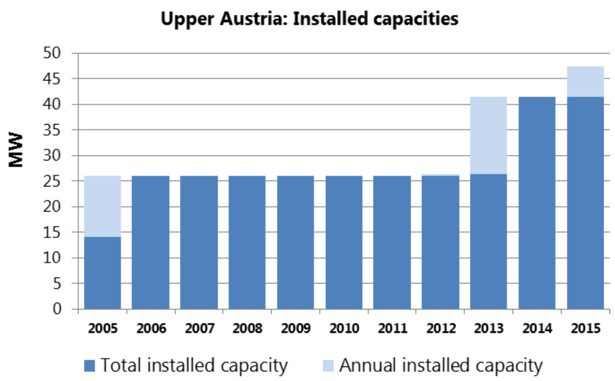


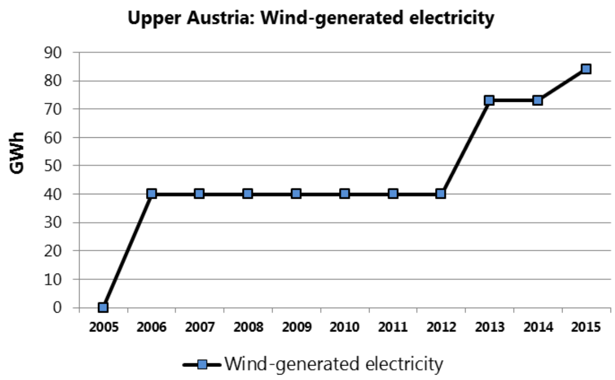


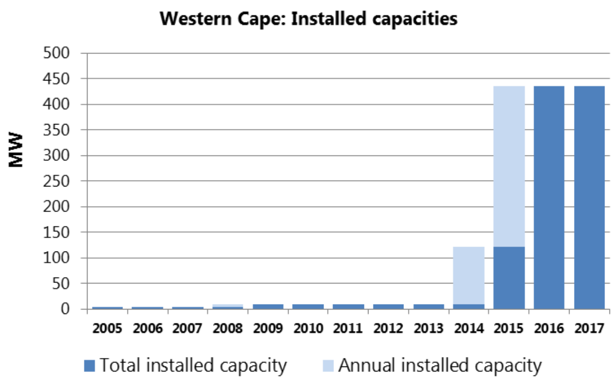


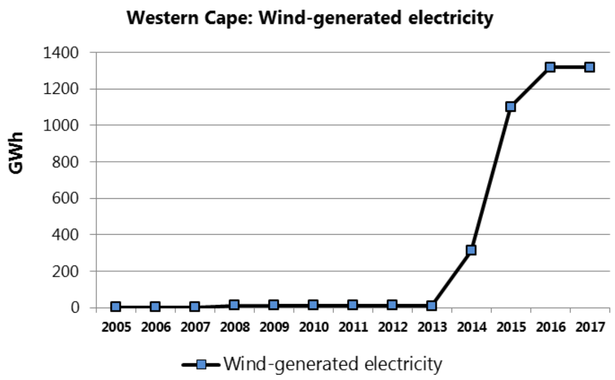












Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-9: Installed wind power capacities and wind-generated electricity in selected RLS regions

Bavaria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total Installed Capacity	MW	258	339	387	411	467	521	684	869	1,120	1,524	1,893	2,233	2,493	-
Annual Installed Capacity	MW	34	81	48	24	56	52	165	188	252	410	372	340	261	-
Wind-generated Electricity	GWh	239	354	524	547	557	601	789	1,183	1,425	1,823	2,784	3,246	-	-
Québec		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total Installed Capacity	MW	207	317	417	527	660	664	923	1,354	2,404	2,843	3,262	3,510	3,510	3,882
Annual Installed Capacity	MW	-	110	100	110	133	4	259	431	1050	439	419	248	0	372
Wind-generated Electricity	GWh	420	427	674	819	1,142	1,433	1,546	2,588	4,768	6,717	8,599	-	-	-
Shandong		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total Installed Capacity	MW	84	145	350	562	1,219	2,638	4,562	5,691	6,981	8,263	9,580	11,185	-	-
Annual Installed Capacity	MW	50	61	202	222	657	1,419	1,925	1,129	1,290	1,283	1,297	1,625	-	-
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total Installed Capacity	MW	26	26	26	26	26	26	26	26	41	41	47	-	-	-
Annual Installed Capacity	MW	12	0	0	0	0	0	0	0	15	0	6	-	-	-
Wind-generated Electricity	GWh	0	40	40	40	40	40	40	40	73	73	84	-	-	-
Western Cape		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Total Installed Capacity	MW	3	3	3	8	8	8	8	8	8	121	436	436	467	-
Annual Installed Capacity	MW	0	0	0	5	0	0	0	0	0	113	315	0	0	-
Wind-generated Electricity	GWh	3	3	3	12	12	12	12	12	9	312	1,101	1,317	1,317	-

Note: '-' : no data available

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2).

Economic impacts

Wind power development directly affects the employment and income of the industry, mainly during the construction phase of a wind power project, but also during its operational phase. Indirectly, wind power construction and operation expenses may create demand for goods and services (e.g. gravel, concrete, vehicles, fuel, hardware, and consumables) produced or sold by other industries in the regional economy. Consequently, increased employment and income in those industries is generated. Consumption goods and services in the regional economy by regional residents and governments from these additional sources of income as well as by workers involved in construction or operations activities can induce further regional economic impacts.

In the Cape, the onshore wind power sector can be estimated via wind specific job creation factors to create an additional 1,700 permanent operational jobs and around 900 installation jobs in 2017. Furthermore, the wind energy industry generates an additional value added of around 0.5 million US$ in this year. In the province of Québec in 2015, the wind energy industry benefited from a ten-year period of predictable and integrated approaches by successive governments, created over 5,000 jobs and generated around 6 billion US$ worth of investments. In Bavaria, investment activities of around 600 million US$ and around 11,800 onshore and offshore wind related jobs were quantified. In Upper Austria in 2015, 30 Upper Austrian companies were suppliers with a turnover volume of around 220 million US$. Together with the additional employment due of the permanent operation staff and installation of wind turbines, around 350 jobs were created. In Shandong, around 30,000 jobs were created to develop wind power plants in 2015.

Table 3-10: Employment effects (rounded) of wind energy in selected RLS regions in 2015

RLS region	Estimated number of jobs in 2015
Bavaria	11,800
Québec	5,000
Shandong	30,000
Upper Austria	350
Western Cape	2,400

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Environmental impacts by displacing fossil fuel power plants

Over the last years, Shandong was able to achieve significant CO_2 reductions, which can be accounted to wind energy in the province. Those CO_2 emissions reduced steadily from 21.5 million tons in 2008 and the reductions are still increasing due to the continuous expansion of wind power capacity. Useful to improving the drought crisis experienced in the Western Cape, is that the displacement of fossil fuels in favour of wind energy results in a water saving of 1.2 litres for every kilowatt hour of wind generated. In Upper Austria, a mitigation of 60 thousand tons CO_2 could be achieved in 2015.

3.3.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of wind energy, several research and development activities in the field of wind energy are taking place.

Table 3-11: Research and development activities with regard to wind energy in selected RLS regions

Québec
In 2017, the Government of Québec released its '2030 Energy Policy'. This strategic plan includes the **development of wind power**, with an emphasis on the prospect of exporting the electricity to the U.S market.
Shandong
Shandong province's wind power research units and enterprises increased year by year. The main research is undertaken by the technology research center of **Shandong University**, specializing in **magnetic suspension vertical axis wind turbine research** and related product development. This includes the aerodynamics, structure, generator, controller, material and location of the blade. The patent technology combining permanent magnetic suspension, self-adjustable pitch and a low voltage charging technology were invented, realizing power generation start at low wind speeds and an automatic pitch changing according to wind speed. Shandong has many **businesses engaged with wind power related products**, e.g. Shandong Rui the Electric Appliance Co. Ltd., Shandong Zhongtai New Energy Group Co. Ltd., Shandong Zhongche Wind Power Co. Ltd., Shandong Datang International wind power limited liability company and Shandong Jupiter Wind Composite Materials Co Ltd.
Upper Austria
Academic and applied research is conducted by the **Energy Institute at the Johannes Kepler University of Linz** regarding the **storage** of wind power, **macroeconomic effects** of wind power and **social acceptance** issues Although wind power plays a minor role in the regional renewable electricity generation mix, **supplier and service companies** in Upper Austria contribute significantly to regional economic growth and wind energy development. There is a planning office (**EWS Consulting**) as well as several suppliers of technology for wind turbines (e.g. **Hainzl**, **Felbermayr**, **Miba**, **Hexel Composites**, **voestalpine**). The **Institute for Industrial Mathematics at the Johannes Kepler University of Linz** researches on condition monitoring for wind energy converters.
Western Cape
R&D activities for wind power in the Western Cape cover educational issues, environmental assessment and monitoring and the development of generation technologies. Research being carried out by the **Power Engineering group at University of Cape Town (UCT)** includes power system operation and control, fault diagnosis, energy efficiency problems induced by solar weather, rural electrification, network protection and power electronics. One of the relevant focus areas is the Integration of Renewable Energy Sources (RES) which includes research on penetration limits on distribution feeders; grid integration and control of small-scale renewable energy systems (RES); concentrated solar power; grid integration of large scale wind power; and wind speed assessment

for electrical power generation. University of Cape Town Department of Electrical Engineering - Machines and Power Electronics

The Advanced Machines Energy Systems (AMES) group in the Department of Electrical Engineering (Machines and Power Electronics) at UCT has developed significant expertise in the management of energy systems, grid integration of renewables, and asset management. The current research areas include: monitoring and fault diagnosis of machines, PM machine design, induction motor efficiency estimation, fuel cell emulators and converters, wind turbine emulation and control, grid-tied inverters for renewable energy applications, load balancing converters, etc.

The Department of Electrical and Electronic Engineering at Stellenbosch University (SU) is researching new generation permanent magnet generators for wind turbines, power electronics required to integrate wind turbines into the electrical grid, as well as the utilisation of wind energy in very cold climates, such as the SANAE base in Antarctica. This group, with the Department of Electrical Engineering at the University of Cape Town, forms the **Wind Energy Spoke**. In 2011 a spin-off company was formed to commercialize some of the designs of this group. This group is also cooperating with Northwest University on wind turbine blade design and manufacturing.

The Centre for Renewable and Sustainable Energy Studies (CRSES) at SU also offers (post) graduate programs in renewable and sustainable energy studies, including courses on wind energy. Also, the South African Renewable Energy Technology Centre (**SARETEC**) is a state-of-the-art wind training facility located in Cape Town, and offers an accredited qualification for wind turbine service technicians. Several research topics in the field of wind energy are assessed interdisciplinary at the Council for Scientific and Industrial Research (**CSIR**), the Energy Research Centre (**ERC**) at the University of Cape Town (**UCT**), the South African National Energy Development Institute (**SANEDI**), the South African Renewable Energy Business Incubator (**SAREBI**) and the sector development agency of the Western Cape Government and the City of Cape Town, **GreenCape**.

With regard to companies engaged with wind power, **Kestrel** manufactures a range of small wind turbines rated at 600 W, 800 W, 1 kW and 3.5 kW, all of which feature robust turbine construction and engineering solutions.

Furthermore, the **government of the Western Cape** offers a sustainable energy database that includes wind power specific data.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.4 Solar thermal energy

Technology description[5]

Solar thermal energy is used to heat water and air. The two general solar heating systems work passively and actively. In this report, the focus is drawn on active solar heating systems.[6] Active solar heating systems combine a collector and a fluid that absorbs solar radiation. Fans or pumps circulate air or heat-absorbing liquids through collectors and then pass the heated fluid straightly to a room or to a heat storage system. Active water heating systems usually have a tank for storing solar-heated water. Solar collectors are either nonconcentrating or concentrating. Nonconcentrating collectors possess a collector area (the area that collects the solar radiation) which is the same as the absorber area (the area absorbing the radiation). Flat-plate collectors are the most mutual type of nonconcentrating collectors and are used when temperatures lower than 200°F are necessary. Solar systems for heating water or air usually have nonconcentrating collectors. With regard to concentrating collectors, the area intercepting the solar radiation is greater than the absorber area. The collector concentrates solar energy onto an absorber. The collector usually moves so that it keeps a high concentration of solar energy on the absorber. Solar thermal power plants use concentrating solar collector systems because they can generate high temperature heat.

Solar thermal power (electricity) generation systems collect and concentrate sunlight to generate the high temperature heat required for producing electricity. Solar thermal power systems consist of solar energy collectors with two main components: reflectors (mirrors) that take and absorb sunlight onto a receiver. In most types of systems, a heat-transfer fluid is heated and circulated in the receiver and used to generate steam. The steam is transformed into energy in a turbine, which powers a generator to produce electricity. Solar thermal power systems have moving systems that keep sunlight focused onto the receiver throughout the day as the sun changes position. Solar thermal power systems can also integrate an energy storage element that permits the solar collector system to heat an energy storage system during the day. The heat from the storage system can be used to generate electricity during periods of low solar radiation. Solar thermal power plants can also be hybrid systems that use other fuels (usually natural gas) to complement energy from the sun during periods of low solar radiation.

[5] based on the definition by U.S. Energy Information Administration

[6] Passive solar space heating occurs when the sun shines through the windows of a building and warms the inner space. Building designs that enhance passive solar heating typically have windows facing to the south which allows the sun to shine on solar heat-absorbing walls or floors during wintertime. The building is heated by natural radiation and convection. Window overhangs or shades prevent the sun from entering the windows during the summer to keep the building cool.

3.4.1 Regional policy frameworks and targets

Table 3-12: Regional policy frameworks and targets for solar thermal energy in selected RLS regions

Bavaria
According to the **Bavarian Energy Concept from 2011**, in order to achieve a substantially climate neutral building infrastructure in Bavaria by 2050, with an at least 50% contribution of renewable energy sources to heating provision, not only will further energy efficiency measures be necessary, but also a doubling of the solar thermal systems and heat pumps installed in buildings. This will primarily be brought about through market incentives, financial support and information provision. The Bavarian State Government intends to: – Work together with the federal government in the framework of the **market incentive program** (MAP - Marktanreizprogramm) to improve the financial support and allocation for solar collectors and heat pumps, while amending it to including an option for solar collectors for solar heating system for heating service water for existing buildings. – Stabilize the market incentive program through setting a budget for a period of at least five years and budgeting for the following period early on, in order to encourage continued investment. – Implement a **Renewable Energy Campaign in the Heating Sector** in order to show consumers the options, the right timing and the advantages to using renewable energy in existing buildings.
Georgia
In the State of Georgia the use of renewable energy is voluntary. The government does not mandate the energy mix. **Public, private, philanthropic partnerships** which utilize state assets to test innovative technologies and prove business models in the areas of renewable energy, transportation and sustainability. The Ray (www.theray.org) an 18 mile highway designated for experimenting and evaluating new technologies. The following **trade organizations** promote and raise awareness of the renewable energy and sustainability in Georgia. **a. Solar Energy Association** **b. Clean Cities of Georgia** **c. Green Chamber of the South** **d. Center for Transportation and the Environment** **e. Georgia Recycling Coalition** **f. Southface**
Shandong
Shandong had a solar thermal active installed capacity of 500 MW in 2015. The potential for further implementation is in this region high. In the year 2020 the installed capacity could increase to 10,000 MW and until 2030 to 25,000 MW.
Upper Austria
In the **Upper Austrian Energy Strategy for 2050**, solar thermal systems are mentioned as a possibility for increasing the share of renewable for heating purpose. Hence, there is funding for the implementation of solar thermal systems in buildings. With around 1,000 square meters of collector surface per 1,000 inhabitants (total installed), Upper Austria is one of the world's leading solar heating regions. With around a quarter of the solar installations installed in Austria in 2016, Upper Austria is at the top of the federal states. Despite many efforts, the annual increase in thermal solar systems is decreasing in Upper Austria. In context of the Upper Austrian building substitutes is regulated that depending on the energetic grading of the new building and the main heating system a combination with a low-emission renewable system like solar thermal is requested.
Western Cape
In the Western Cape, and in South Africa in general, solar thermal has not yet graduated to a

competitive level due to the low cost and availability of coal for heat generation. That being said, South Africa, under the Copenhagen Accord, has committed to reduce its greenhouse gas (GHG) emissions by 34% by 2020 and 42% by 2025. As 85% of GHG emissions in South Africa are attributable to energy, increasing the uptake of renewable energy, such as solar thermal, is critical to ensuring South Africa meets its commitment. As solar thermal systems can be a direct substitute for fossil fuels used to generate heat, it is a key carbon emission savings opportunity. South Africa's proposed carbon tax per tonne CO_2e offers a clear incentive to switch to solar thermal and other renewable technologies that result in carbon emission savings.

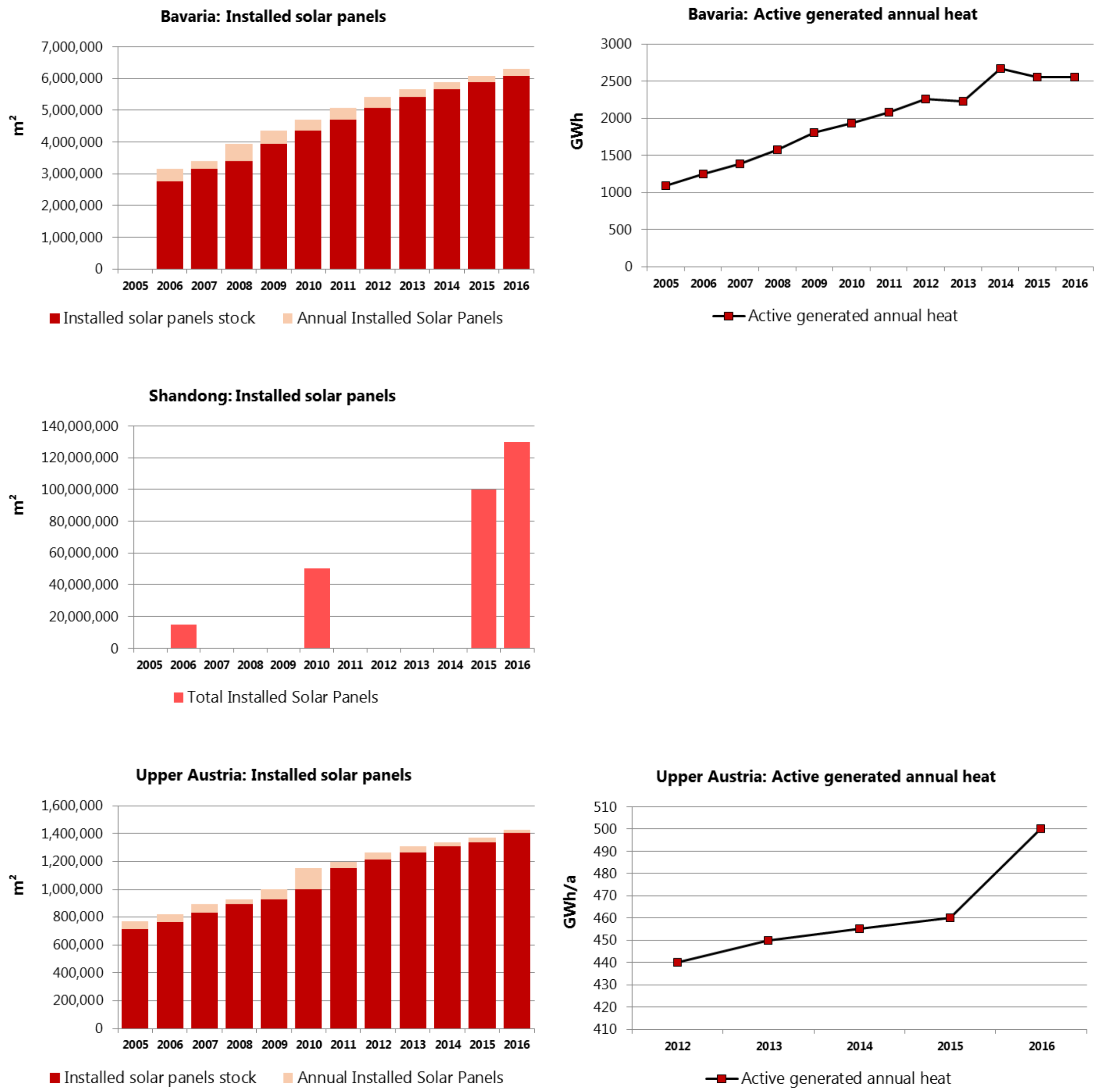
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.4.2 Status quo

In the regions Bavaria, Shandong and Upper Austria approximately 138 million m^2 solar thermal collectors were installed in 2016.

In Bavaria, 6.3 million m^2 of solar thermal collectors produce about 2556 GWh heat annually in 2016. The installed amount of solar panels per 1000 capita was 487 m^2. Solar thermal energy led to an additional employment of 2.620 persons in Bavaria in 2013. In Shandong, the installed solar thermal area has nearly tenfold within ten years. While about 15 million m^2 were installed in 2006, 130 million m^2 of solar producing thermal energy were installed in 2016. Nowadays about 1 m^2 solar panels per inhabitant were installed in Upper Austria. Because of this, Upper Austria belongs to one of the world's leading solar thermal regions. About one quarter of the installed solar thermal panels is located in Upper Austria. Nevertheless, the annually installed solar thermal plants are decreasing. 1,429,000 m^2 of collectors are installed in Upper Austria, while 1,314,000 m^2 of them are active and provide a capacity of 920 MW_{therm} in total in 2016. Taking into account a technical life of 25 years, the thermal solar collectors are collecting approximately 500 million kWh of heat per year. In the Western Cape, coal still dominates the heating space and therefore solar thermal technology is not yet competitive. As low temperature applications are most economical for solar thermal, there is an estimated potential for solar thermal installation of between 76, 500m^2 and 676, 440m^2 in the agri-processing sector, where the majority of the sector's energy demand is for low temperature heat.

Figure 3-6: Installed solar panels and active generated annual heat in selected RLS regions



Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-13: Solar thermal energy in selected RLS regions, 2012-2016

Bavaria		**2012**	**2013**	**2014**	**2015**	**2016**
Total Installed Solar Panels	m²	5,401,200	5,667,400	5,889,400	6,068,100	6,295,500
Annual Installed Solar Panels	m²	331,200	266,200	222,000	178,700	227,400
Active Generated Annual Heat	GWh	2,260	2,230	2,668	2,561	2,556
Solar Panels per 1,000 capita	m²/1,000	431	450	464	472	487
Shandong		**2012**	**2013**	**2014**	**2015**	**2016**
Total Installed Solar Panels	m²	-	-	-	100,000,000	130,000,000

Upper Austria		2012	2013	2014	2015	2016
Total Installed Solar Panels	m^2	1,266,000	1,309,000	1,339,000	1,369,000	1,429,000
Annual Installed Solar Panels	m^2	51,000	43,000	30,000	30,000	25,000
Active Installed Capacity	MW_{therm}	890	920	940	960	920
Active Generated Annual Heat	GWh	440	450	455	460	500
Solar Panels per 1,000 capita	m^2/1,000	900	920	890	900	1,000

Note: '-' : no data available

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.4.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of solar thermal energy, the following research and development activities are taking place.

Table 3-14: Research and development activities with regard to solar thermal energy in selected RLS regions

Bavaria
Solar thermal collectors are seen as being technically well-developed. However, there is a demand and the potential for simplifying the installation in existing buildings through standardization and innovative, simplifying system solutions. To achieve this, the research and development projects in the should be intensified in the cooperation between the **Bavarian Centre for Applied Energy Research** (ZAE-Bayern) and the **Fraunhofer Institute for Building Physics**. **In order to reach a supply of around 4% of the total energy consumption in Bavaria from solar thermal and ambient heat sources by 2022, research is needed in the development more efficient and more cost-effective collectors, the use of new materials, production techniques and concepts. In addition, there is a need for concepts and technologies for heat storage, especially targeting higher storage densities, reduced heat losses and more efficient system integration of storage.** A specific need for research and development has been identified in the areas of: • The use of solar thermal energy with low thermal losses through the integration of the generated heat in existing gas and steam power plants. • The development of new materials and material combinations for improved efficiency and reliability of solar thermal energy conversion processes (high temperature materials, storage materials, coatings, adaptive materilas). • Testing equipment for solar thermal receiver. • Combining of high temperature solar thermal technologies with chemical storage.
Upper Austria
The **Austria Solar Innovation Centre (ASiC)** is a research and development institute and part of the **University of Applied Sciences Upper Austria Campus Wels** which is committed to the distribution of renewable sources of energy in general and more specifically to the intensification of research in the field of solar technology. The ASiC has been involved in research and development in the area of solar technology in Wels since March 2000. **A platform between research, training and commercial enterprises has been created thanks to the financial support of the region of Upper Austria, the city of Wels and the electric power company of Wels.** The main tasks of the ASiC include research and development in addition to project management in the field of solar energy. The following specific services are provided:

- Measurement of solar thermal collectors and photovoltaic modules
- Functional and revenue monitoring of thermal solar plants and PV systems
- Project management and concept development in the field of renewable energy
- Simulations to support planning activities
- Determination of optical characteristics of materials
- Consultation which is not specific to firms or products
- Lectures
- Training

The **Institute for Organic Solar Cells at the Johannes Kepler University** of Linz focuses within its research activities on **organic semiconductors and photoactive nanostructures**.

Western Cape

In the Western Cape, the leading authority on solar thermal is a regional initiative called **SOLTRAIN** (Southern African Solar Thermal Training and Demonstration Initiative) on capacity building and demonstration of solar thermal systems in the SADC region. Its aim is to support the target countries in changing from a largely fossil energy supply system to a sustainable supply structure based on RE in general, and on solar thermal in particular. **The South African National Energy Development Institute** (SANEDI) and the Southern African-German Chamber of Commerce and Industry (SAGCCI) have teamed up for the international 'Solar Payback' project, which aims to increase the use of solar thermal energy in industrial processes. University of Stellenbosch – Department of Mechanical and Mechatronic Engineering

The research at Stellenbosch University focuses on the thermal energy from the sun and, for the time being, does not include photovoltaic systems. The **Solar Thermal Energy Research Group (STERG)** situated in the Department of Mechanical and Mechatronic Engineering at SU was formally constituted in 2010. Research covers concentrated solar power (CSP) system concepts, development & analysis; thermal energy storage; condenser cooling (wet, dry & hybrid); heliostat and overall collector R&D; linear Fresnel collector R&D; stirling dish R&D; solar resource assessments, measurements & GIS mapping; and application of solar heat in industry.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.5 Photovoltaic power

Technology description[7]

Photovoltaics (PV), also called solar cells, are electronic devices that transform sunlight[8] directly into electricity. The electricity generation process happens via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to be sent through an electrical circuit, powering electrical devices or transporting electricity to the grid. Solar PV installations can be incorporated to the provision of electricity on a commercial scale, or implemented in smaller configurations for mini-grids or personal use. Using solar PV to power mini-grids is a way to transport electricity to consumers who do not live close to power transmission lines, particularly in developing countries with excellent solar energy resources. Currently, photovoltaic is one of the fastest-growing renewable energy technologies.

3.5.1 Regional policy frameworks and targets

Table 3-15: Regional policy frameworks and targets for photovoltaics in selected RLS regions

Bavaria
Target for Germany: 2.5 GW of added energy generated by solar photovoltaic per year. According to the German federal Renewable Energy Law (§§ 20, 21 EEG 2017), since 1 January 2017 all photovoltaic systems of at least 100 kWp are required to directly sell the electricity generated. For this they receive a management premium of 0.4 cents/kWh. In order to reach an installed capacity of photovoltaic systems in Bavaria of 14,000 MW by 2021, the Bavarian State Government set to work together with the German federal government in the framework of the Renewable Energy Law (EEG) in order to expand on the remuneration conditions with a bonus for technologies which are promising in the regards of energy efficiency and the potential for cost reduction.
Georgia
In the State of Georgia the use of renewable energy is voluntary. The government does not mandate the energy mix. **Public, private, philanthropic partnerships** which utilize state assets to test innovative technologies and prove business models in the areas of renewable energy, transportation and sustainability. The Ray (www.theray.org) an 18 mile highway designated for experimenting and evaluating new technologies. The following **trade organizations** promote and raise awareness of the renewable energy and sustainability in Georgia. **a. Solar Energy Association** **b. Clean Cities of Georgia** **c. Green Chamber of the South** **d. Center for Transportation and the Environment** **e. Georgia Recycling Coalition** **f. Southface**

[7] based on the definition of International Renewable Energy Agency and U.S. Energy Information Administration

[8] Some PV cells can convert artificial light into electricity.

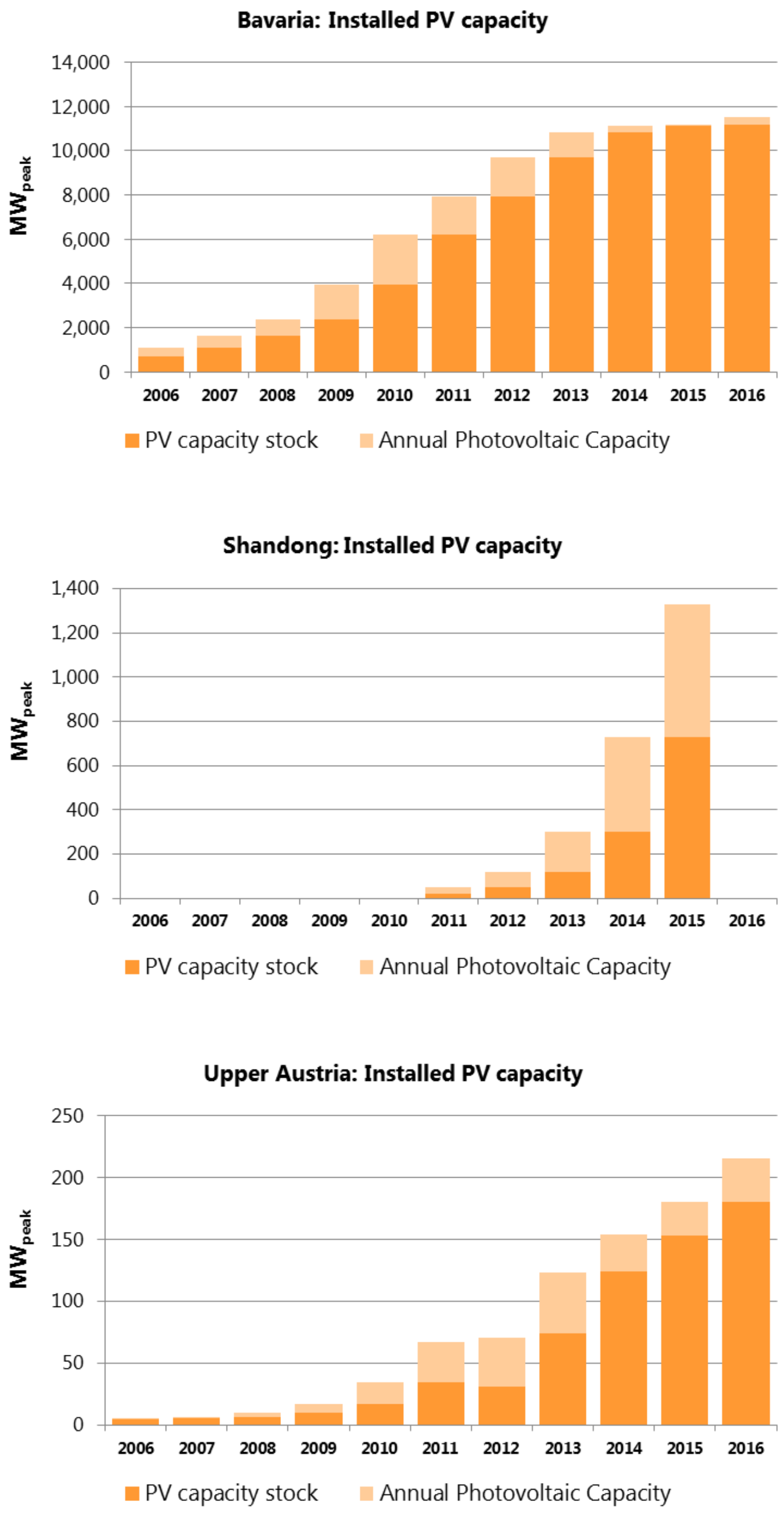
Upper Austria
Feed-in tariffs: The promotion of grid-controlled photovoltaic systems in Austria takes place in the form of increased current feed-in tariffs in accordance with the applicable Ökostromverordnung (Green Electricity Regulation). There exist **investment funding** for the installation and expansion of PV systems and the expansion of a PV system with power storage systems or the expansion of existing power storage systems. The integration and expansion of photovoltaics are a component of the **Energy Strategy 2050** of the Upper Austrian government, whereby depending on the scenario a potential for electricity production in the range of 800 to 2,600 GWh is estimated for the year 2030.
Western Cape
The **Integrated Energy Plan**, which was developed in terms of the National Energy Act of 2008, seeks to ensure diversity of energy supply. Developed in its context, the upcoming **Integrated Resource** Plan (expected in 2018) will provide and overall plan indicating the quantities of various electricity sources to meet the country's electricity demand in the next 20 years. A change in the 'single buyer' model whereby the country's single public utility for electricity (Eskom) is given exclusive rights to procure electricity for resale, including electricity from RE IPPs, would see SSEG investors receiving an opportunity to sign alternative offtake agreements with municipalities, resulting in an improvement in potential returns, and the creation of new business cases. To this end, 21 out of 25 municipalities in the Western Cape now allow SSEG and more than half of these have **feed-in tariffs** approved by the National Energy Regulator (NERSA). Such regulatory developments facilitate the growing uptake of RE options, particular rooftop solar PV that falls in the less than 1 MW space. This is one of two major changes taking place on the local government level. The other offering being developed in the Western Cape is the opportunity for IPPs to wheel their energy directly to a willing buyer in their respective municipalities, which is known as **electricity wheeling**.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.5.2 Status quo

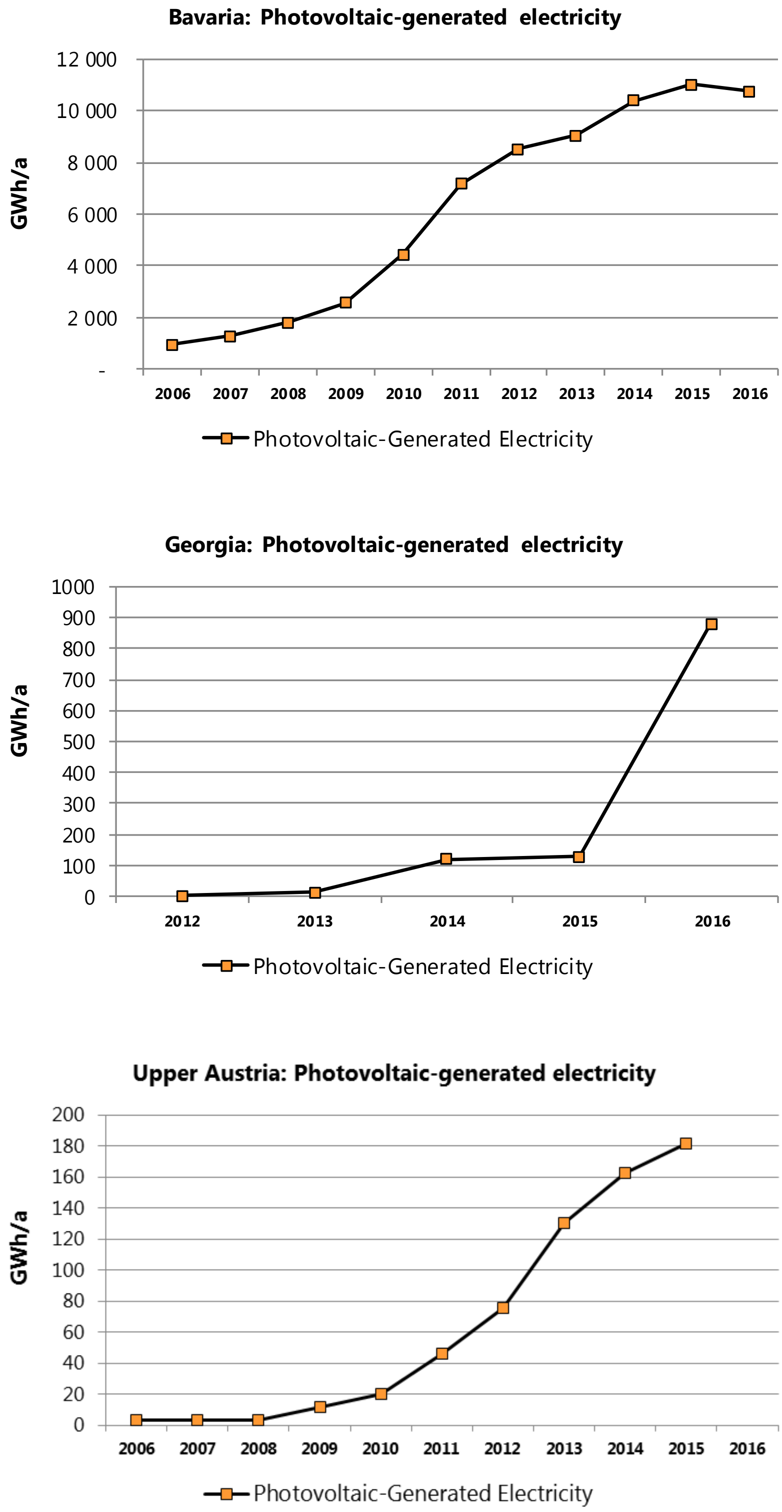
In Bavaria, a strong increase of total installed capacity from 1,103 MW_{peak} in 2006 to 10,826 MW_{peak} in 2013 can be observed. This development is run by the additional annual installed capacities of ca. 1,700 MW_{peak} in average between 2009 and 2013. In 2016, 10,765 GWh of photovoltaic electricity were produced. In Georgia, an increase in photovoltaic electricity from 129 GWh in 2015 to 881 GWh in 2016 can be observed. In Shandong, photovoltaics' total installed capacity increased from 48 MW_{peak} in 2011 to 1,327 MW_{peak} in 2015. In 2015, the additional installed capacity amounted to ca. 600 MW_{peak}, an increase of around 80 % with regard to the total installed capacities in 2014. From 2009 until 2016 about 76,000 PV systems were installed in Upper Austria. On the national level, there is only one other federal province where more PV systems were installed, namely Lower Austria. About 22,000 PV systems were connected to the electricity grid with a capacity of 215 MWp in Upper Austra in 2016. In 2015, electricity of 181 GWh was generated by photovoltaics. In Western Cape rooftop PV systems of 47 MW_{peak} are installed per the year 2017. Within the Renewable energy Independent Power Producers Procurement Programme (REIPPPP) 439 GWh of electricity were produced by PV within the period November 2013 until June 2017. Five projects of PV systems have been realized based on the REIPPPP. The connected PV systems are operation right now with a capacity of 134 MW_{peak}. The total installed capacity of PV systems was 91 MWp per the year 2017 and 104 GWh of electricity was generated by PV systems in São Paulo,. The average capacity factor is around 13 %

Figure 3-7: Installed photovoltaic capacities in selected RLS regions



Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Figure 3-8: Photovoltaic-generated electricity in selected RLS regions



Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-16: Installed photovoltaic capacities and photovoltaic-generated electricity in selected RLS regions

Bavaria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total photovoltaic Capacity	MW_{peak}	700	1,103	1,637	2,359	3,955	6,200	7,921	9,701	10,826	11,100	11,184	11,489
PV capacity stock	MW_{peak}	700	700	1,103	1,637	2,359	3,955	6,200	7,921	9,701	10,826	11,100	11,184
Annual photovoltaic capacity	MW_{peak}	-	403	534	722	1,596	2,245	1,721	1,780	1,126	274	84	305
Photovoltaic-generated electricity	GWh	560	962	1,283	1,808	2,555	4,451	7,161	8,530	9,043	10,382	11,026	10,765
Georgia		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Photovoltaic-generated electricity	GWh	-	-	-	-	-	-	-	3	14	119	129	881
Shandong		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total photovoltaic Capacity	MW_{peak}	-	-	-	-	-	19	48	120	300	730	1,327	-
PV capacity stock	MW_{peak}	-	-	-	-	-	-	19	48	120	300	730	-
Annual photovoltaic capacity	MW_{peak}	-	-	-	-	-	-	29	72	180	430	597	-
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total photovoltaic Capacity	MW_{peak}	4	6	7	10	17	34	66	70	123	154	180	215
PV capacity stock	MW_{peak}	-	4	6	7	10	17	34	31	74	124	153	181
Annual photovoltaic capacity	MW_{peak}	-	1	1	3	7	18	32	40	49	30	27	35
Photovoltaic-generated electricity	GWh	3	3	3	3	12	20	46	75	131	163	181	-

Note: '-' : no data available

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.5.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of photovoltaic power generation, the following research and development activities are taking place.

Table 3-17: Research and development activities with regard to photovoltaics in selected RLS regions

Bavaria
In Bavaria, research investment is taking place in particular at the **Universities of Bayreuth,** Munich, **Erlangen-Nuremberg and Wuerzburg**, as well as at the **Centre for Applied Energy Research (ZAE)** in the areas of building-integrated photovoltaics, as a partial replacement for the building envelope. Companies in the fields of semi-conductor technologies, printed electronics, mechanical engineering, printing technologies and materials development are also present which have the potential to successfully engage in the "**Next Generation" of photovoltaics**. **Concrete research and development areas** identified by experts in the framework of the **Bavarian Alliance for Energy Research and Technology:** – Cost-effective, resource and energy efficient photovoltaic technology, in particular for the wafer production, the module coating and the recyclability (thick-film, conventional technology). – Increasing the efficiency of conventional solar modules through the improvement of the circuitry, design and assembly of the modules. – New cost saving production processes for thin-film photovoltaic modules (anorganic) in which separate process steps have been performed in series until now. – For the third generation of photovoltaics there should be a development of organic and hybrid material systems, the development of component architectures and of cost-effective production processes through the use of printing technologies. – For the third generation of photovoltaics there should be an analysis and optimization of light collection, of transport and injection processes, charge separation, as well as the stability behavior. The use of materials whose raw material base and energy balance are not problematic. The increase of effectiveness through innovative material design and the coordination of the technological processes with different material classes. With the goal of further cost reductions and improved efficiency for photovoltaic systems, the Bavarian State Government supports research and development, in particular in the framework of the **investment programme "Aufbruch Bayern"** which financially supports the Bavarian Centre for Applied Energy Research (ZAE-Bayern) and to expand the **Solar Factory of the Future "Solarfabrik der Zukunft"** with an energy efficiency test center in close cooperation with the Energy Campus Nuremberg to expand to create an excellence centre for printed organic photovoltaics.
Georgia
In the State of Georgia the use of renewable energy is voluntary. The government does not mandate the energy mix. **Public, private, philanthropic partnerships** which utilize state assets to test innovative technologies and prove business models in the areas of renewable energy, transportation and sustainability. The Ray (www.theray.org) an 18 mile highway designated for experimenting and evaluating new technologies. The following **trade organizations** promote and raise awareness of the renewable energy and sustainability in Georgia. **a. Solar Energy Association** **b. Clean Cities of Georgia** **c. Green Chamber of the South** **d. Center for Transportation and the Environment**

e. Georgia Recycling Coalition **f. Southface**
Upper Austria
The **Austria Solar Innovation Centre (ASiC)** is a research and development institute and part of the **University of Applied Sciences Upper Austria Campus Wels** which is committed to the distribution of renewable sources of energy in general and more specifically to the intensification of research in the field of solar technology. The ASiC has been involved in research and development in the area of solar technology in Wels since March 2000. **A platform between research, training and commercial enterprises has been created thanks to the financial support of the region of Upper Austria, the city of Wels and the electric power company of Wels.** The main tasks of the ASiC include research and development in addition to project management in the field of solar energy. The following specific services are provided: – Measurement of solar thermal collectors and photovoltaic modules – Functional and revenue monitoring of thermal solar plants and PV systems – Project management and concept development in the field of renewable energy – Simulations to support planning activities – Determination of optical characteristics of materials – Consultation which is not specific to firms or products – Lectures – Training The **Institute for Organic Solar Cells at the Johannes Kepler University** of Linz focuses within its research activities on **organic semiconductors and photoactive nanostructures**.
Western Cape
The **Energy Research Centre** at UCT is a multi-disciplinary research centre which focuses on technology, policy and sustainable development research, education and capacity building programmes at a local and international level. The five focus areas are: – **Energy, Poverty and Development**: focuses on energy issues that affect sustainable development and improved livelihoods for poorer communities in South Africa and other developing countries. – **Energy efficiency** focuses at the demand level, looking at the effects on single businesses and the national picture. – **Energy systems analysis and planning** focuses on energy modelling with the aim of assisting local industry and government identify and assess technology and policy options. The focus is on modelling aspects unique to developing nations, – **Energy, environment and climate change** considers the intersection between energy, local environment and global climate change. It aims to contribute to minimising impacts of energy use and production, from social, economic and environmental perspectives. – **Renewable energy** focusses on the technological, social and economic challenges of RE. The **South African Renewable Energy Technology Centre (SARETEC)** is the first national renewable energy technology centre in South Africa and has been established at the Cape Peninsula University of Technology (CPUT) - Bellville campus. SARETEC expedites specialized industry-related and accredited training for the entire renewable energy (RE) industry including short courses and workshops. As a National Centre, SARETEC endeavours to make locally developed technologies more accessible to the renewable energy industry in partnership with education and research institutions in all provinces. Focus areas include renewable energy skills development for solar photovoltaic, wind energy, energy efficiency, biomass and biogas. The **Nanosciences Platform** at the University of the Western Cape does research on nanomaterials, solar cells, photovoltaics, sensors and thin films.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.6 Bioenergy

Technology description[9]

Bioenergy is defined as "organic matter derived from plants or animals available on renewable basis" and is used for energy applications covering a diversity of practices and technologies, ranging from traditional heat production for cooking and/ or space heating to modern combined heat and power generation or biofuels production. The data compiled in this section covers bioenergy for heat and power production while biofuels are assessed in Section 3.7. Fluidized bed combustion, biomass co-firing in large-scale coal power plants and biomass-based medium-to-small combined heat and power (CHP) plants contain widely-applied technology options for power generation. As biomass is available worldwide, one of the advantages of biomass utilization for energy production is that almost every country can use their own biomass resources. On the other hand, the energy density of biomass is lower than that of fossil fuels. Although the biomass pre-treatment process has been advanced technically, proper collection and transportation is necessary for its efficient exploitation. Seasonal and/or annual variation in biomass supply is another significant characteristic. Additionally, biomass plays a complex role as it is currently consumed for food, feed, fibre and energy supply, all using the identical land for its production. As it also supports different types of ecological aims (e.g. biodiversity, greenhouse gas emission reductions and landscape development), the utilization of biomass can dynamically change those interactions and lead to either positive or negative impacts, both regionally and globally.

3.6.1 Regional policy frameworks and targets

Table 3-18: Regional policy frameworks and targets for bioenergy in selected RLS regions

Bavaria
Target for Germany: 100MW of added energy generated from biomass per year. According to the Bavarian Energy Concept of 2011, in order to reach the target of 50 billion kWh/year of primary energy and 8 billion kWh/year of electricity from biomass, there needs to be more efficient use of organic residuals and waste materials, the energy potential for straw and wood need to be more effectively exploited and the efficient conversion technologies further developed. Additional targets include an increased diversity in the energy crops an increased installation of wood pellet heating systems. To achieve these goals the Bavarian State Government established an expert group for bioenergy at the Centre of Excellence for Renewable Resources ("Expertengruppe Bioenergie" am Kompetenzzentrum für Nachwachsende Rohstoffe) in Straubing to deal with overarching considerations regarding resource management and for informing the public. An informational campaign about biogas is also planned to be carried out through C.A.R.M.E.N. e.V. and other bavarian specialist agencies, with the intention to provide neutral information about the use of biogas as a regional energy form with the potential for storage. There will also be increased support in the planning and project development for those interested in bioenergy through the specialized energy consultants at the nine Centres of Expertise for Diversification, through wood energy consultants at the agencies for Nutrition, Agriculture and Forestry, as well as the municipalities and

[9] based on the definition of International Renewable Energy Agency

the community associations in the framework of rural development. The Bavarian funding programme "BioKlima", applying to biomass heating systems, was also expanded and the timeline extended. There will also be further development in the use straw for thermal energy generation and short rotational plantations as pilot and demonstration plants.

Québec

In November 2009, the **Gouvernement du Québec** set its GHG emission reduction target to 20 % below its 1990 level by 2020. According to the Suzuki Fundation, this is the most ambitious target in North America. This target was taken to 37,5 % below the 1990 level by 2030, in November 2015.
The Gouvernement du Québec also aims at **banning the elimination of organic matters by 2022**.
The Government du Québec released in April 2016 his latest energy policy, la Politique énergétique 2030 (**PE2030**). The PE2030 aims at reducing the amount petroleum products consumed by 40 %, increasing the renewable energy output by 25 %, including a **50 % increase of bionergy production**. Thermal coal use will also be eliminated.
The **2017-2020 Action Plan of the PE2030 has many measures related to bioenergy:**

- Action 5 supports energy innovation projects
- Action 14 establishes a regulation requiring minimal renewable content of 2 % in diesel and 5 % in gasoline consumed in Québec and plans a gradual increase of these requirements
- Action 16 supports the conversion of fuel oil heating systems to other forms of energy
- Action 19 supports the conversion to or acquisition of equipment that operates using cleaner forms of energy than fuel oil
- Action 24 supports innovative, structuring green energy projects using the Capital Mines Énergie fund (objective of 3 projects finances by 2020)
- Action 36 helps financing organic matter biomethanation projects
- Action 37 sets the adoption of a regulation establishing 5 % as the minimum proportion of renewable natural gas that Québec natural gas distributors must inject in their distribution network for clients in Québec
- Action 38 aims to help finance the construction of biofuel demonstration plants

São Paulo

The main goal of the **São Paulo State Energy Plan - PPE / 2020 -** is enable the Government of the State of São Paulo to define public policies to keep a **safe energy supply regarding the energy demand envisaged for 2020**.
The main goals are:

- For the Industrial Sector: 5% energy efficiency gain.
- For the Residential, Commercial and Public Sector: 10% fuel efficiency end-use gain.

Upper Austria

Around 41% of the Austrian area is woodland, so bioenergy is a significant regional energy source. One central measurement in the **Upper Austrian Energy Strategy 2050** is **usage of residual wood and organic residues**, taking into account available, regional resources. The importance of the increased usage of bioenergy is underlined in the funding systems. Natural and legal persons, including homeowners and farms are funded up to 50 % for

- the installation of a pellet, wood chip or firewood heating system as new plant
- the conversion of a fossil old plant (oil, gas, coal, all-burner) on a pellets, wood chips or firewood heating
- the renewal of an old biomass heating (at least 10 years) on a pellets, wood chips or firewood heating

Furthermore, pellets or single ovens in living spaces are eligible if biomass is the only source of heat. There are also funding programs for solid biomass cogeneration in the small power range (eg Pellets-Stirling). Furthermore power plants based on biomass and biogas are funded with higher **feed-in tariffs** for the electricity based on the **Electricity Act**.

Western Cape

There are currently no specific policy frameworks or targets for bioenergy in the Western Cape.
At a national level there is also currently no specific policy frameworks for bioenergy. However the

national Integrated Resource Plan (IRP) for 2010 , the main electricity planning document for the country, included 60MW of landfill gas over 2025-2027 as the bioenergy technology to be implemented. However, the experience in the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has indicated that waste-to-energy struggles to be competitive compared to other renewable energy technologies such as solar and wind at utility scale.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.6.2 Status quo

In Bavaria, the usage of biomass for heating purpose increased significantly over the last ten years. While 107 PJ were gained from biomass in 2005, 205 PJ were gained in 2015. The biggest amount came from solid biomass with nearly 112 PJ, followed by liquid and gaseous biomass. The increase of the usage of biomass for the purpose of electricity production was even higher in Bavaria. 2005 about 2,400 GWh electricity were generated by biomass, in 2014 the generation exceeded 8,100 GWh.

In Québec in 2016, there were 29 bioenergy plants which are holding an operating permit for wood processing plants (this includes combined heat and power; heat only; wood pellets, woodbriquette and wood charcoal). Besides that, there are various other wood processing plants (i.e., sawmills, pulp and paper plants, etc.) that consume forest biomass for their own energy purposes. There were 12 CHP plants operating in Québec in 2016. In 2016, approximately 6 PJ of thermal energy and 1,957 GWh of electrical energy were gained from biomass.

The production of electricity based on biomass has been significantly increasing in Shandong: in 2006, 140 GWh of electrical energy was produced from bioenergy. In 2015, the production amounted to 1,523 GWh in 2015. The target it to increase this amount to 2,300 GWh in 2020 and 5,000 GWh until 2030.

In 2017, there were nearly 72,000 biomass plants (including big biomass plants connected to the district heating grid and small plants installed in private households) installed in Upper Austria. In total, 60 PJ were gained from biomass in 2015, 42 PJ out of solid biomass and 18 PJ from liquid resp. gaseous biomass. Besides heating purpose biomass is also used for electricity production, in the year 2015 nearly 1 TWh of electrical energy was produced.

In 2017, there were 220 biomass plants operating in São Paulo. The amount has more than doubled over the last 10 years - 102 plants were operating in 2007. There exist 17 CHP plants in São Paulo. In 2016, produced energy by biomass amounted to more than 1,300 PJ heat and about 8 GWh electricity. For the future, a further increase of using biomass for producing energy is planned. 18,300 PJ of heat are planned to be gained from biomass in total by 2020 and 86,568 GWh electricity are planned to be produced by biomass. The electricity production is planned to divide between different sources: 753 GWh from landfill biogas, 7,718 GWh from forest residues, 77,438 GWh from sugar cane and 659 GWh from urban solid waste. Especially, the utilization of urban solid waste is planned to increase significantly, in the year 2030 about 2,269 GWh electricity is planned to be generated out of it.

In the Western Cape and in South Africa as a whole, the biogas industry is in its infancy. The South African Biogas Industry Association (SABIA) estimates there to be 500 digesters in South Africa. Of these, 200 are located at wastewater treatment works, while the remaining 300 are being used for other purposes. The majority of these are small-scale domestic digesters, with only several dozen commercial / industrial scale digesters in operation. The Western Cape green economy sector development agency, GreenCape, has recorded 24 biogas facilities in the Western Cape, of which 11 are currently operational, one is decommissioned, and the remaining 12 are planned. These facilities include those that process agricultural residues and organic waste. Those four operational plants processing primarily solid waste have a capacity to process an estimated 524 tonnes of organic material per day. Once all ten facilities processing solid waste are up and running, the total capacity should reach around 1,052 tonnes per day.

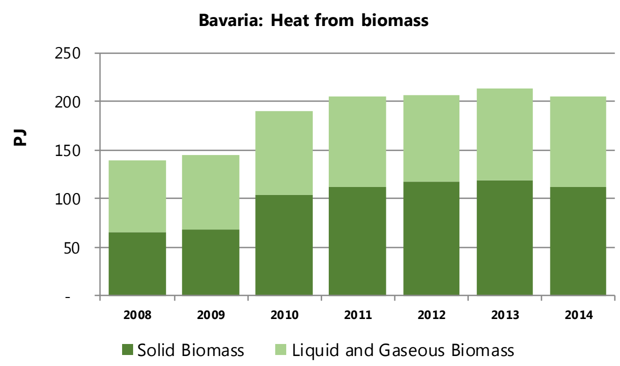
Notable large scale facilities include the New Horizons Waste-to-Energy Plant in Athlone, Cape Town which processes about 500 tonnes per day of mixed municipal solid waste (approximately 200 tonnes per day of which is organic waste). The other notable large scale plant biogas plant is to be constructed on the Vyvlei Dairy farm, Malmesbury in 2018. The plant will process 200 to 300 tonnes of organics per day, mainly bovine manure and food waste. The expected 4.8 MWh energy produced will be fed into the electricity grid and sold to an offtaker as part of a wheeling arrangement.

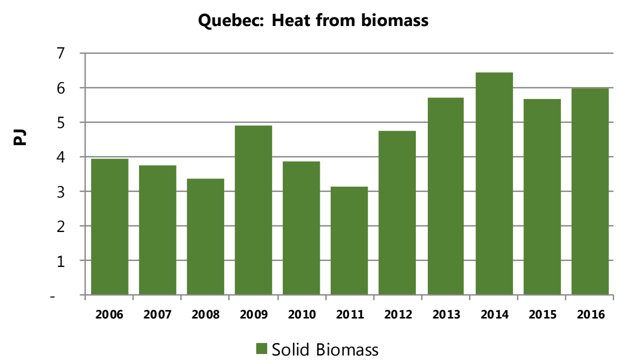
There are no incentives or subsidies for bioenergy in South Africa. A GreenCape study on the business case for small to medium scale biogas from solid waste in the Western Cape indicates that the viability of a biogas plant is dependent on four key variables: the size of the facility, current cost of energy on the site, how much of current energy requirements can be replaced, and the gate fee for waste / cost of current residue handling. Medium size biogas facilities of between 50 kWe and 1 MW can be financially viable when waste management costs are high (assuming current energy prices and high to full utilisation of energy on-site). The study indicates that waste management costs could be a stronger driver for biogas installations in South Africa than energy savings, due to relatively low energy costs in South Africa.

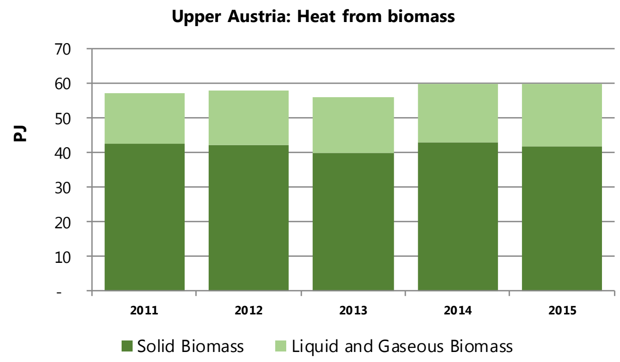
At a municipal level, the biosolids from two wastewater treatment works of the City of Cape Town are currently used to generate biogas at one of these wastewater treatment works. The energy generated from the burning of this biogas is used for drying sludge. However, the City of Cape Town is currently examining the use of biogas at all of its wastewater treatment works for electricity generation for on-site use / feeding onto grid.

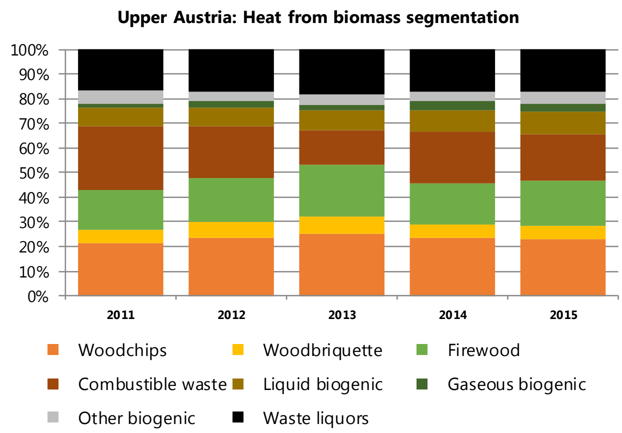
The City of Cape Town has also been installing infrastructure for landfill gas capture at its three major landfills. The first of these has commenced with flaring of the landfill gas, but the intent is to use the landfill gas for electricity generation in the longer term. However, in response to national directives, the Western Cape Government (WCG) Department of Environmental Affairs and Development Planning (DEA&DP) has made the decision to implement an organic waste diversion plan. The plan seeks to divert 50% of organic waste from landfill by 2022, and to achieve 100% diversion by 2027. The plan will include addendums to the licences of waste disposal facilities. These addendums will require municipalities to set annual targets and identify procedures to meet the organic waste diversion targets. In effect, this will restrict disposal of all organics to Western Cape landfills by 2027. It is thus expected that municipalities in the Western Cape will step up plans for alternative waste treatment which may see an increase in waste-to-energy facilities. It is worth noting that the conditions that make waste-to-energy (e.g. incineration with energy recovery and anaerobic digestion of municipal solid waste) financially viable in other countries are not necessarily present in the South African context, notably economies of scale, as well as markets for byproducts such as heat. There are thus numerous challenges for the implementation of waste-to-energy in the South African context, several of which are outlined in the 2018 GreenCape Market Intelligence Report for the Waste Sector (available from https://www.green-cape.co.za/market-intelligence/)

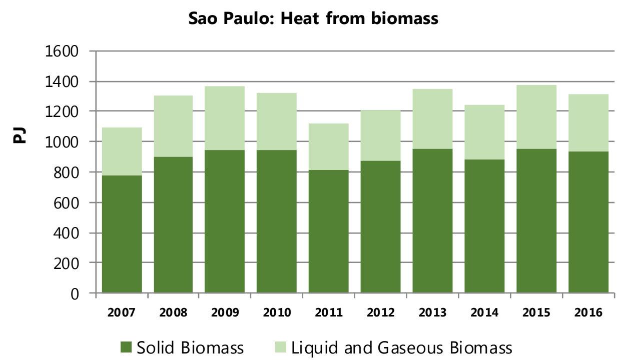
Figure 3-9: Heat yield from Biomass in selected RLS regions

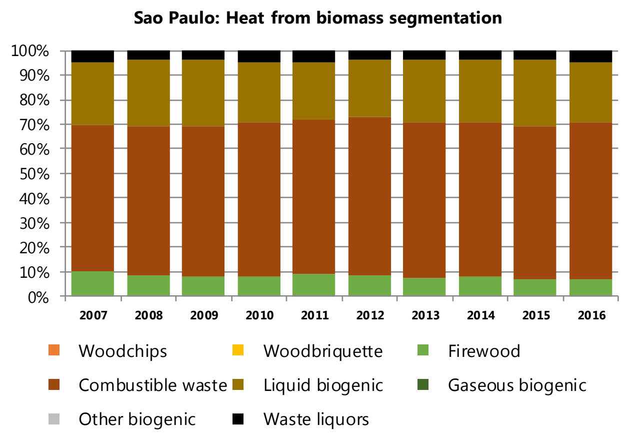






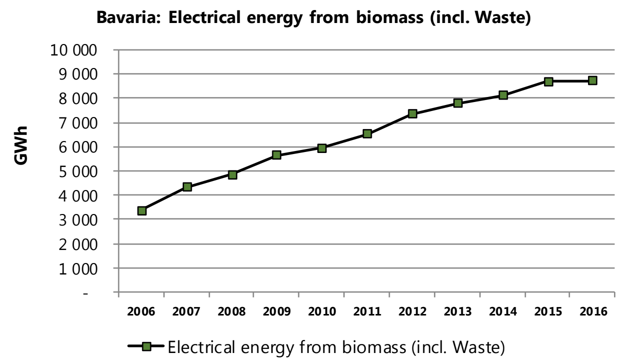


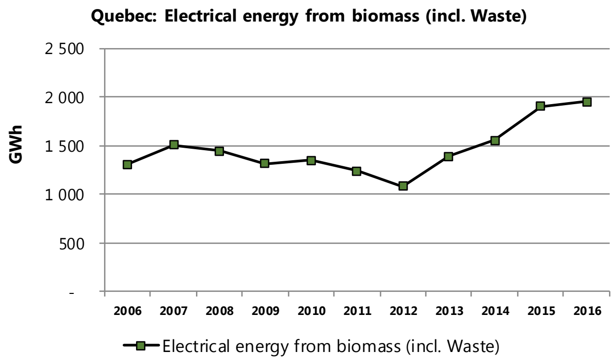


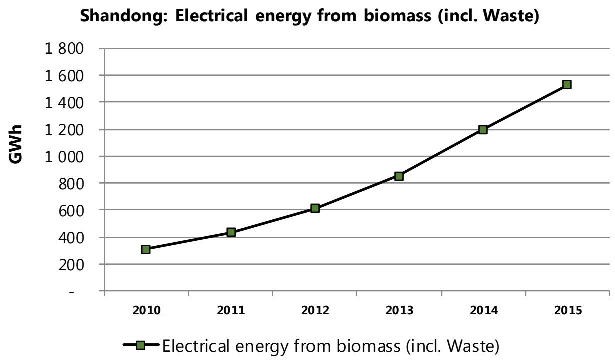


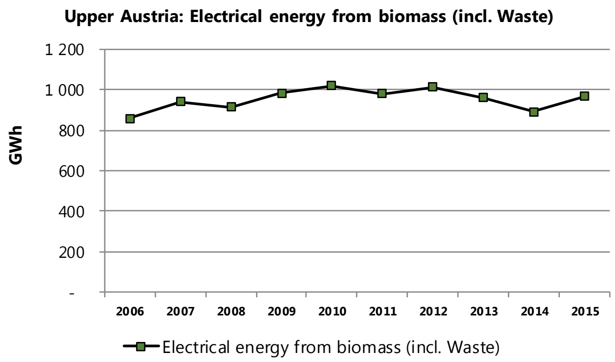
Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

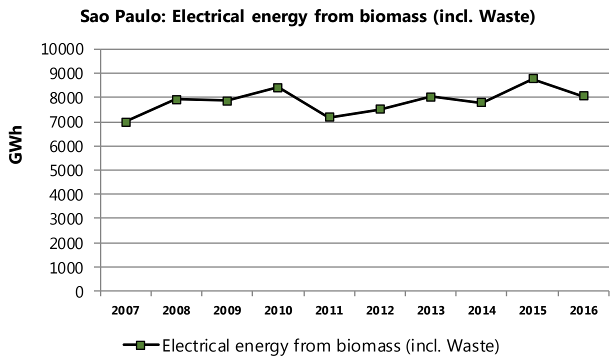
Figure 3-10: Electricity production out of biomass in selected RLS regions

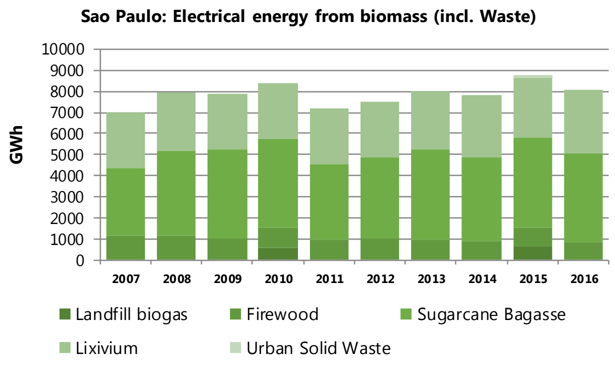












Source: *Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)*

Table 3-19: Heat yield and electrical energy from biomass in selected RLS regions

Bavaria		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid biomass	PJ	-	-	-	66	68	103	111	117	119	112	-	-
Liquid and gaseous biomass	PJ	-	-	-	73	77	87	93	89	94	94	-	-
Total biomass	PJ	107	131	140	139	146	190	205	206	213	205	-	-
Electrical energy from biomass (incl. waste)	GWh	2,397	3,362	4,337	4,845	5,657	5,954	6,519	7,334	7,781	8,105	8,704	8,726
Québec		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Solid biomass	PJ	3	4	4	3	5	4	3	5	6	6	6	6
Total biomass	PJ	3	4	4	3	5	4	3	5	6	6	6	6
Woodbriquette	%	0%	3%	8%	14%	13%	12%	12%	8%	7%	7%	9%	9%
Other biogenic	%	100%	97%	92%	86%	87%	88%	88%	92%	93%	93%	91%	91%
Electrical energy from biomass (incl. waste)	GWh	1,199	1,310	1,511	1,446	1,317	1,347	1,239	1,085	1,393	1,556	1,902	1,957
São Paulo		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Solid biomass	PJ	-	-	775	904	948	942	809	872	956	883	951	937
Liquid and gaseous biomass	PJ	-	-	319	403	417	384	311	333	392	362	421	381
Total biomass	PJ	-	-	1,094	1,307	1,365	1,326	1,120	1,205	1,348	1,245	1,372	1,318
Woodchips	%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Woodbriquette	%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Firewood	%	-	-	10%	9%	8%	8%	9%	9%	8%	8%	7%	7%
Combustible waste	%	-	-	60%	60%	61%	63%	63%	64%	63%	63%	62%	64%
Liquid biogenic	%	-	-	25%	27%	27%	24%	23%	23%	25%	25%	27%	24%
Gaseous biogenic	%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other biogenic	%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Waste liquors	%	-	-	5%	4%	4%	5%	5%	4%	4%	4%	4%	5%
Electrical energy from biomass (incl. waste)	GWh	-	-	6,978	7,919	7,874	8,404	7,176	7,525	8,037	7,792	8,779	8,060
Landfill biogas	GWh	-	-	-	-	-	543	-	-	-	-	631	-
Firewood	GWh	-	-	1,140	1,151	989	1,000	954	1,012	965	919	896	837
Sugarcane Bagasse	GWh	-	-	3,233	4,047	4,222	4,198	3,559	3,861	4,292	3,954	4,303	4,222
Lixivium	GWh	-	-	2,605	2,721	2,663	2,663	2,663	2,652	2,780	2,919	2,826	3,001
Urban Solid Waste	GWh	-	-	-	-	-	-	-	-	-	-	123	-

Shandong		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Electrical energy from biomass (incl. waste)	GWh	-	140	-	-	-	311	435	610	853	1,200	1,532	-
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Solid biomass	PJ	-	-	-	-	-	-	43	42	40	43	42	-
Liquid and gaseous biomass	PJ	-	-	-	-	-	-	15	16	16	17	18	-
Total biomass	PJ	-	-	-	-	-	-	57	58	56	60	60	-
Woodchips	%	-	-	-	-	-	-	21%	24%	25%	24%	23%	-
Woodbriquette	%	-	-	-	-	-	-	5%	6%	7%	5%	5%	-
Firewood	%	-	-	-	-	-	-	17%	18%	21%	17%	18%	-
Combustible waste	%	-	-	-	-	-	-	26%	21%	14%	21%	19%	-
Liquid biogenic	%	-	-	-	-	-	-	8%	7%	8%	9%	9%	-
Gaseous biogenic	%	-	-	-	-	-	-	2%	3%	3%	4%	3%	-
Other biogenic	%	-	-	-	-	-	-	5%	4%	4%	4%	4%	-
Waste liquors	%	-	-	-	-	-	-	16%	17%	18%	17%	17%	-
Electrical energy from biomass (incl. waste)	GWh	576	857	940	914	984	1,019	981	1,012	960	891	967	-

Note: '-' : no data available

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.6.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of usage of biomass, the following research and development activities are taking place.

Table 3-20: Research and development activities with regard to bioenergy in selected RLS regions

Bavaria
According to the **Bavarian Energy Concept from 2011**, the Bavarian State Government made a commitment to intensify the research being done at government institutions on new energy plants being grown conventionally, which could be used supplementary or alternatively, as well as research towards optimization of the cropping systems. The comprehensive Bavarian research network of academic, non-university institutions and industrial partners active in the development and implementation of new technologies for the biogas production, storage and provision is able to represent the entire value-added chain. Demonstration plants, such as at the **Excellence Centre for Renewable Resources** (Kompetenzzentrum für Nachwachsende Rohstoffe) in Straubing, which has **Germany's largest cellulose-ethanol plant**, show the potential for the development of an industry which has superior opportunities for growth through sales of such systems internationally to agricultural intensive regions. Through the Excellence Centre for Renewable Resources in Straubing, the Bavarian State Government has brought together activities relating to renewable resources through **the Scientific Centre in Straubing** (WZS), **the Technology and Support Centre** (TFZ) and **C.A.R.M.E.N. e.V..** A specific need for research and development has been identified in the areas of: – Improved efficiency in the biomass production (cultivation) and conversion to energy. – Expansion of the scope of applications for the biomass gasification through the use of new raw materials or through new processes such as thermal gasification. – The efficient conversion of wet biomass rich in lignocellulose to solid energy carriers. – Reference facility for the competitive production of bioethanol from residual biomass. – Development of waste heat utilisation concepts for biogas plants. – Effective conversion from biogas to natural gas qualities. – Innovative and ecological logistic strategies for woods and plants as energy sources. **Combined heat and power plants** could contribute greatly to a highly efficient, cost-effective and decentralized energy supply in communities, the industrial sector, hospitals or in private residences. A specific need for research and development has been identified in the areas of: • Studies on increasing the energy efficiency of combined heat and power plants, on the use of biogenic fuels, regular energy provision, low temperature heat networks, gas turbines and alternative drivers. • Optimization of the energy generation by combined heat and power plants through the combination of multiple individual plants and the integration of thermal storage. • The use of industrial heat pumps to recapture industrial residual heat and use in local heating and district heating systems while considering volatile electricity prices. The connection to a Smart Grid is intended. • Development of a new means of fuel cell generation as a decentralized means to generate efficient energy (with the combination of electrolysis and fuel cells – see Sections 3.9 and 3.12). In order to expand the use of combined heat and power technologies, the Bavarian State Government intends to actively work towards improved framework conditions in cooperation with the amendments to the federal law on combined heat and power technologies. By working towards a general investment subsidy for the reconstruction of heating networks from heat steam to hot

water, which is foreseen to reduce the necessary temperature of heat offtake and therefore increase the electricity generated and reduce the heat losses in the pipeline system. In order to develop and to test the practicality of efficient concepts for the temporal decoupling for meeting the thermal and electrical demand by centralized combined heat and power systems, model projects will be carried out studying the use of centralized combined heat and power as peak-load heating plants, with the integration of thermal storage. It is also necessary to specifically fund highly efficient mini and micro combined heat and power systems in order to encourage market penetration of the technology and the joint decentralized generation of electricity and heat. The expansion of combined heat, cooling and power will be encourage in order to reduce the demand peaks on the electricity grid in the summer and to allow an efficient operation of the combined heat and power plants.

Québec

Many R&D centers and companies have been active in the past years to develop the biofuels industry in Québec. Grants have been allowed to many pilot and demo projects in the biofuels industry.

As of the **Plan d'action sur les changements climatiques** 2006-2012 (**PACC-1**), 135 M$ were avalaible to support GHG mitigation research & development and demo projects. Also a measure of the PACC-1, the ministère des Ressources naturelles et de la Faune (**MERN**) has financed since 2007 the activities of the Chaire industrielle sur l'éthanol cellulosique et les biocommodités of l'Université de Sherbrooke (**CRIEC-B**). This chair was created by the will of the MERN and the first Chairholder was Professor Esteban Chornet, former Université de Sherbrooke professor and cofounder of Enerkem. The purpose of the CRIEC-B is to **accompany the cellulosic and other renewable fuels and product industrials in Québec**. The same enveloppe has been available to **test cellulosic ethanol processes at demo scale (Enerkem/CRB Innovations)**.

The MERN also supports the non-profit organization **Bioénergie La Tuque** by financing its activities to understand well the biomass economically available in the area, develop new forestry approaches and logistics to improve the economics of exploiting the residual forest biomass and understand the impact of theses activities on the forest itself. The phase 2 of the project also aims at testing at pilote or demo scale the best biorefining processes availables.

FPInnovations, a private R&D center financed by the canadian forestry companies, the Chaire de recherche industrielle CRSNG-Total en modélisation hydrodynamique de procédés polyphasiques dans des conditions extrêmes of Polytechnique Montréal, BioEngine of l'Université Laval and the Chaire de recherche industrielle bioéconomie / bioénergie région of the Université du Québec à Trois-Rivières, Oleotek and Ceprocq are active research group in bioenergy.

Énergir, the largest natural gas distribution company in Québec, has set up a test bench for converting forest biomass into renewable natural gas in 2016. Following conclusive tests, the company is currently considering the construction of a pilot plant in Québec (https://www.energir.com/en/about/media/news/20160706/).

São Paulo

FAPESP

The Foundation for Research Support of the State of São Paulo is one of the main agencies promoting scientific and technological research in Brazil. With autonomy guaranteed by law, FAPESP is linked to the Department of Economic Development, Science, Technology and Innovation of the city's government.

The FAPESP Bioenergy Research Program (BIOEN), launched in 2008, aims to stimulate and articulate research and develop activities using academic and industrial laboratories to promote the advancement of knowledge and its application in areas related to the production of bioenergy in Brazil.

SPBioenRC

SP BIOEN Research Center (SPBioenRC) was created in 2009 through an agreement signed between São Paulo's State Government, FAPESP, Unicamp, Unesp and the University of São Paulo (USP).

Each university has adopted a different model to apply the resources. Unicamp created the Bioenergy Research Laboratory, Unesp formed the Bioenergy Research Institute (IPBEN), and USP, the Research Support Nucleus (NAP) in Cellular and Molecular Biology in Agriculture (Biocema), the

Biological and Industrial Processes for Biofuels (CeProBIO), Metabolomics Laboratory and The Biomass Systems and Synthetic Biology Center (BSSB). Under the SPBioenRC, an Integrated Bioenergy PhD's Program was created, offered by the three universities together (USP, Unicamp, Unesp) **GBio** The Bioenergy Research Group (GBio), created in 2015, is formed by the team of researchers that previously were part of CENBIO, the National Biomass Reference Center, created in 1996 at the University of São Paulo, at the Institute of Electrotechnology and Energy. Gbio develops studies for the analysis of technical and economic feasibility, as well as environmental and social aspects of various types of bioenergy: ethanol, biodiesel, energy utilization of agroindustrial, rural and urban waste, life cycle analysis and externalities of processes related to bioenergy.	
Upper Austria	
The Combined Agro-Forest Biorefinery **(CAFB)** project at the **Energy and Environment Research Center Wels** (University of Applied Sciences Upper Austria) produces fuels such as butanol and ethanol as well as other recoverables. The **Institute for Chemical Technology of Organic Materials at the Johannes Kepler University of Linz** is conducting research on high pressure biotechnology using extremophiles to generate CH_4 from CO_2. The research project **GRASSFinery** with the involvement of the **Energieinstitut at the JKU Linz** focuses on the biorefinery process to gain amino acids, lactic acid and sugar out of grass silage at an industrial scale. The waste streams of the product finishing process are exploited at a biogas plant to gain thermal and electrical energy.	
Western Cape	
Development of an internationally certified **Biogas Testing Facility** is underway at SU to provide industry with reliable data on the water reclamation and energy potential of their wastes and ensure that successful commercial projects can be developed based on reliable energy output estimates. The **Chemical Engineering** Department of the Cape Peninsula University of Technology has a focus on waste to energy system analysis and design.	

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.7 Biofuels

Biofuels are defined as fuels which are generated directly or indirectly from biomass and can be solid, gaseous, or liquid. Regarding the global energy demand, traditional unprocessed biomass such as fuelwood, charcoal, and animal feces represent the central energy source in many developing and poor countries, especially in Africa and Asia. More advanced and efficient transformation technologies allow the production of biofuels from materials such as wood, crops, and waste material. Biofuels may be produced from forestry, agricultural, or fishery products or municipal wastes, as well as from agro-industry, food industry, and food service by-products and wastes. A distinction is made between primary, secondary, and tertiary biofuels. Primary biofuels are used in their organic form for heating, cooking, or electricity production. Secondary biofuels are generated via the transformation of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes. Tertiary biofuels are based on integrated technologies that produce feedstock as well as fuel and require the destruction of biomass.

3.7.1 Regional policy frameworks and targets

Table 3-21: Regional policy frameworks and targets for biofuels in selected RLS regions

Bavaria
Target for Germany: 20% renewable fuels sources by 2020, an increase from 6.8% in 2015 With the implementation of the **Directive 2009/28/EG of the European Parliament and the Council on the promotion of the use of energy from renewable sources** on June 25 2009, the first target was set for the European Union as a whole to raise the proportion of renewable energy sources to 20% of the total energy consumption by the year 2020, as well as achieving a proportion of at least 10% renewables in the transportation sector. In light of this goal, the German Federal Government has set subgoals to reach a proportion of energy from renewable sources by 2020 of 30% of electricity consumption, 14% in the heating sector and 12% of fuel consumption. These targets for electricity and heating have already been reached in Bavaria. According to the **Bavarian Energy Concept of 2011**, the Bavarian State Government committed to the following measures: • The continuation of the 85-Initiative through **C.A.R.M.E.N. e.V**. and other Bavarian specialist agencies. • The continuation and expansion of the **Research Network for Biogenic Fuels (ForNeBiK)** at the Centre of Excellence for Renewable Resources in Straubing, as an initiative linking research institutes in Germany, Austria and Switzerland in the area of biogenic fuels. • An informational campaign about biogenic fuels coordinated with the federal government activities, especially regarding E10-Fuels, in order to develop a positive perspective towards biogenic fuels through the adherence to ambitious sustainability criteria. • The implementation of incentives for an increased use of fuel from rapeseed oil in Bavarian agriculture. As of 2016, there were no LNG terminals present in German harbors. The first LNG fueling stations for heavy goods vehicles opened for business at the end of 2016. Further, to provide for the LNG supply for heavy goods vehicles, There is a target of initiating a basic network of fueling stations along the **trans-European transport network (TEN-V)** in order to allow for pan-European traffic of LNG trucks. Studies have shown that an adequate basic network can be sufficient with minimal (less than 10) locations along the TEN-V core network.

According to the **Bavarian Energy Concept**, the State Government will work opposite of the gas market in order to ensure that Europe has **sufficient infrastructure available for liquefied natural gas (LNG)** in order to allow for LNG supply to Germany and Bavaria. It also **supported the construction of an LNG terminal on the Adriatic.**

Québec

In November 2009, the **Gouvernement du Québec** set its GHG emission reduction target to 20 % below its 1990 level by 2020. According to the Suzuki Fundation, this is the most ambitious target in North America. This target was taken to 37,5 % below the 1990 level by 2030, in November 2015.

The Gouvernement du Québec also aims at **banning the elimination of organic matters by 2022**.

The Government du Québec released in April 2016 his latest energy policy, la Politique énergétique 2030 (**PE2030**). The PE2030 aims at reducing the amount petroleum products consumed by 40 %, increasing the renewable energy output by 25 %, including a **50 % increase of bionergy production**. Thermal coal use will also be eliminated.

The **2017-2020 Action Plan of the PE2030 has many measures related to bioenergy:**

- Action 5 supports energy innovation projects
- Action 14 establishes a regulation requiring minimal renewable content of 2 % in diesel and 5 % in gasoline consumed in Québec and plans a gradual increase of these requirements
- Action 16 supports the conversion of fuel oil heating systems to other forms of energy
- Action 19 supports the conversion to or acquisition of equipment that operates using cleaner forms of energy than fuel oil
- Action 24 supports innovative, structuring green energy projects using the Capital Mines Énergie fund (objective of 3 projects finances by 2020)
- Action 36 helps financing organic matter biomethanation projects
- Action 37 sets the adoption of a regulation establishing 5 % as the minimum proportion of renewable natural gas that Québec natural gas distributors must inject in their distribution network for clients in Québec

Action 38 aims to help finance the construction of biofuel demonstration plants

São Paulo

São Paulo State Energy Plan - PPE / 2020

The main goal of the São Paulo State Energy Plan - PPE / 2020 - is enable the Government of the State of São Paulo to define public policies to keep a safe energy supply regarding the energy demand envisaged for 2020.

The goals for the transportation sector are:

- 90% of new Otto vehicles flex running 90% of the time with ethanol;
- Maintenance of the percentage of anhydrous ethanol in gasoline C;
- Adoption of B10 (addition of 10% biodiesel to traditional diesel);
- Public transportation bus fleet in the capital and metropolitan regions operating with biodiesel;
- Expansion of the rail transport in the metropolitan region according to the Metropolitan Transportation Department (STM) planning;
- Implementation of the Tourism Development Master Plan (PDDT) changing the structure participation of modalities (waterway from 0.5% to 5%, railroad from 8.1% to 20%, pipeline from 1.6% to 5%) ;
- Transportation planning and management reducing empty journeys from 46% to 36%.

Decree nº 59.038/2013

The Decree nº 59.038, of 04/03/2013, establishes the State's Program for Biofuels, with the purpose of encouraging and expanding the participation of renewable fuels within the scope of direct administration, counties and foundations of the State of São Paulo

ANP

The National Agency of Petroleum, Natural Gas and Biofuels, ANP, created in 1997 is the regulatory agency of activities that integrate the oil and natural gas and biofuels industries in Brazil.

Currently, two types of biofuels are produced in large scale in São Paulo, Ethanol and Biodiesel.

The **Ethanol's regulatory framework** is:

ANP Resolution n ° 19, of 04/15/2015
It establishes the specifications of Anhydrous Fuel Ethanol and Hydrated Fuel Ethanol, and the quality control obligations by the economic agents who commercialize the product in the national territory.
ANP Resolution nº 696, of 08/31/2017
It makes mandatory the analysis of the methanol content in fuel ethanol by suppliers of fuel ethanol and distributors of liquid fuels.
ANP Resolution nº 23, of 07/07/2010
It establishes the specifications of fuel ethanol or reference ethanol for fuel consumption evaluation and vehicle emissions for motor vehicles approval.
The **Biodiesel's regulatory framework** is:
ANP Resolution nº 30, of 06/23/2016
It Establishes BX to B30 diesel specification.
ANP Resolution nº 45, of 08/25/2014
It establishes the specification of biodiesel and the quality control obligations by the economic agents that commercialize the product in the national territory.
Law nº 13.263, of 23.3.2016
Provides the biodiesel's percentage that must be added to the diesel sold in the national territory.
Schedule of biodiesel's increase content from 2017:
• Until March 2017 - 8%
• Until March 2018 - 9%
• Until March 2019 - 10%

Upper Austria

In the year 2015 about 5.1 PJ biogenic fuels were used in Upper Austria, this is equatable to 7.6 % of the total fuel consumption. Important for achiving this amount was the implementation of the **EU directive on the promotion of the use of biofuels or other renewable fuels in the transport sector**. If electric mobility is taken into account (including the iron, road and cable car, etc.), the share of renewable energy is 10.1%

Western Cape

Initial policies and regulations to promote the blending of biofuels in South Africa have stalled. This is to a large extent due to the price of fossil fuels, which make biofuels not cost competitive, and the resulting subsidies and incentives that would be required prohibitive to the national fiscus.
The national **Department of Science** has however funded the development of an online **Bioenergy Atlas for South Africa** which indicates the biomass availability for different types of biomass in a geographically explicit format. The Bioenergy Atlas is available at http://bea.dirisa.org/

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

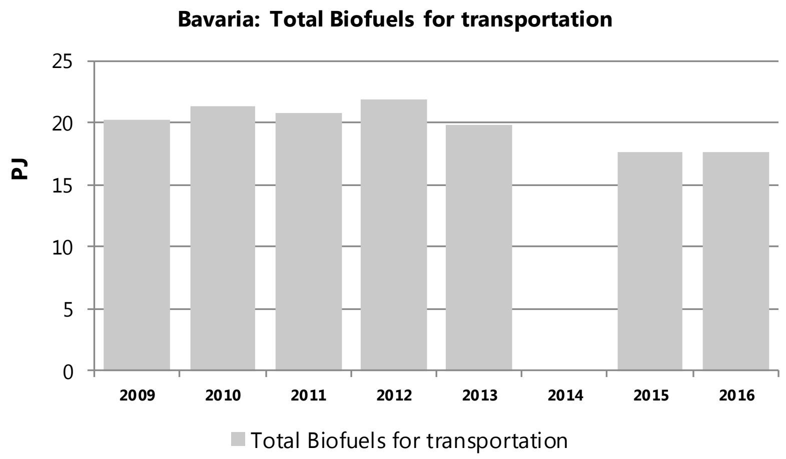
3.7.2 Status quo

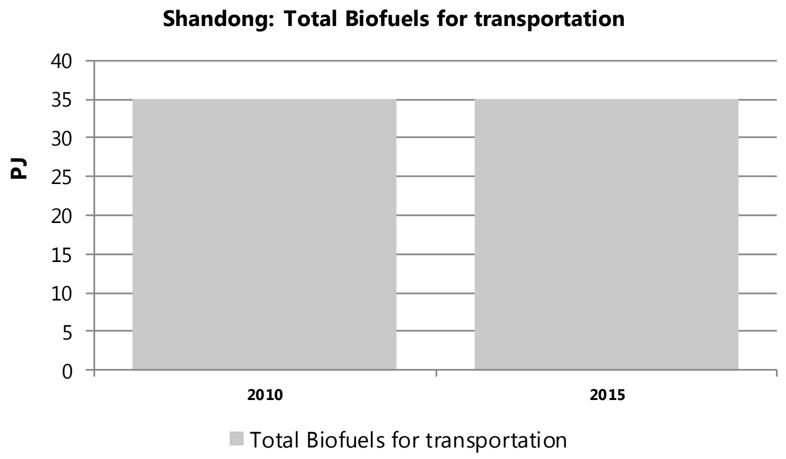
The share of renewable fuels in the field of transportation and mobility was 4 % in Bavaria and amounted to 18 PJ in 2016. The share of renewable fuels shall increase drastically over the next years - by 2020, an amount of 19 % is planned to be reached. In Québec, the consumption of ethanol in the transport sector was about 10 PJ in the year 2014. The production amounted to 4 PJ in the year 2017. Since 2007, Québec has one corn-ethanol plant operating. Furthermore, Québec has 2 cellulosic demo plants - one using thermochemistry (Enerkem) and one using chemical fractionation and fermentation (CRBI). GreenField Global also works on second generation ethanol. The usage of LNG/CNG (liquefied and compressed natural gas) has increased significantly over the last years. While it was 0.1 PJ in 2012, it amounted to ca. 10 PJ in 2017. For Shandong, the usage of LNG is a future topic. The amount of LNG is planned to be 23.4 PJ by 2020 and 27.6 by 2030. The total amount of biofuels for transportation is planned to be 35 PJ, which is equal to the current amount. In Upper Austria, the addition of biofuels to non-renewable fuels increased significantly. In 2005, the share of renewable was around 0.6 % (369 PJ), in 2015 it amounted to7.6 % 5,100 PJ). Furthermore, there are developments in the LNG sector: Currently, one LNG station is in operating in Upper Austria and 0.04 PJ of LNG is gained. The implementation of an additional LNG production station in Upper Austria is planned for the next years. In São Paulo, the share of renewables in the field of transportation was 26 % in the year 2016. A big enhancement is planned over the next years: By 2020, the share of renewables is planned to be 46 %. This corresponds to 567 PJ of biofuels, in terms of ethanol and biodiesel.

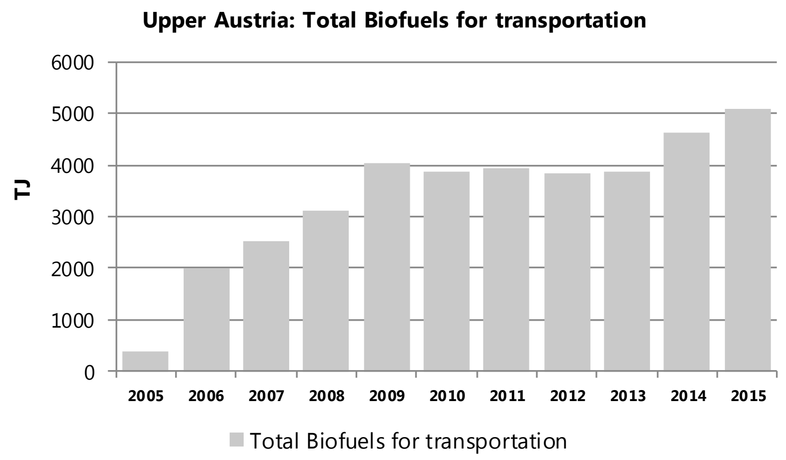
In the Western Cape, given the stalling of national policy frameworks for biofuels, there are no large scale biofuels facilities in the region, although an assessment of the biofuels potential has been done and an academic study has been done by the University of Stellenbosch on the financial viability of large scale ethanol production from triticale. There are a few companies producing biodiesel from waste fats and oils, but these companies are marginal and/or sell to niche buyers as biodiesel is not cost competitive compared to fossil alternatives. The focus was on incubating the industry to a 2% biofuels penetration level and encouraging the use of agricultural feedstocks from currently underutilised lands. The proposed blending ratio for South Africa was B2 or 2% biodiesel and E8 or 8% Bioethanol blends. Proposed plants for Bioethanol were sugar cane and sugar beet whilst soya bean, canola and sunflower were proposed for Biodiesel. The option of enforcing or mandating biofuels uptake in the initial phase was not favoured. Mandatory off-take could be introduced only when security of biofuels supply could be guaranteed. Only biofuels production happening is with non-commercial scale biodiesel producers that process used cooking oil into biodiesel (not part of the grander biofuels strategy). Currently only these small scale biodiesel producers are blending, the percentage penetration is negligible.

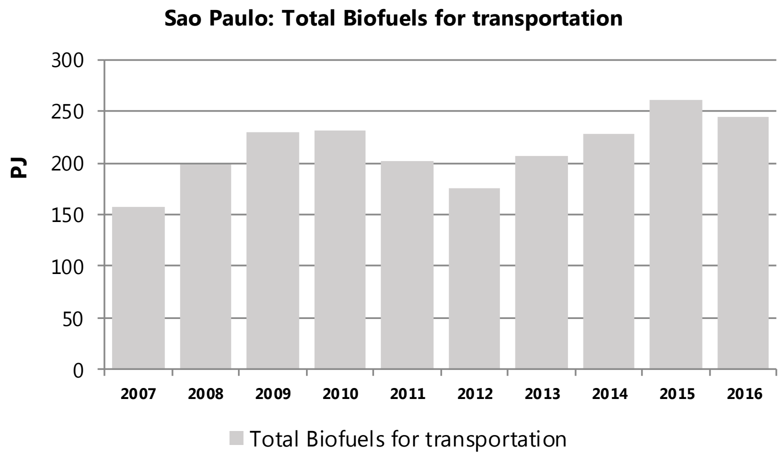
Biomass is not used at scale for energy production in the Western Cape, although biomass (wood and waste wood) is used as cooking fuel in less affluent residents, with attendant environmental and health impacts. At the industrial scale biomass boilers, primarily using waste wood, are gaining some traction with at least two known installations (one at a bakery and one at a printing company). In the Eden district of the Western Cape there are also several biomass boilers operating at sawmills.

Figure 3-11: Usage of biofuels for transportation in selected RLS regions



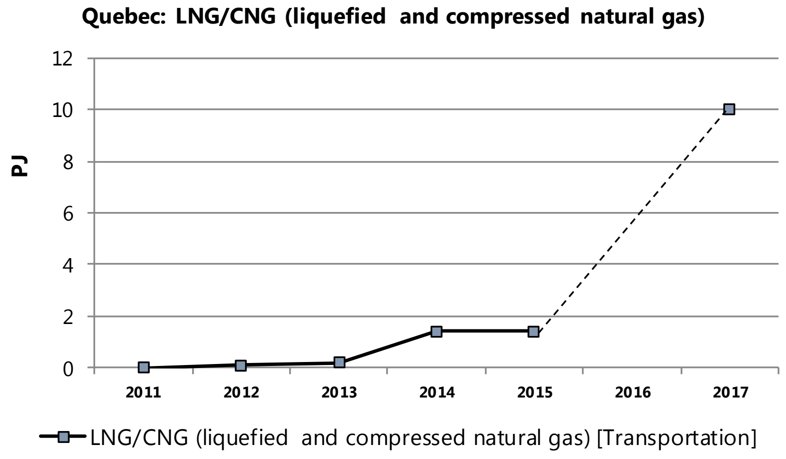


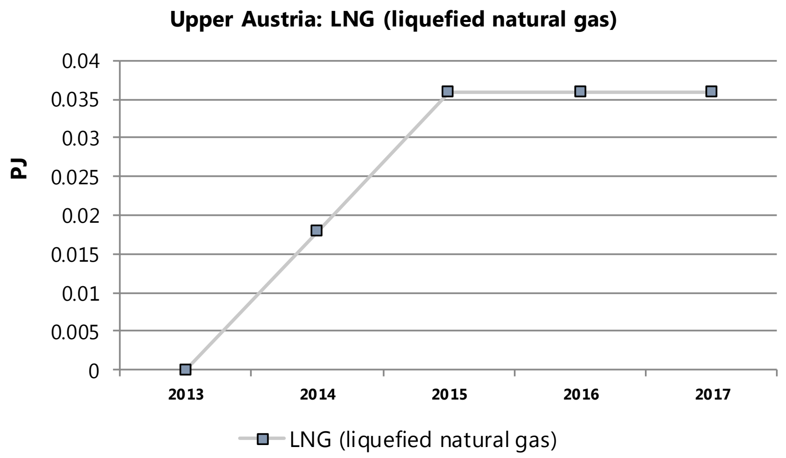




Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

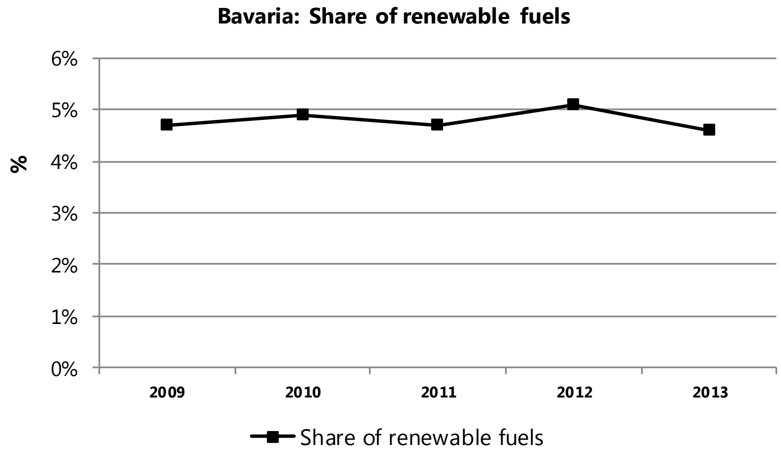
Figure 3-12: Usage of LNG resp. CNG in selected RLS regions

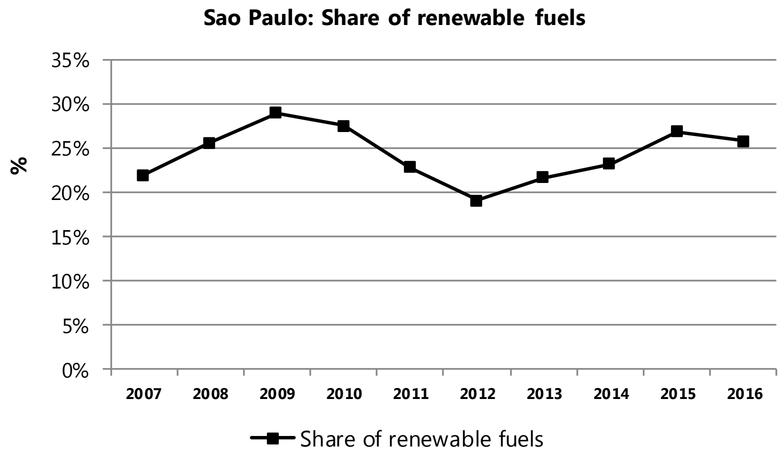




Source: *Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)*

Figure 3-13: Share of renewable fuels of total fuels in transportation in selected RLS regions





Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-22: Usage of biofuels for transportation, LNG/CNG and share of renewable in selected RLS regions

Bavaria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total Biofuels for transportation	PJ	12	-	-	-	20	21	21	22	20	-	18	18	-
Share of renewable fuels	%	3.4%	-	-	-	4.7%	4.9%	4.7%	5.1%	4.6%	-	-	-	-
Québec		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
LNG/CNG (liquefied and compressed natural gas) [Transportation]	PJ	-	-	-	-	-	-	-	0.1	0.2	1.4	1.4	-	10
Shandong		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total Biofuels for transportation	PJ	-	-	-	-	-	35	-	-	-	-	35	-	-
São Paulo		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total Biofuels for transportation	PJ	-	-	158	199	230	232	202	176	207	229	261	244	-
Share of renewable fuels	%	-	-	22%	26%	29%	28%	23%	19%	22%	23%	27%	26%	-
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total Biofuels for transportation	TJ	369	1,982	2,525	3,110	4,023	3,883	3,923	3,854	3,878	4,632	5,100	-	-
LNG (liquefied natural gas)	PJ	-	-	-	-	-	-	-	-	-	0.02	0.04	0.04	0.04

Note: '-' : no data available
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.7.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of biofuels, the following research and development activities are taking place.

Table 3-23: Research and development activities with regard to biofuels in selected RLS regions

Bavaria
Among the **bioenergy and biofuel pilot and demonstration plants** in Bavaria, there is research being done about the applications of **lignocellulose biomass** in the production of **bioethanol, hydrogenated plant oils** and **BtL** (biomass to liquid). One example is the demonstration plant of **Südchemie AG** in Straubing which produces bioethanol, as well as the development of the **Fraunhofer Project Group "BioCat,"** both supported by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology. Support is also being given by the Bavarian State Government for research at the Technology and Support Centre of the Centre of Excellence for Renewable Resources on the reduction of emissions produced by solid biomass fuels, as well as increased applied research on the topic of energy efficiency and low emission wood gasification.
Québec
Many R&D centers and companies have been active in the past years to develop the biofuels industry in Québec. Grants have been allowed to many pilot and demo projects in the biofuels industry. As of the **Plan d'action sur les changements climatiques** 2006-2012 (**PACC-1**), 135 M$ were avalaible to support GHG mitigation research & development and demo projects. Also a measure of the PACC-1, the ministère des Ressources naturelles et de la Faune (**MERN**) has financed since 2007 the activities of the Chaire industrielle sur l'éthanol cellulosique et les biocommodités of l'Université de Sherbrooke (**CRIEC-B**). This chair was created by the will of the MERN and the first Chairholder was Professor Esteban Chornet, former Université de Sherbrooke professor and cofounder of Enerkem. The purpose of the CRIEC-B is to **accompany the cellulosic and other renewable fuels and product industrials in Québec**. The same enveloppe has been available to **test cellulosic ethanol processes at demo scale (Enerkem/CRB Innovations)**. The MERN also supports the non-profit organization **Bioénergie La Tuque** by financing its activities to understand well the biomass economically available in the area, develop new forestry approaches and logistics to improve the economics of exploiting the residual forest biomass and understand the impact of theses activities on the forest itself. The phase 2 of the project also aims at testing at pilote or demo scale the best biorefining processes availables. **FPInnovations**, a private R&D center financed by the canadian forestry companies, the Chaire de recherche industrielle CRSNG-Total en modélisation hydrodynamique de procédés polyphasiques dans des conditions extrêmes of Polytechnique Montréal, BioEngine of l'Université Laval and the Chaire de recherche industrielle bioéconomie / bioénergie région of the Université du Québec à Trois-Rivières, Oleotek and Ceprocq are active research group in bioenergy. **Énergir**, the largest natural gas distribution company in Québec, has set up a test bench for converting forest biomass into renewable natural gas in 2016. Following conclusive tests, the company is currently considering the construction of a pilot plant in Québec (https://www.energir.com/en/about/media/news/20160706/).
São Paulo
At the University of São Paulo (**USP**), there are two laboratories dedicated to study and research of biofuels, the **Biofuels Development Laboratory**, in the Institute of Energy and Environment (**IEE**) and the **Laboratory of Biofuels and Applied Chemistry (LaBiQA / ZEB)** in the Department of Animal Science and Food Engineering.

Upper Austria
The Combined Agro-Forest Biorefinery **(CAFB)** project at the **Energy and Environment Research Center Wels** (University of Applied Sciences Upper Austria) produces fuels such as butanol and ethanol as well as other recoverables. The Energieinstitut at the JKU Linz is working at the EU project **SUNLIQUID**. The aim of this project is to confirm the commercial maturity of the sunliquid® process for the production of cellulosic ethanol from agricultural residues - an advanced, sustainable and climate-friendly biofuel. Since 2012, the technological maturity of the process has been demonstrated in a prototype plant.
Western Cape
Biofuels research in the Western Cape is centred on the **Department of Microbiology, Stellenbosch University**, together with a team of core members from the **Department of Process Engineering at Stellenbosch** and the **Department of Chemical Engineering at University of Cape Town**. The focus is on technological interventions required to develop commercially-viable value chains for 2nd generation biofuels in South Africa, and elsewhere. Specific research is being done on the production of cellulosic biofuels via biochemical and thermo-chemical conversion, model integrated bio-refineries for biofuels and high-value chemicals production and assist in applying these technologies through costs and life-cycle analyses to evaluate the environmental and economic impacts of these technologies. Some of the focus areas of the **Chemical Engineering Department at SU** are biochemical conversion of biomass and organic wastes into fuels and chemicals ; pyrolysis processing of biomass and organic/carbonaceous wastes; biorefineries for foods, fuels and chemicals from biomass and organic wastes; bioprocess development with microbial and enzymatic systems.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.8 Hydropower

Technology description[10]

Hydropower is energy generated from flowing water whereas its basic principle is using water to drive turbines. Hydropower is an extremely flexible electricity generation technology and provides also other key services, such as flood control, irrigation and potable water reservoirs. Hydropower plants contain two main components: with dams and reservoirs, or without (run-of-the-river scheme). Hydropower dams with a reservoir can store water over time to meet peak demand. The components can also be separated into smaller dams for different purposes, such as night or day use, seasonal storage, or pumped-storage reversible plants, for both pumping and electricity generation. Hydro reservoirs provide built-in energy storage that enables a quick response to electricity demand fluctuations across the grid, optimization of electricity production and compensation for loss of power from other sources. Special attention is now paid to pumped hydropower plants as they are at present the most competitive options for large-scale energy storage to be used in combination with variable renewables (e.g. solar and wind power). Hydropower without dams and reservoirs induces a generation at a smaller scale, normally from a facility designed to operate in a river without interfering in its flow.

3.8.1 Regional policy frameworks and targets

Table 3-24: Regional policy frameworks and targets for hydropower in selected RLS regions

Bavaria
According to the **Bavarian Energy Concept** of the Bavarian State Government (2011), in order to achieve the targeted growth in electricity generation from hydropower (excluding pumped storage hydro power stations) to reach approximately 14.5 billion kWh per year by 2021 (17% of the electricity consumption in Bavaria), the potential contribution through the expansion of environmentally sustainable hydropower through new construction, refurbishment and retrofitting of existing plants an additional 1 billion kWh of electricity could be produced annually. It further expresses support for the authorities responsible for the approval of the use of hydropower throught clear political targets towards an intensified hydropower utilization, including the sustainable development of new hydropower plants. It intends to encourage new hydropower technologies, especially the further development of shaft power plants, as well as supporting the installation and expansion of innovative, environmentally sustainable hydropower plants, which would otherwise not be economically feasible.
Upper Austria
The implementation of additional water power plants and improvement of the efficiency of existing ones is a measure mentioned in the **Upper Austrian Energy Strategy 2050**. In 2015, a **potential analysis for water power in Upper Austria** estimated and evaluated the potential for the energetic revitalization and expansion in environmentally friendly locations in medium and larger waters in Upper Austria. Criteria were defined to divide between very sensitive, sensitive and less sensitive river sections in (partial) river areas. The results show that there are currently very intensive uses –

[10] based on the definition of International Renewable Energy Agency and U.S. Energy Information Administration

48% of the processed waterways are already used for energy purposes, which corresponds to a potential use of around 80%. After an ecological assessments, an energy economic quantification of ecologically compatible and sustainably exploitable expansion potential was carried out. In the entire treated area, 48% of the watercourse length is already characterized by energy use in the form of congestion or diversion. A total of 513.5 of 1,240 river kilometers or 41.4% of the water network is very sensitive, where additional energy use is by definition not compatible with aquatic ecology. 24% of this very sensitive areas are already used. Sensitive rated routes occur on a length of 349 river kilometers or with a share of 28% of the worked water network. The existing degree of utilization in the sensitive areas is about one third. By definition, additional energy uses are possibly ecologically acceptable under special conditions. Less sensitive watercourses, where additional energy uses are generally compatible with aquatic ecology, are only 25 of 1,240 river kilometers resp. 2%. About 30% of this less sensitive areas are used for hydro power generation. The quantification of the expansion potential at sensitive and less sensitive areas came to the result of an expansion resp. new construction potential of 114 GWh. The potential for optimization (increase in the amount of extraction water, turbine replacement) of existing hydro power plants is 374 GWh. **This results in a cumulative expansion and optimization potential of 488 GWh.** Due to the ecological conditions, protection aspects such as hydromorphologically very good routes, particularly protected areas and the EU water guideline, as well as the already high level of expansion, the ecologically compatible expansion potential is with 114 GWh legally limited for Upper Austria. With 374 GWh, however, relatively high ecologically sound growth potential would still be possible for the existing hydropower plants, since the natural hydropower potential is often not used optimally in terms of energy management (predominantly for older plants). There are regulations for hydro power plants in the **Green Electricity Act 2012**. Small hydro power plants are subsidized by higher feed-in tariffs and large hydro power plants with more than 10 MW capacities get power purchase agreements with tariffs of the market prices.
Western Cape
The management of water supplies in South Africa has developed into a science to ensure that it is used to its full potential and to this end, unique partnerships have developed between Eskom and the Department of Water Affairs. In the **2010 Integrated Resource Plan** (which will soon be updated), the main source of hydropower will come from imported electricity (5.2 GW by 2030), while local, small-scale hydropower shares an allocation of 125 MW with landfill gas-based electricity. Irrespective of the size of installation, any hydropower development will require authorisation in terms of the National Water Act 1998, Act 36 of 1998. The Southern African Power Pool (SAPP) allows the free trading of electricity between Southern African Development Community (SADC) member countries, providing South Africa with access to the vast hydropower potential in the countries to the north, notably the significant potential in the Congo River (Inga Falls). Global pressures regarding the environmental impact and displacement of settlements by huge storage dams will likely limit the exploitation of hydropower on a large scale.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.8.2 Status quo

In Bavaria, electricity production from hydropower amounts to 13,400 GWh in 2016. Currently, there exist 67 large hydropower plants and 4,130 small hydropower plants (capacity up to 10 MW).

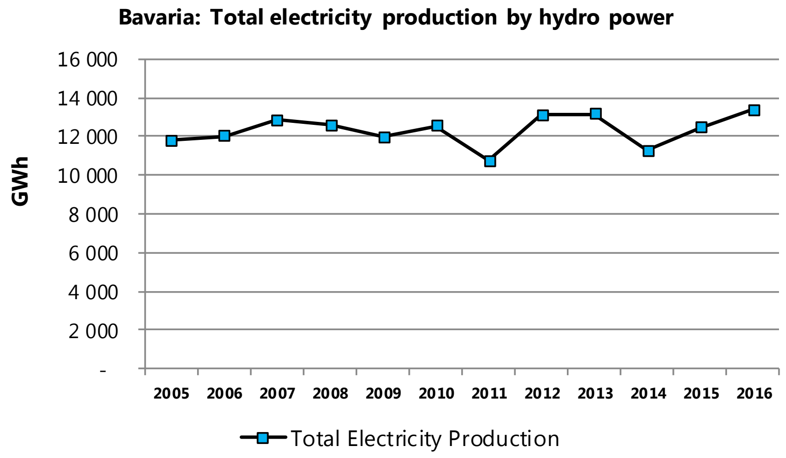
Québec has vast hydraulic resources in the form of some 500,000 lakes and 4,500 rivers. This wealth offers enormous hydroelectric potential. In 2015, the electricity produced in Québec accounted for 32 % of Canada's total power generated from all sources, but was responsible for only 1 % of GHG emissions linked to electric utilities. In 2017, Hydro Québec allocated $402 million to refitting and refurbishing generating stations and structures. Investments in the transmission system are also taking place. Hydro Québec's 2017 investments totalled $1,971 million, of which $569 million went to growth projects and $1,402 million to asset sustainment and reliability projects.

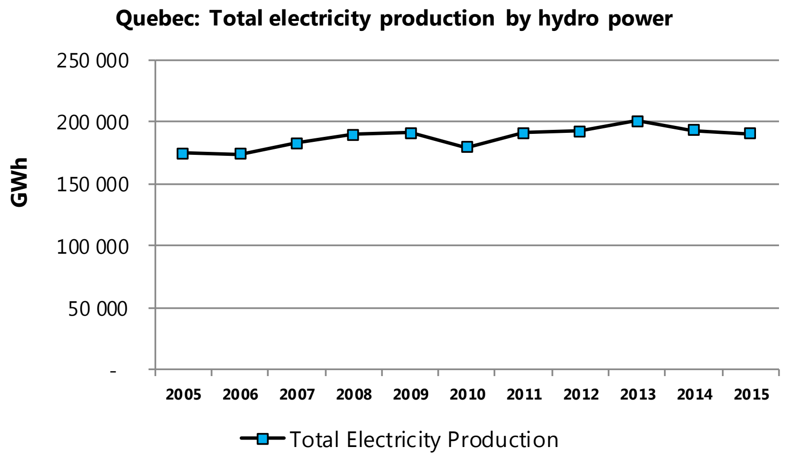
In Upper Austria, electricity production from hydropower is about 9,000 GWh per year and after biomass quantitatively the most important domestic source of energy. There exist 28 large hydropower plants and 676 small hydropower plants (capacity up to 10 MW) with a bottleneck capacity of over 150 MW and a regular work capacity greater than 700 GWh. There are around 900 hydropower plants (including also micro hydropower plants). Currently, there is the Bad Goisern hydropower plant (2.6 MW / 13 GWh, trial operation from February 2017). With regard to the total electricity consumption in Upper Austria, about 5% comes from small hydropower. Over the last 14 years, about 260 small hydropower plants have been modernized within the Upper Austrian electricity funding program and according to the regulations of the federal state electricity law. Thus, the power generation of these plants could be increased by more than 40 % on average and in total about 80 GWh per year of additional green electricity have been generated from small hydropower.

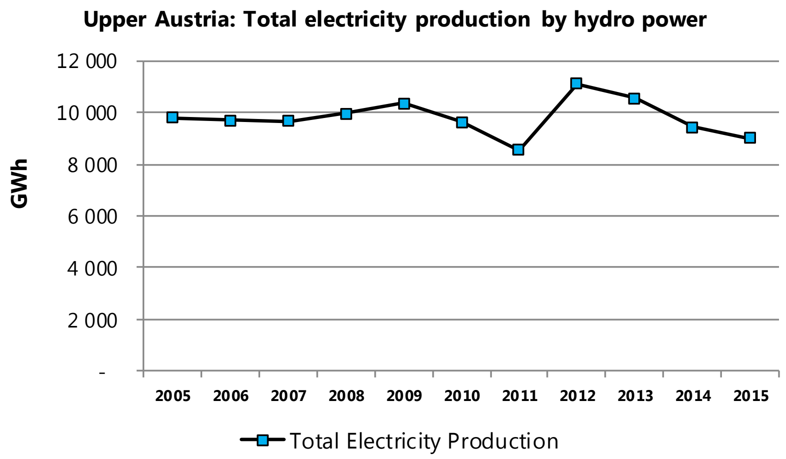
In the Western Cape, there are two hydro-electric systems. One is a 180MW pumped storage scheme situated at the Steenbras dam; the other is the 400MW Palmiet Pumped Storage Scheme, which transfers water from the Palmiet River catchment to Cape Town. Palmiet is located in the Kogelberg Biosphere Reserve, the heart of the Cape Floral Kingdom and the first biosphere in South Africa. Eskom was a signatory to the application for biosphere status from UNESCO and is committed to upholding the principles of MAB (Man and Biosphere) in supporting the biodiversity of this unique fynbos region. There are also smaller hydropower sites in the Western Cape: a 300 kW mini hydro plant in Clanwilliam; 700kW at Blackheath Water Treatment Plant; 1.475 MW at Faure Water Treatment Works; and 260 kW at Wemmershoek Water Treatment Works.

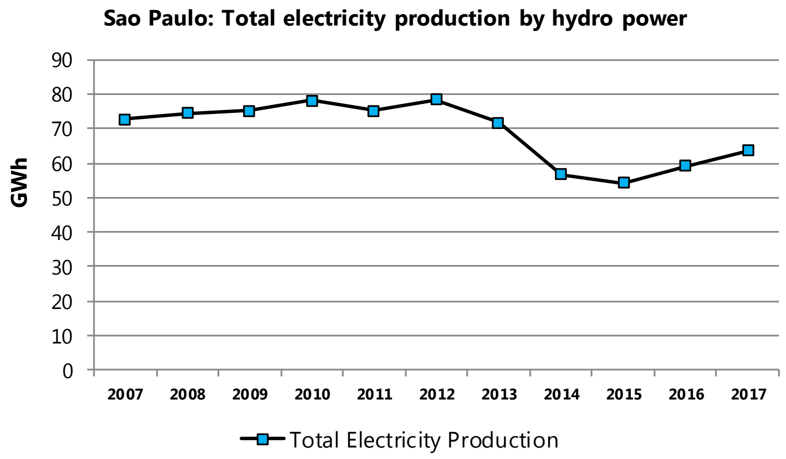
In São Paulo are 48 large hydropower plants existing, which produced 62,280 GWh in 2017. The other 40 small hydro power plants with a capacity up to 10 MW generated 1,389 GWh at this year. For the future an increase of hydro power is planned, by 2020 about 70,080 GWh and by 2030 approximately 73,093 GWh of electricity shall be generated.

Figure 3-14: Electricity production by hydropower in selected RLS regions









Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-25: Number of hydropower facilities and hydropower-generated electricity in selected RLS regions

Bavaria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total electricity production	GWh	11,779	12,031	12,837	12,577	11,987	12,531	10,741	13,112	13,143	11,260	12,459	13,400
Large hydropower plants	#	-	-	-	-	-	-	-	-	-	-	61	67
Small hydropower plants	#	-	-	-	-	-	-	-	-	-	-	4,114	4,130
Québec		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total electricity production	GWh	175,090	174,313	182,860	189,523	191,510	179,314	191,048	192,325	200,828	193,483	190,501	-
Large hydropower plants	#	79	81	82	83	85	86	87	87	89	90	92	92
Small hydropower plants	#	75	75	75	75	76	76	78	79	79	79	79	79
Upper Austria		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total electricity production	GWh	9,813	9,709	9,672	9,967	10,372	9,632	8,556	11,120	10,549	9,437	9,006	-
Large hydropower plants	#							28	28	28	28	28	
Small hydropower plants	#							640	650	660	660	676	682

Note: '-' : no data available; large hydropower plants comprise a capacity greater than 10 MW; small hydropower plants comprise a capacity greater than 10 MW
Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.8.3 Research & development activities

Within the RLS partner regions, which were evaluated in this report in detail with respect to the regional role of hydropower, the following research and development activities are taking place.

Table 3-26: Research and development activities with regard to hydropower in selected RLS regions

Bavaria
Hydropower is of great importance in Bavaria, not only because of the targeted 17% provision of electricity consumption by 2022, but also for its potential to balance out the instability and peak created through an increased reliance on renewable energies. A specific need for research and development has been identified in the areas of: • **New power generating systems, automation and cooling systems.** • **Development of generators and in-stream turbines which allow for a decentralized use of hydropower without disturbing the river systems.** • **New technologies for small hydropower plants and for the restoration of aging small hydropower plants in order to increase energy output.**
Upper Austria
The aim of the **Connect_Hydro** project is to generate a new intelligent networking system for small hydropower plants. It incorporates current power plant data from a chain of small hydro power plants on a river and allows for optimal overall control a joint regulation instead of a pure singular control. The Energy Institute is involved at this project.
Western Cape
Centre for Renewable and Sustainable Energy Studies (CRSES) at SU acts as a central point of entry into Stellenbosch University for the general field of renewable energy, including hydro energy at a smaller scale. Some contract research projects are completed within CRSES while others are done by academic departments or research entities of the university. **Microhydropower.net** is an online database developed by renowned international expert, Wim Jonker Klunne, covering most activity within South Africa.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.9 Hydrogen & fuel cells

Technology description[11]

Hydrogen can be derived from hydrocarbons through the application of heat. This process is known as reforming. Nowadays, most hydrogen is produced this way from natural gas. An electrical current can also be used to separate water into its components of oxygen and hydrogen. This process is known as electrolysis. Hydrogen is a flexible energy carrier that can be generated from any regionally prevalent primary energy source. Furthermore, it can be converted into any form of energy for diverse end-use applications. Hydrogen is mostly well suited for usage in fuel cells that efficiently use hydrogen to produce electricity. A fuel cell uses hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both technologies transform the energy produced into electric power via a chemical reaction. Though, the fuel cell will generate electricity as long as hydrogen is provided, never losing its charge.

As an energy carrier, hydrogen can create new connections between energy supply and demand. This can occur in centralized or decentralized ways, so that the overall energy system flexibility is improved. By linking different energy transmission and distribution networks, sources of low-carbon energy can be linked to end-use devices in transport, industry and building that are facing the challenges of decarbonization. In isolated areas with little access to the power grid, these linkages can increase off-grid access to energy services while minimizing emissions. Primarily, it will be generated within existing energy systems based on different conventional primary energy carriers and sources. In the longer term, renewable energy sources will become the most important source for the production of hydrogen. Green hydrogen and hydrogen produced from fossil-based energy conversion systems with capture and storage (sequestration) of CO_2 emissions are nearly entirely carbon-free energy concepts.

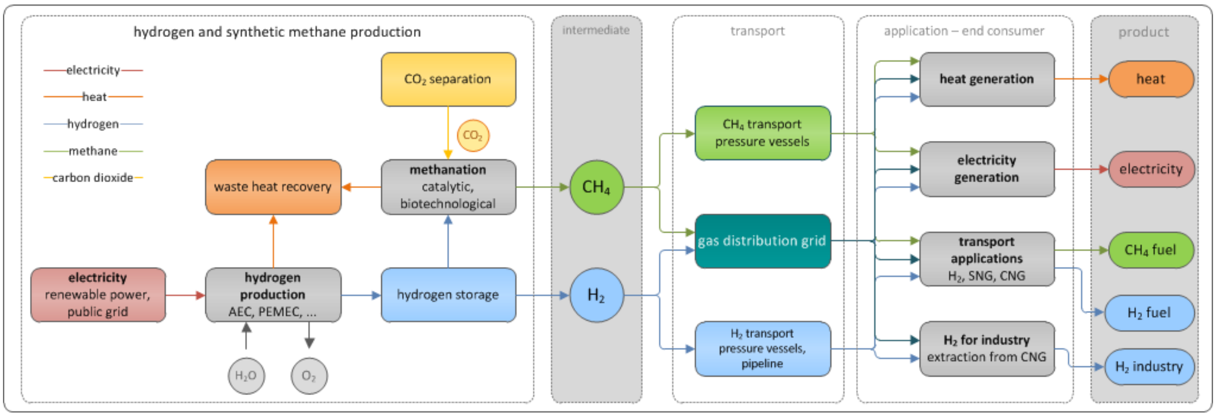
Focus on power-to-gas research

Electrolysis is the key component in the power-to-gas approach. In power-to-gas processes, renewable electrical power is converted into gaseous energy and in that form is easily transportable and storable. Furthermore, gaseous energy can be utilized in various ways. Depending on the used electrolyte it can be differentiated between alkaline (AEC), proton exchange membrane (PEMEC) and solid oxide (SOEC) electrolysers. Both, alkaline and PEM electrolysers, have a system efficiency between 60 % and 80 %. The key challenges for this electrolysis technologies are mainly dealing with fluctuating power input (from renewable sources) and currently, based on the current state of development, related lower efficiency and hydrogen quality in partial load operation. A highly dynamic operation has moreover

[11] based on the definition by International Renewable Energy Agency and U.S. Energy Information Administration

negative effects on the life time of the systems. To make the power-to-gas technology economically attractive, the currently high investment costs for the electrolysers have to be lowered significantly.

Figure 3-15: The power-to-gas concept



Source: Energieinstitut at the Johannes Kepler University of Linz

Depending on the used electrolyte it can be differentiated between alkaline (AEC), proton exchange membrane (PEMEC) and solid oxide (SOEC) electrolysers. Both, alkaline and PEM electrolysers, have a system efficiency between 60 % and 80 %. The key challenges for this electrolysis technologies are mainly dealing with fluctuating power input (from renewable sources) and currently, based on the current state of development, related lower efficiency and hydrogen quality in partial load operation. A highly dynamic operation has moreover negative effects on the life time of the systems. To make the power-to-gas technology economically attractive, the currently high investment costs for the electrolysers have to be lowered significantly. In Upper Austria, there are testbeds for converting energy to hydrogen or synthetic methane already in operation.

Table 3-27: Research and development activities with regard to power-to-gas in selected RLS regions

Bavaria
In order to support the aim of the **National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)** for mobility with fuel cell powered vehicles to be competitive in Germany by 2025, research and development, as well as the market activation of the technology will continue to be funded, also with regards to the production of hydrogen from renewable energy sources. According to the Federal Motor Transport Authority (KBA), as of January 1 2016, there were 196 passenger vehicles, 15 busses and 4 commercial vehicles with fuel cells registered in Germany. 89 of the passenger vehicles were operated as prototypes or small series production vehicles in the framework of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP). The first series production of passenger vehicles has been on the German market since 2013. **Research is ongoing about fuel cells in the areas of future demand and fueling standards.**

Upper Austria

H2FUTURE is a European flagship project for the generation of green hydrogen from electricity from renewable energy sources. Under the coordination of the utility VERBUND, the Upper Austrian steel manufacturer **voestalpine** and Siemens, a proton exchange membrane (PEM) electrolyser manufacturer, a large-scale 6 MW PEM electrolysis system will be installed and operated at the voestalpine Linz steel plant in Austria. The Austrian transmission system operator (TSO) Austrian Power Grid (APG) will support the prequalification of the electrolyser system for the provision of ancillary services. The Energy research centre of the Netherlands (ECN) and K1-MET will study the replicability of the experimental results on larger scales in EU28 for the steel industry.

The **Energy Cell** of **Fronius International** pursues this decentralized approach at the level of a detached house in order to generate energy where it is needed. Another advantage is that the resulting waste heat can be used directly for hot water and heating purposes. Thus, a very high overall efficiency is achieved. In central power plants there is generally no demand for the waste heat at the location or district heating networks are rarely realized due to the cost and customer structure. The solution During the day and with sufficient solar radiation, the electricity consumers can be operated directly via the PV inverter. Electricity surpluses are used in several ways. On the one hand, it charges batteries that provide the required energy during the evening and night hours (short-term storage). On the other hand, the electricity surpluses of the summer months supply an electrolyser in the Fronius energy cell. This generates hydrogen, which is stored in the external tank. In winter, the stored hydrogen is converted back into electricity with the fuel cell function of the Fronius Energy Cell (long-term storage). These conversion processes additionally generate waste heat, which is used for hot water preparation and for heating support. The energy management system ensures the optimized use and distribution of energy in the overall system. Thus, the **Fronius House of the Future** is completely energy-autonomous, 100 percent of the required energy is generated from PV and are available at all times.

The **Center for Surface and Nanoanalytics** of the **Johannes Kepler University Linz** undertakes research on energy storage via hydrogen storage in metal hydrides.

Numerous research and development activities by the **Energieinstitut at the Johannes Kepler Universität Linz** in the past years characterized economic viability, the demand for energy storage, the demand for the renewable products H_2 and CH_4 in the transportation and industry sectors, and the environmental performance as the predominant influencing parameters on the implementation of power-to-gas. Based on these activities, toolboxes for actual and prospective techno-economic and environmental benchmarking of power-togas systems were developed. The *PoweR To Gas assEssment tool*, **PResTiGE**, and the *Component Level Learning Curve Tool*, **CoLLeCT**, comprises data from demo sites and benchmark systems as other options for electricity storage or application of the gaseous products H_2 or CH_4 in the transportation sector at different scales, regionally adaptable over all process steps of the power-to-gas system and product application. The **techno-economic optimization** of the power-to-gas system focuses on reducing the investment costs through experience curves, learning effects, and economies of scale. The tools are capable of evaluating future investment cost reductions based on those effects.
Power-to-gas not only requires further technological development and real life large-scale implementation and deployment, but also a comprehensive assessment of the economic and business aspects, its societal impact and acceptance, and an analysis of the large-scale storage and market-uptake potential in the short and long term. The Energy Institute's experts identify potential barriers, e.g., **safety, public acceptance, IP, regulatory, and legal issues.** Policy issues determining incentives such as subsidies, taxation, or command-and-control measures are crucial to investigate as these technologies are still at the start of the learning curve. Additionally, the Energy Institute at the JKU Linz assists in **site planning** via identification of infrastructure prerequisites (i.e., electricity, gas, heat grids, and CO_2-source) and synergies for byproduct utilization (oxygen and heat), to provide insights into this technology as a base of a future large-scale energy storage.

Currently, the **Energieinstitut at the Johannes Kepler Universität Linz** is involved in the following power-to-gas research activities:

- **Power to Gas – a system analysis. Market and technology scouting (Funded by BMWFW)**
  National and international market and technology scouting for PtG, with a focus on electrolysis, methanation, CO_2 capture, legal, economical and ecological assessments; Publications on the ecological assessment of PtG technologies in the context of greenhouse gas potential and primary energy demand
- **STORE&GO - Innovative large-scale energy storage technologies and Power-to-Gas concepts after Optimization**
  With three demonstration units (in Germany, Switzerland and Italy), the project investigates different PtG concepts, including methanation. The research includes technical, economic and legal issues.
- **OptFuel – Optimization of renewable energy carrier production from biomass with surplus electricity**
  Phase 1: Characterization of a zero emission biogas plant that produces CO_2 for a subsequent methanation. Elaboration of advantages and disadvantages of different methanation methods. Furthermore, optimal process conditions for all process chains were developed. Phase 2: The overall technical process chain was established. Conversion of the produced CO_2 to synthetic methane (SNG). Optimization of the overall process chain, based on the experimental results.
- **Renewable methane from CO_2 - Development of a catalytic process for methanation of CO_2 from industrial sources**
  Development of novel ceramic honeycomb methanation catalyst, which has been successfully tested under laboratory conditions and optimized for the requirements of PtG applications. The laboratory unit assembled in the RSA, as well as the experience gained will be of great benefit for the present project.
- **Batterlyser – Integration of a battery storage for optimized hydrogen production via PtG: techno-ecological exploration**
  Exploration project for the investigation of a PtG plant in combination with a battery storage system, focused on dynamic efficiency and lifetime of the electrolyzer, as well as on increasing the economic efficiency and identification of relevant application scenarios.
- **Underground Sun Conversion - Renewable Energy Storage and Conversion by in—situ biological methanation in porous undergrund gas reservoirs**
  The project investigates the in-situ microbial methanation of carbon mono- and dioxide using hydrogen in depleted natural gas reservoirs, and aims to develop a process chain for its industrial utilization. Such a technology would make it possible to generate and convert large amounts of renewable energy, both in Austria and in areas with a high potential (wind from Patagonia, sun in desert areas) and export this energy to densely populated areas with a lower renewable energy generation potential.
- **Renewable Steel Gases - Integration of renewable energy in the steel production in order to increase energy efficiency and to reduce CO_2-emissions**
  In the course of the project total process chains for the utilization of steel gases of an integrated steel plant will be developed and experimentally investigated. Renewable power is used in water electrolysis, and biomass is used in a fluidized bed gasification to produce H_2 for the catalytic methanation of steel gases. Main targets are a significant reduction of the CO_2-emissions, an increase of the energy efficiency in the production, the integration of renewable energy and the chemical storage of excess energy.
- **Hydrometha - Development of a stationary electricity storage system via high temperature co-electrolysis and catalytic methanation**
  With the project HYDROMETHA a novel, fully integrated system of CO_2+H_2O high-temperature co-electrolysis (Co-SOEC) and catalytic methanation will be developed. The interconnection of these processes, as well as component and operational optimization will allow a significant increase in conversion efficiencies above 80%el. Due to system simplifications, increased lifetime and durability, as well as optimizations of the process chain, essential cost reductions and thus enhanced market potentials are expected.
- The project "**OptFuel**" aims to develop a novel process for the recycling of biogenic residues and their conversion into different energy sources with the involvement of surplus electricity. The core components include H_2 fermentation and electrolysis for hydrogen production, biogas plant and product processing for the production of methane, as well as chemical or biological methanation. Each of these process steps is marketable on its own and produces independent products. At the end of the project, the optimized overall process will be displayed in a continuously operable pilot plant and form

	the basis for an industrial demo plant. – **WIVA P&G - Wasserstoffinitiative Vorzeigeregion Austria Power & Gas** For the further development of the European and the Austrian energy system, an increased integration and implementation of green hydrogen and other (therefrom generated) hydrocarbons such as methane is necessary for a manifold of both ecological and economic reasons. Austria as key energy storage region, as hub for energy transport and as important location for renewable energy sources is perfectly suited to realize the Austrian energy model region WIVA P&G, which illustrates the conversion of the Austrian energy system to green hydrogen. Sectorally integrated projects using green electricity will boost the transition to sustainable energy system. WIVA P&G subsumes the experiences of more than 30 completed and ongoing projects and is going to implement 25 sub-projects within the energy model region. The founded research association WIVA P&G coordinates and implements the model region with the structure of an Austria-wide and therefore transregional, thematically focused and internationally visible cluster project. It has a multidisciplinary innovation structure, demonstrates and tests intelligent system solutions in practice, and provides applicable systems for users. There is no geographical restriction within Austria, so that WIVA P&G has a significant international visibility with its outstanding research projects.
Western Cape	
The **HySA Systems Integration & Technology Validation Competence Centre (HySA Systems)** is hosted at **University of the Western Cape (UWC)** and specifically the **South African Institute for Advanced Materials Chemistry (SAIAMC)**. The main objective with HySA Systems is to (i) develop hydrogen fuel cell (HFC) systems and prototypes, (ii) perform technology validation and system integration in three key HySA programmes: (1) Combined Heat and Power (CHP), (2) Portable systems and (3) Hydrogen Fueled Vehicles (HFV). HySA Systems is also responsible for the development, prototyping, testing, validating and commissioning of the following key technologies: Membrane Electrode Assemblies (MEAs) for High Temperature (HT) (≥120 degrees C), Proton Exchange Membrane (PEM) fuel cells, HT-PEM fuel cell stacks, metal hydrides for hydrogen storage and compression, Li-ion batteries and system integration of Energy Storage Devices for domestic and automotive applications.	

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.10 Geothermal energy

Technology description[12]

Applications of geothermal energy use the earth's temperatures close to the surface, while others need drilling long distances into the earth. The main systems of using geothermal energy are direct use and district heating systems, electricity production power plants and geothermal heat pumps. Direct use and district heating systems utilize hot water from springs or reservoirs located near the surface of the earth. Geothermal energy is also used to heat buildings through district heating systems. Hot water near the earth's surface is piped directly into buildings for heat. The most mutual industrial use of geothermal energy is food dehydration. For electricity generation, high or medium temperature resources are required, which are usually located close to tectonically active regions. Geothermal heat pumps use the constant temperatures near the surface of the earth to heat and cool buildings. Geothermal heat pumps transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer.

The monitoring process revealed the usage of geothermal district heating systems for Bavaria and Upper Austria. In Bavaria, 20 geothermal district heating grids could be identified for the year 2015. A geothermal heat production of 679 GWh for 2015 and of 796 GWh for 2016 was calculated. According to the Bavarian Energy Concept of 2011, in order to achieve a 1% share of the total consumption and 0.6% of electricity consumption in Bavaria by 2021, the Bavarian State Government will work towards the simplification and transparency of the application federal market incentive program for geothermal energy, as well as increasing the stability of the support program for an improved investment security. This will be achieved through the following measures:

- An increase in the basic compensation of the *Renewable Energy Law (EEG)* for geothermal electricity feed-in up to 20 ct/kWh and for the heating bonus up to 7 ct/kWh, as well as maintaining the early starter bonus of 4 ct/kWh (with a reduction of 10% starting in 2019) and the technology bonus of 4 ct/kWh.
- A continuation of the *Bavarian Deep Geothermal Energy Programme* for the expansion of the heating network and working towards improved funding conditions in the equivalent federal geothermal energy programme.
- In order to focus and expand on research in the area of geothermal energy in Bavaria, all topics from the development to utilization and storage should be taken into account.

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[12] based on the definition of International Renewable Energy Agency and U.S. Energy Information Administration

The Upper Austrian Molasse Basin has the best geological and hydrogeological conditions for the development and use of hydrothermal energy in Austria. These are based on the one hand on the increased terrestrial heat flux and on the other hand on the occurrence of a regionally widespread, locally highly permeable aquifer in the limestones and dolomites of the / Upper Jurassic / Lower Cretaceous (Malm and Purbeck). The high permeabilities are related to aeration and karstification, especially in the area of influence of disturbances. Consequently, Upper Austria is the region with the highest market penetration in the use of geothermal energy in Austria. Currently, eight geothermal district heating grids are in operation, and in the plants in Altheim and Braunau-Simbach. A geothermal district heat production of 246 GWh in 2016 was calculated.

Within the RLS partner regions, several research and development activities in the field of geothermal energy are taking place.

Table 3-28: Research and development activities with regard to geothermal energy in selected RLS regions

Bavaria
In order expand on the expertise Bavaria has already developed in the utilization of geothermal energy in low temperature ranges, the following innovation and research projects were proposed within the **Bavarian Energy Concept of 2011**: – A test project should be funded in Bavaria studying **petrothermal geothermal energy**, which can exploit geothermal energy sources for power generation independent of the presence of thermal water. – The further development of the **EGS (Enhanced Geothermal System)** process for electricity generation from geothermics is being funded in Mauerstetten. – The funding of a **Bavarian demonstration plant combining solar absorbers and geothermal spiral sensors**, which can serve as latent storage to supply heat pumps at shallow depths. The potential for geothermal energy in Germany is estimated at 324 TWh electricity generation (compared to 604 TWh of electricity consumption in 2010) and a potential for heating with hydrogeothermal energy of 300 times the the heating demand in Germany. The research and development potential involves the technologies for both the underground systems, such as by the discovery, exploitation and drilling, as well as for improving the efficiency of above ground systems. Research and development activities in Bavaria should be coordinated and expanded, in order to work towards solutions in all aspects of geothermal energy from exploitation through use and storage. **A specific need for research and development has been identified in the areas of:** – **Testing of petrothermal technologies for the use of geothermal energy to allow for the use of geothermal energy in other regions of Bavaria.** – **Improving efficiency of geothermal electricity plants, for ex. through heat supply.**
Upper Austria
The **Energieinstitut at the JKU Linz** is a part of a project which aims to analyze the technical and **systemic integration of deep geothermal energy in the Upper Austrian industry** and to investigate the possibilities of gradual use of deep heat by various industrial customers. The Upper Austrian energy sectors is classified within the project based on temperature and heat requirements, and potential geothermal heat consumers are identified. Furthermore, the creation of a map with specific potentials of geothermal energy in Upper Austria is a result of the project.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.11 Grids

According to the Bavarian Energy Concept of 2011, the Bavarian State Government aims to encourage cooperation at the federal, state, regional and community level in order to meet the challenges of grid expansion. This includes:

- The acceleration of the planning and approval process for the construction of power lines.
- Increasing public acceptance of power line construction.
- Increasing focus on a Europe-wide coordinated network expansion.

To achieve this, measures are planned to:

- Support measures at the federal levels which facilitate the expansion of the electricity network. Bavaria plans to be active in the network platform and the working groups of the Federal Ministry of Economics.
- Through its clear political commitment to the expansion of the electricity infrastructure, the State Government will ensure that the planning and approval process for network expansion measures and for new storage facilities is quick and investment friendly.
- One of the most important aims for Bavaria is the increase of the transit capacity between Thuringia and Bavaria (Altenfeld – Redwitz), as well as between Germany (Southern Bavaria) and Austria (Isar - St. Peter).
- Further expansion of transit capacities is planned between Germany and the Czech Republic, the increased transit capacities required by the European Commission between Germany and Denmark and the interconnector between Germany and Norway.
- Support the federal government in the establishment of the law for the acceleration of the grid infrastructure (Netzausbaubeschleunigungsgesetz).

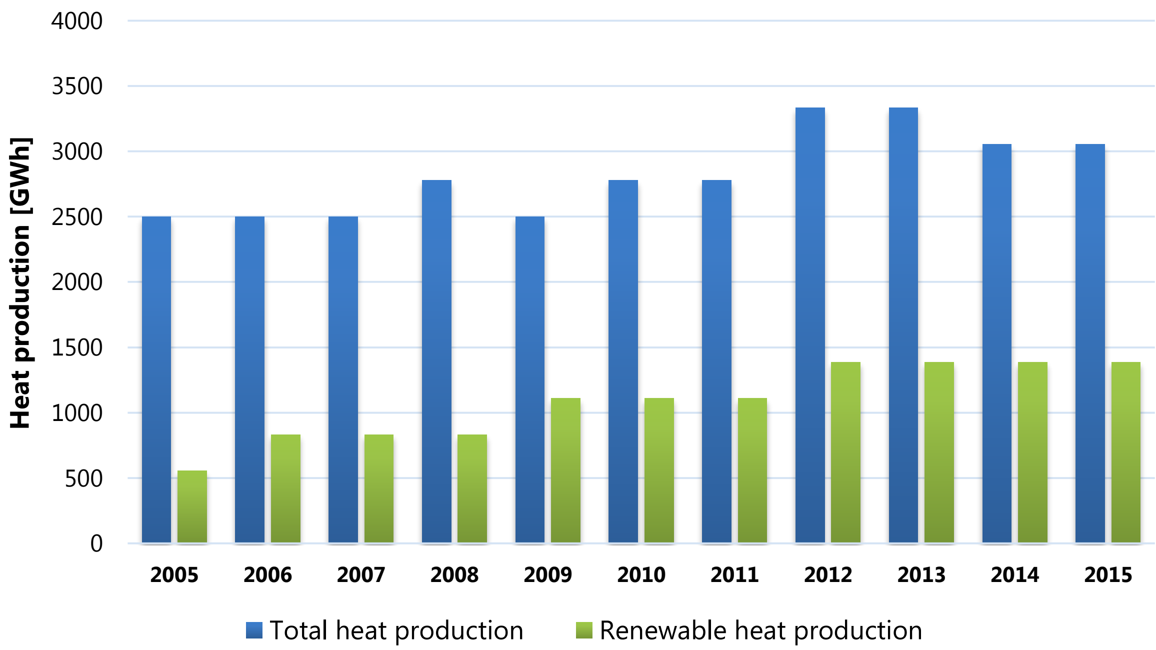
With the implementation of the Directive 2009/28/EG of the European Parliament and the Council on the promotion of the use of energy from renewable sources on June 25 2009, the first target was set for the European Union as a whole to raise the proportion of renewable energy sources to 20% of the total energy consumption by the year 2020, as well as achieving a proportion of at least 10% renewables in the transportation sector. In light of this goal, the German Federal Government has set subgoals to reach a proportion of energy from renewable sources by 2020 of 30% of electricity consumption, 14% in the heating sector and 12% of fuel consumption. These targets for electricity and heating have already been reached in Bavaria.

District heating with renewables[13]

District heating and cooling in combination with renewable energy sources can support to face rising urban energy challenges, improve energy efficiency, mitigate emissions and increase local air quality. District heating and cooling systems are presently dominated by fossil energy sources such as coal and gas but can be advanced to integrate solid biofuel, solar and geothermal energy technologies. Depending on local conditions, renewable-based district heating implies a range of benefits, including increased energy security, enhanced health and reduced climate effects.

In Bavaria, 20 geothermal district heating grids could be identified for the year 2015 (see Section 3.10). A geothermal heat production of 679 GWh for 2015 and of 796 GWh for 2016 was calculated. Currently, district heating grids of more than 400 km are currently in operation in Upper Austria.[14] Almost half of the district heat was produced by renewable energy carriers in 2015.

Figure 3-16: District heat production in Upper Austria



Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

13 based on the definition by International Renewable Energy Agency
14 In Upper Austria, district heating covered 319 particular grids in 2016.

Energy grids and storage are an important part of the present Energy Strategy 2050 in Upper Austria, especially in the context of security of supply. The following aims are established in the Upper Austrian Energy Strategy 2050:

- Simplify and accelerate the approval of pipeline infrastructure & generation facilities, while preserving the interests of the parties concerned
- Additional debureaucratization
- Securing back-up capacities in power generation
- Maintaining power quality and downtime at the current level
- Diversification of energy sources, carriers and routes
- Promotion of own funding and regional resources incl. the usage of natural geological potentials

Besides that, the Upper Austrian Energy Strategy 2050 explicitly mentions measure as the exploitation of economically feasible remote and waste heat potentials as well as the expansion and optimization of district heating, district cooling to reach the targets.

Table 3-29: Total district heat and renewable district heat production in Upper Austria

	Upper Austria	
	Total district heat production [GWh]	Renewable district heat production [GWh]
2005	2,500	556
2006	2,500	833
2007	2,500	833
2008	2,778	833
2009	2,500	1,111
2010	2,778	1,111
2011	2,778	1,111
2012	3,333	1,389
2013	3,333	1,389
2014	3,056	1,389
2015	3,056	1,389

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-30: Research and development activities with regard to energy grids in selected RLS regions

Bavaria
Due to the changing energy market, especially in light of the decommissioning of nuclear power plants and the transition to primarily renewable energy sources, research in Bavaria relating to electricity networks focuses on the **stabilization of the electricity grid**, the challenges related to **decentralization of energy provision** and **efficiency of energy transportation**, as well as the development and implementation of systems such as **Smart Grids**. Some examples of Bavarian

research projects relating to electricity networks include: **SyNErgie** http://fenes.net/forschung/energienetze/laufende-projekte/synergie/http://fenes.net/forschung/energienetze/laufende-projekte/synergie/ Stabilization of electricity networks with a focus the transition of the energy market from nuclear and coal power to renewable energy sources. **UMTRIS** http://fenes.net/forschung/energienetze/laufende-projekte/umtris/ More stable and efficient transformer technology and isolator fluids. **CrossEnergy** http://fenes.net/forschung/energienetze/laufende-projekte/crossenergy/ Network adaptation for decentralized power networks. Concepts for network expansion and software based network design. Evaluation of different network expansion strategies. **FENES** (Forschungsstelle für Energienetze und Energiespeicher) https://www.gwf-gas.de/fileadmin/GWFGasEnergie/gwf_gas_Ausgaben/gwf_gas_2017/gwf_gas_12_17/GE_12_2017_Im_Profil.pdf Integration of renewable energy sources into the grid. Further research is being carried out in Germany relating to the **development and transition of the heating networks**, as well as the **transition to more sustainable heat provision**. Examples of these research topics are: Efficiency improvement and network optimization – Low exergy technology to reduce transmission loss – Incorporation of decentral heat (solar) into the grid – Thermal energy storage for flexible heat grids – Research on system stability and energy storage
Upper Austria
The aim of the project "**Heat_Portfolio**", where **the Energieinstitut at the JKU Linz** is involved, is to create the technical basis for significantly increasing the share of the often decentralized alternative heat sources (in particular industrial waste heat, solar thermal energy and near-surface geothermal energy) in heat networks. For this purpose, the integration of storage and heat pumps, control strategies and hydraulic integration variants and user measures in generalizable or replicable form are developed and adapted to each other with the help of dynamic simulation calculations, tested and using economic indicators and in terms of sustainability performance rated. The **Energieinstitut at the JKU Linz** was working on the project **"Future district heating system Linz"** which focuses on the industrial waste heat of the Linz, the capital of Upper Austria. There The exploration of the technical potentials for the integration of industrial waste heat in district heating systems and the evaluation of the associated integration of large heat storage, large heat pumps, back-up systems and the identification of innovative financing options for the realization of the associated investments. The investigations are based on the city of Linz, but are exemplary for other industrial sites in Austria.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

3.12 Energy storage and system integration

Technology description[15]

With the falling costs of renewable power generation technologies, the focus is increasingly moving to the next stage of the energy transition, leading to a shift in emphasis towards an energy system approach that seeks to integrate different technologies and sectors. This, in turn, will minimize the cost of the transition to an energy future in which variable renewables and electric vehicles will play an increasing role. This shift in dynamic as the energy transition accelerates has served to highlight numerous new technologies, market designs, business models and "systems thinking" at the energy sector level that will be required – and will become economic – in this second stage of the energy transition. Individual storage technologies often have the ability to supply multiple energy and power services. The optimal role for energy storage varies depending on the current energy system landscape and future developments particular to each region. Also, the role of battery energy storage systems for stationary and transport applications is therefore gaining prominence.

The RLS regions Bavaria and Upper Austria in the context of hybrid grids

Several studies, which are illustrating 100 % scenarios of renewable energies, are referring to a strong connection between power, gas and heat. This leads automatically to hybrid networks in order to reuse losses in one energy system as sources in the other one.

Regarding the implementation of hybrid grids, new technologies have been developed that enable a much stronger link between the three mentioned grids. Technologies like Power-to-Gas (see Section 3.9), fuel cells (see Section 3.9), Stirling engines or new heat pumps were being developed during the last few years. They allow for a closer linking of the grids and thereby create opportunities in those areas in which separate grids reached its limits formerly. This improved connection of grids can thus result in the so-called hybrid grid. Hence, a hybrid grid is an energy system of several energy networks which are strongly connected / integrated by (new) interface technologies and interact bidirectionally - if technically feasible.

The implementation of hybrid networks enables an optimized integration of existing infrastructures with the involvement of all (energy) networks in the future: the gas grid, the heat grid, the power grid, the water grid, the communication grid and the transport grid. Based on this, strategic decisions regarding energy and environmental planning can be made. Thereby, the energy system is developed initially in a regional context and can provide crucial contributions in order to strengthen the domestic economy and living space via an advanced extension of the hybrid grid to the supra-regional / national level.

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15 based on the definition by International Renewable Energy Agency

Basically, the following overall objectives are connected with the establishment of hybrid grids:

- increase of the resource efficiency (incl. the optimization of production and consumption, increasing the load shift potential in the energy system)
- storage of fluctuating energy
- new transportation options in the energy system
- new transformation options
- reduction of network expansion costs or stranded investments

On the one hand, improved load management and opportunities for the intermodal storage of energy in other networks enhance the security of supply. On the other hand, the increase of resource efficiency and the reduction of singular grid expansion costs strengthen the economic efficiency. Because of that, the implementation of hybrid networks is crucial for the future Austrian and European energy system. The development of hybrid networks might be cost-effective in the long term because of the increased resource efficiency and high-quality and secure supply of energy. The cost-cutting leads to more competitive companies and, at least hypothetically, could also reduce the costs of end costumers.

Based on that, significant foundations for a resource-optimized energy supply of households and companies can be created in urban areas as the use of existing resources and energy flows is the basis for future smart structures of municipal utilities. The energy producers and energy consumers are both included in the system boundary. In addition to households and business entities, large industrial energy consumers should also be considered and incorporated. However, it is important for the establishment of hybrid grids that the power nodes (transition from one to another grid) are available and work accurately. Such technologies or technology components are, for example,

- electrolysis plants for producing hydrogen from water
- storage of hydrogen in gas storages (see Section 3.9)
- methanation as a part of Carbon Capture and Utilization (CCU)
- high temperature heat pumps
- seasonal thermal storage for the integration of waste heat
- battery storage
- installations for the recovery of biogenic waste materials for the production of electricity, heat and fuels
- information and communication infrastructure

The development of these system components and the general progress of a new energy system is intensively stimulated and supported by research in Bavaria and Upper Austria.

In this context, research and development activities can be mentioned from the **Bavarian** point of view (focusing on energy storage). The **Energy Campus Nuremberg**, the **Technical**

University of Munich and the **Technology Center for Energy (TZE)**, an institute of the University of Applied Sciences of Landshut, acts as a research partner for regional and also industrial questions around the energy storage, mostly but not exclusively coupled to renewable energy sources: Typical action fields on the research site are:

- Integration of several battery technologies (e. g. Redox-Flow batteries, modern Lithium-technologies, saltwater batteries, ...) into the business infrastructure and testing environment of the Technology Centre for Energy (TZE)
- Creating test capacities to investigate the parameters of storage systems which are intended for the use in houses, small industries and local grids.
- Developing a test plant for the investigation of a hybrid-system, consisting of CHP and Photovoltaics, coupled with heat- and powerstorage systems, covered with an intelligent control system for resource-efficient operating.
- Laboratory cell assembly line for research on key technologies of all steps of Lithium cell production and of all materials needed therefore.
- Low-temperature Methane separation and liquefacation.
- Realisation of a Competence Centre for Energy Storage together with the **University of Applied Sciences of Upper Austria** (EU-Project CompStor, about 6.6 Mio. € of investment in two laboratory locations on both sides of the Bavarian-Austrian border)
- Developing a research platform for Flow Batteries, i.e. Redox-Flow Systems, together with the Czech Institute NTC (New Technologies Centre) of University Pilsen/Prag.
- The "**Aufbruch Bayern**" initiative has laid the groundwork for this, among others, with a research network in storage technologies. The Bavarian State Government decided to focus especially on the natural gas network as a further option for the potential storage alternatives and to realize a development and demonstration project on the topic of methanization of peak electricity from renewable energies (**Ökogasinitiative**)

The following research and development activities can be mentioned from an **Upper Austrian** point of view:

- Energy Cell (PEM fuel cell and hydrolyser) as a basis for the self-sufficient energy supply of households and as a way to integrate wind and solar power in the mobility sector - ***Fronius***
- Underground Sun Storage (storage of 10% hydrogen, together with methane in a pore storage) – ***RAG*** (see Section 3.9)
- Seasonal thermal storage integrating waste heat - ***Linz AG, voestalpine***
- Increased production of biogas from organic waste in a two-stage fermentation process by integrating electrolysis and methanation
- Analysis of system components (photovoltaic, battery storage, thermal storage, P2G plants) in a hybrid system as an important component in the transition to a Smart City (see Section 3.9)

- At the **University of Applied Sciences Upper Austria**, Wels, **research on thermoelectric generators** is conducted. The research covers analysis of building blocks by means of R-thermography, basic material characterization and basic material research by means of model calculations.
- The evaluation on how regional, renewable resources can be used to provide regional e-mobility in the long term, to be optimally integrated into the municipal distribution network system and to be economically sustainable is the focus of the research project "Move2Grid" with the involvement of the **Energieinstitut at the JKU Linz**. At the end of the project, a hybrid, cell-resolved layer model is developed, which serves the "layers" energy-related mobility aspects, energy (distribution network expansion, energy storage and regional potentials), business model processes and overall systemic conditions. The developed guideline makes it possible to develop the e-mobility supply analogously, as shown in the present project, in many other Austrian middle centers.
- The **Energieinstitut Linz** contributes to the project **LEAFS** – *Integration of loads and electric storage systems into advanced flexibility schemes for low voltage networks*. The renewable energy future poses major challenges not only to the large transmission and distribution grids, but also to the low-voltage grids that provide the flow of electricity to and from households. This is due to the growing number of photovoltaic systems as well as more and more additional electrical consumers such as heat pumps or electric vehicles. Recently, small electrochemical power storage units are increasingly entering the market, with which the self-generated power can be locally stored and later used for personal use. In addition, there are always times when generating electricity from renewable energy, where too much or too little energy is available, depending on local conditions. Electric grids can only partially offset the differences between regions. In addition to technological issues, it also explores how to motivate customers to adapt their consumption and associated everyday habits to local production.

In the Western Cape, battery storage is expected to become the keystone of the future energy storage market. This is based on replacement of some of South Africa's gas fired power (3.5 GW), Eskom's need for almost 2 GW of additional daily balanced energy storage and private sector/customer side investment in demand-side management and backup power. The biggest opportunities for the private sector (funded by public investment) are in: demand charge reduction and backup power for municipalities; frequency regulation and distribution deferral, to an extent, and for the network operator, transmission and distribution deferral. There are various storage applications for different categories of the electricity sector in the region. These are:

- Customer services, which pertain to electricity end-users has opportunities in time-of-use bill management; demand charge reduction; increased PV self-consumption,

- Distribution services, which involve medium voltage distribution networks (mainly municipalities) has opportunities for energy arbitrage; frequency regulation; spin/non spin reserves; voltage support; and black start,
- Utility services, which include electricity transmission (mainly Eskom), but also distribution (both Eskom and municipalities) has opportunities for resource adequacy; distribution deferral; transmission congestion relief; and transmission deferral.

In terms of research, **Energy Storage Innovation Lab (ESIL) at the South African Institute for Advanced Material Chemistry**, merges expertise on advanced battery development, manufacturing and validation. The facility's main aim is to create an interface between energy storage technology development projects (such as its unique ultra-low cost battery development for national grid stability), innovation partners and potential industrial customers in need of advanced energy storage solutions.

3.13 Energy Efficiency

Technology description

The existing potential to improve energy use in several sectors of the economy is widely recognized. Investments in more efficient energy technologies represent more cost-effective alternatives when compared to the expansion of the energy supply base. Mandatory efficiency standards in many countries have induced constant modernization of appliances, vehicles, and buildings. Demand-side policies have contributed to the dissemination of efficient technologies and practices, reducing the energy required for energy services. A focus on energy efficiency additional to the usage of renewable energy decreases import dependency strengthens security of supply and reduces energy costs for businesses and consumers.

3.13.1 Energy efficiency policy frameworks and key facts in selected RLS Regions

Bavaria

The energy efficiency strategy of the 18th German federal Cabinet is described in the *National Energy Efficiency Action Plan* (NAPE). It aims to engage all societal actors in energy efficiency measures through a mix of consultations, communication and providing information about rewarding energy efficiency measures, funding measures, as well as setting standards for new installations. The immediate measures central to NAPE include:

- the introduction of new, competitive calls for energy efficiency
- an increase in the level of funding for building restoration and the implementation of tax incentives for energy efficiency in the building sector at both the national and state level
- the creation of energy efficiency networks together with industry and commerce

Through changing the consciousness of consumers and industry in their use of energy and therefore affecting their actions, which for example may be additionally increase the use of intelligent electricity meters, would save almost 10% of the household electricity consumption, approximately 1.6 billion kWh/a. Through a thorough and transparent system for energy consumption labeling, as well as further developments of the minimum efficiency standards for electricity consuming devices, a further savings of approximately 5% (approximately 2.4 billion kWh) can be realized for private households and other small consumption sectors. Through the identification and the full use of the efficiency potential of companies in herewith also strengthening their competitiveness and innovativeness. By implementing intelligent energy management systems the Bavarian industry could achieve electricity savings of 7% or approximately 2.3 billion kWh/a. In the *Bavarian Energy Concept* the total electricity consumption through increased electricity saving measures which was targeted for Bavaria over the next 10 years was to maintain a level of 85 billion kWh/a.

In the framework of the *LfA-programme "Infrakredit Kommunal"*, building on the *KfW-programme Energy Efficient City Lighting*, financing will be offered towards municipalities towards the upgrade of street lights to highly efficient lamps and more efficient light bulbs.

The Bavarian State Government will engage with the federal government for the further development of instruments for energy efficiency and energy savings, such as energy savings certificates or models for electricity customer accounts. It will also strengthen the execution of regulations at the state level regarding minimum efficiency standards for products (ecodesign) and the energy consumption labeling of products. There is considerable potential for energy savings in the industry and commerce sectors. Of the annual German process heat consumption of around 400 billion kWh, at least 30 kWh could economically be saved - calculated for Bavaria, this is an estimated savings potential for Bavaria of at least 6 billion kWh. This savings potential is yet unrealized in part due to ignorance and in part due to the lack of economic incentives.

In order to double the fraction of buildings being restored in the private sector, the Bavarian Government is committed to supporting the *CO_2 Building Restoration Programme of the KfW* for residential buildings and to provide funding in the sum of four billion euros annually. It also intends to provide tax incentives in order to create an impulse for the energetic restoration of residential and commercial buildings, while working with the federal government to create attractive tax conditions for energy saving investments in the buildings sector.

Energy savings contracting is an effective, budget neutral instrument to realize the unused energy savings potential in the building sector quickly and non-bureaucratically. The Bavarian Government has set to strengthen the in 2011 renewed measure "*Contracting-Initiative-Bayern*." It also funds municipal plans for energy use and neighbourhood level heat conduction plans, while expanding its provision of information about funding measures in the area of energy efficiency and further developing the internet portal "Energie-Atlas Bayern", which provides information about the energy market and potential in Bavaria a map format.

Measures to to set standards for the increase in energy efficiency in particular sectors include the Energy Savings Ordinance (EnEV) and the EU wide applicable regulation regarding the energy consumption product labelling.

Québec

In Québec, the 2030 Energy Policy has adopted as a target to enhance energy efficiency by 15 % within 15 years. The regulation for energy efficiency based on legal responsibilities and jurisdiction comprises

- The Act respecting *Energy Transition Québec*: This act does enact Energy Transition Québec to prepare the master plan to reach the energy efficiency target.

- The Regulation/Act respecting the *energy efficiency of electrical or hydrocarbon-fuelled appliances*: These regulation mechanisms set minimum energy performance requirements for appliances sold in Québec.
- The Regulation/Act respecting *energy conservation in new buildings*: These regulation mechanisms set minimum energy performance requirements for new residential buildings.

There are also voluntary actions and actions where the government serves a role model:

- Energy distributors and government instances, such as Hydro- Québec, Energir and Energy Transition Québec do offer extensive voluntary programs in energy efficiency.
- The *2030 Energy Policy* has adopted as a target to enhance publics buildings energy efficiency (GJ/m^2) by 15 % and to enhance publics light vehicles energy efficiency (l/100 km) by 50%, both within 15 years, from level of 2009-2010 .
- The *Action plan on climate changes 2020* has adopted a target to reduce publics buildings GHG emissions by 15 % and to reduce publics light vehicles GHG emission by 9%, both in 2020, from level of 2009-2010.

Information, promotion and raising awareness with regard to energy efficiency is given by the fact, that energy distributors and government instances, such as Hydro- Québec, Energir and Energy Transition Québec do support education and information in energy efficiency.

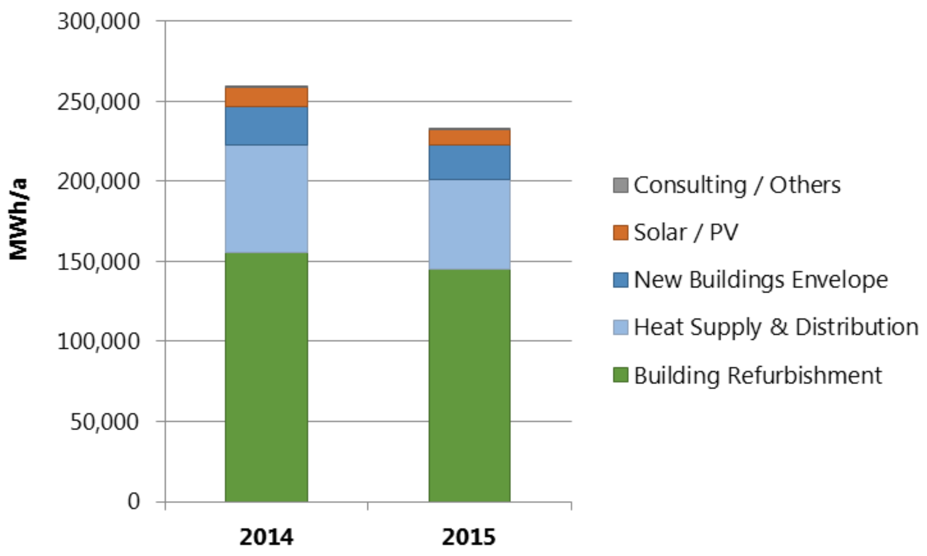
Upper Austria

Increasing energy efficiency is an important aim of the Upper Austrian Energy Strategy 2050. A target is that the energy efficiency shall continuously increase with a reduction of energy intensity by 1.5 to 2 % per year. Furthermore, a continuous improvement of heat intensity, reduction of energy use per m^2 by 1% per year is an aim. Beside this measurements, a target is to improve mobility efficiency (energy consumption / passenger kilometers) by increasing the share of public transport (in comparison to private transport) and by increasing the use of alternative propulsion concepts as well as increasing the efficiency of car fuel consumption per 100 km in the corridor of 0.5 to 1 % per year. The following measurements are defined in the Upper Austrian Energy Strategy 2050 in the context of energy efficiency:

- Energy Efficiency and Renewable Energy Initiative for municipal and regional buildings and infrastructure (role model)
- forcing efficient compressed air applications, pumps, lighting and drives
- incentives for device replacement (in all application segments)
- improvement of heating, hot water, air conditioning and ventilation efficiency
- increase of the thermal refurbishment rate
- offensive for energy efficiency and renewable energy sources for buildings

To illustrate the increase in energy efficiency, methods have been developed in recent years. Based on calculation approaches defined in the European directive on final energy efficiency and energy services evaluation methods were implemented into federal law. The development of calculation methods is not completed yet and will be continued. The calculations of energy saving due to measures initiated in Upper Austria derive final energy savings of approximately 3.6 TWh for the time period 2005 to 2014. For 2015, energy savings due to energy efficiency measures of more than 230,000 MWh were reported (see Figure 3-17 and Table 3-31). Further, Upper Austrian energy suppliers reported energy saving of more than 53 GWh.

Figure 3-17: Energy savings in Upper Austria due to energy efficiency measures, 2014/2015



Source: Own representation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Table 3-31: Energy savings in Upper Austria due to energy efficiency measures, 2014/2015

	Upper Austria				
	Building Refurbishment	Heat Supply & Distribution	New Buildings Envelope	Solar / PV	Consulting / Others
	[MWh/a]	[MWh/a]	[MWh/a]	[MWh/a]	[MWh/a]
2014	155,353	67,441	24,219	11,378	1,484
2015	144,970	56,170	21,930	9,007	1,160

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

Western Cape

The aim of the original NEES (2005) was 'to explore the potential for improved energy utilisation through reducing the nation's energy intensity (thus reducing greenhouse gas emissions), and decoupling economic growth from energy demand' (Modise 2013) by achieving overall sectoral energy intensity reduction targets of 12% by 2015. In 2008 and 2011, the NEES was reviewed to discuss its scope and elements. The Post-2015 National Energy Efficiency Strategy will be based on 25 policy recommendations within seven priority areas developed by the International Energy Agency (IEA 2014): cross-sectoral; buildings; appliances and equipment; lighting; transport; industry; and energy utilities. This updated strategy document builds on the original NEES. It is framed to complement the policies and strategies put forward by other national departments. The draft document was published for public comment in December 2016 but has not yet been finalised. Tax incentives such as the Section 12L stand to provide a tax deduction to a tax payer who is energy efficient, with a focus on renewable energy. There are also building regulations in place which requires construction standards on energy efficiency and energy use in the built environment, with all new buildings requiring energy efficiency initiatives. This has become significant with the green building market in the country, and especially the Western Cape, having grown exponentially since 2010. The Energy Security Game Changer also has a focus on energy efficiency, calling for a 30% reduction in energy consumption in both public and private buildings by 2020.

According to the National Business Initiative's Private Sector Energy Efficiency programme, $5 million capital was leveraged to achieve savings of 646 GWh. This was off energy efficiency interventions for 336 small and large businesses that were identified and implemented by the programme between 2013 and 2015. Nationally, the programme identified a total of 6, 921 opportunities at 1103 businesses, resulting in a potential lifetime energy saving of 21, 896 GWh.

3.13.2 Research & development activities

Within the RLS partner regions, several research and development activities in the field of energy efficiency are taking place.

Table 3-32: Research and development activities with regard to energy efficiency in selected RLS regions

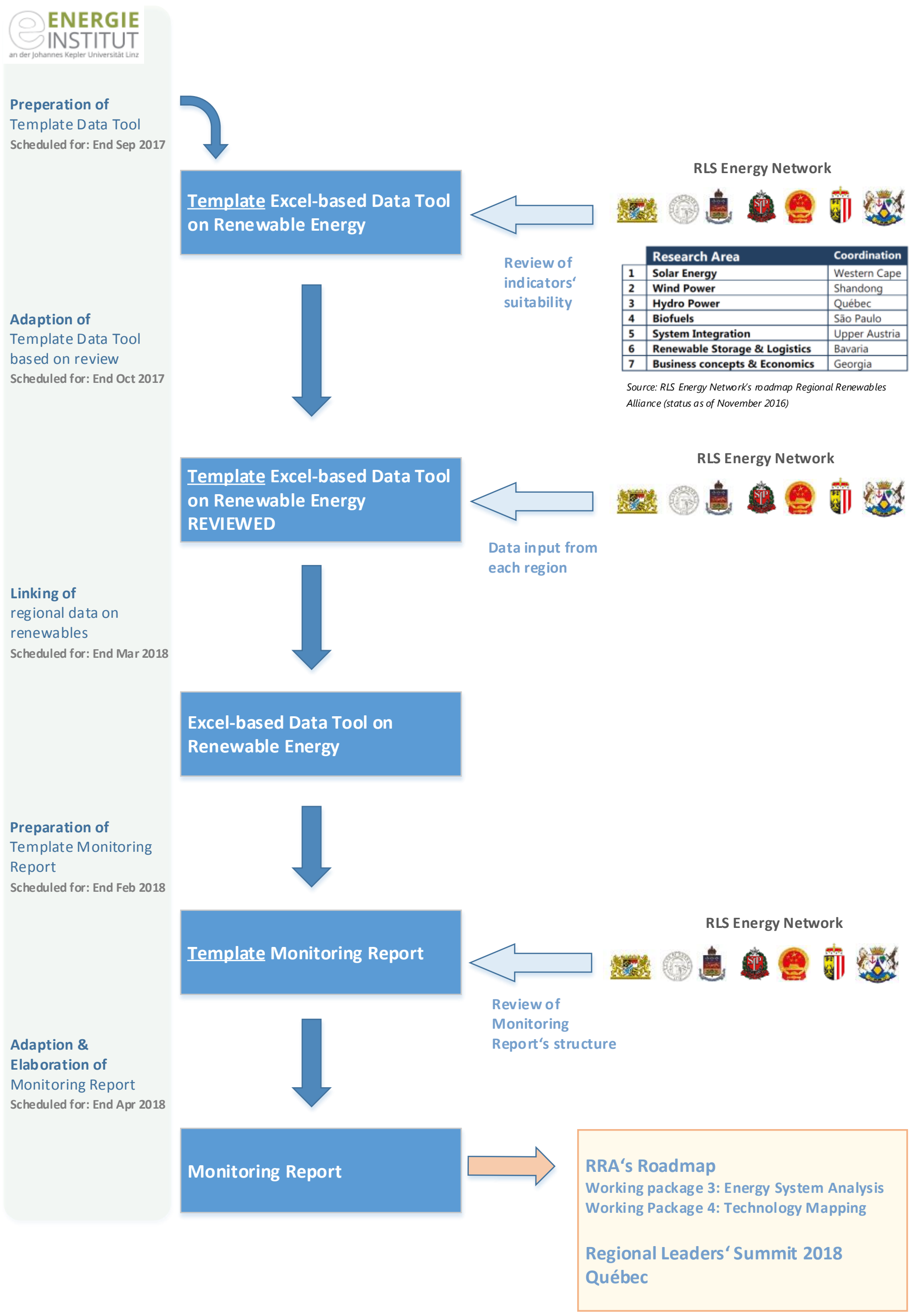
Bavaria
In the framework of the **6th federal Energy Research Program** in 2013, 297 million Euros went towards supporting projects in the areas of **energy efficiency along the entire energy production -consumption chain - from provision and transport, distribution and storage to final consumption in various sectors**. In the sectors industry, commerce, trade and services, the targets of the projects funded range from optimization of the energy use of individual process steps, to the development and implementation of new technologies and system components, to more complex distribution and concepts for the use of residual heat.
Québec
Hydro-Québec can enable Québec manufacturing firms or enterprises with cutting-edge expertise to seize business opportunities in high-growth markets. Among new growth potential stemming from the commercialization of its research and development activities, mention should be made of promising fields linked to more efficient electricity use and GHG emission reduction such as heavy duty batteries and efficient engine technologies aimed at vehicle manufacturers. **TM4**, a wholly-owned subsidiary of Hydro-Québec, markets electric motor technologies developed by the **Institut de recherche d'Hydro-Québec** (IREQ). The **Fonds de recherche du Québec – Nature et technologies** (FRQNT) is a non-profit agency created under the Act respecting the Ministère de l'Éducation, de l'Enseignement supérieur et de la Recherche. Research in energy efficiency is funded trhrough this organization. Energy distributors and government instances, such as Hydro- Québec, Energir and Energy Transition Québec also provide financial support in the industry for implementation of innovations in energy efficiency.
Upper Austria
The innovation network **NEFI**, **New Energy for Industry**, focuses on switching to renewable energies and **increasing energy efficiency** in order to achieve European climate protection goals which pose a **major challenge to the Austrian manufacturing and energy-intensive industries**. At the same time, there is a great opportunity for Austrian technology providers to expand their market leadership worldwide and make a significant contribution to securing Austria as an industrial location. Over the next 8 years, NEFI will demonstrate the path to complete **decarbonization of the manufacturing and energy-intensive industries**. The NEFI innovation network has formed a consortium with the AIT, **Austrian Institute of Technology**, **Montanuniversität Leoben**, Upper Austria **Energiesparverband** (Energy Saving agency of Upper Austria) and the **Upper Austria Business Agency.** The network bundles the extensive experience of these stakeholders in the field of energy research and project implementation. Together, a consortium was formed with more than 80 companies, 14 research partners and 5 institutional partners. NEFI involves companies in all sectors, such as from the **food, engineering, plastics, cement and steel industries**. The range of companies involved in NEFI ranges from large leading companies to innovative SMEs. The industrially strong federal states of Upper Austria and Styria support the development. To promote the overall energy efficiency increase at local level, the program "**Energiespargemeine EGEM**" (Energy saving municipality) was implemented. 183 municipalities took part in it, the implementation phase started on 1 March 2017. These activities are supervised and networked by the Upper Austrian **Energiesparverband** (Energy Savings Agency). Since 2009, the Federal Climate

and Energy Fund has also been initiating and supporting the development of climate and energy model regions, which are also supported and by the State of Upper Austria. The **Energieinstitut at the Johannes Kepler University of Linz** conducts **road mapping processes** for research and development activities for Austrian industries (energy-intensive industry, textile and food industry) with regard to energy efficiency. The studies identify potential fields of action for research and technology development in order to ensure the competitiveness of the industrial location of Austria and the fulfillment of the energy and climate policy requirements of the Austrian Federal Government. Further, energy efficiency measures are **evaluated according to European and national guidelines**. This evaluation includes the calculation of the energy saving resulting from the measure, e.g. for e-cars and many other measures by developing default values and default formulas. In addition, the design of energy-efficient products, so that the legal and regulatory requirements are met, is developed.
Western Cape
One of the research focus areas of the **Energy Research Centre (ERC**) at UCT is energy efficiency, looking the demand level: the effects on single businesses and the national picture. Focus areas at the **South African Renewable Energy Technology Centre (SARETEC)** also has focus areas which include energy efficiency. The **National Cleaner Production Centre (NCPC)** runs an Industrial Energy Efficiency (IEE) Project which was established in 2010 in response to the growing need to improve the energy efficiency of South Africa. The project has assisted industry to achieve energy savings worth over R 1.54 billion nationally. This has been achieved through the promotion and implementation of Energy Management Systems (EnMS) and Energy Systems Optimisation (ESO) in over 384 companies.

Source: Own compilation based on the collection of data and information during the monitoring process (see Section 2.3.3 and Annex 2)

4 ANNEX 1: Monitoring report - workflow and timeframes

The monitoring of the status quo and potentials of renewable energy technologies within the framework of the RRA includes the implementation of a database and the elaboration of a monitoring report. The roadmap of the RLS Energy Network (as of November 2016) states that *"each participating region coordinates the activities for the respective research area and contributes additional data for the related research activities of the other participating regions"*. However, based on the available capacities in Upper Austria, the Energy Institute at the Johannes Kepler University of Linz coordinated the monitoring conception and documentation as displayed below.



5 ANNEX 2: Monitoring report – literature and internet sources

The monitoring report data for each RLS region was collected by using the following literature and internet resources.

Bavaria
Agentur für Erneuerbare Energien
AgrarMeteorologie Bayern
Bayerische Landesanstalt für Landwirtschaft
Bayerische Staatsregierung
Bayerisches Landesamt für Umwelt / Statistik
Bayerisches Staatsministerium für Wirtschaft und Medien, Energie und Technologie
Bayern Innovativ, Projektnews
BMWi
Bundesministerium für Verkehr und digitale Infrastruktur
Bundesnetzagentur
Bundesverband WindEnergie
Deutsche WindGuard
Deutscher Wetterdienst
DEWI-Magazin
Energieatlas Bayern
Energiebilanz Bayern 2005-2010
Forschungsstelle Für Umweltpolitik / Environmental Policy Research Centre Freie Universität Berlin
GENESIS-Online Datenbank
Länderinitiative Kernindikatoren
Rahmenkonzept der Bayerische Allianz für Energieforschung und –technologie
Regionaldatenbank Statistische Ämter des Bundes und der Länder
Strategieplattform Power to Gas
Umweltbundesamt (UBA), Fachgebiet I 2.5
Umweltökonomische / volkswirtschaftliche Gesamtrechnungen der Länder
Georgia
Georgia Energy Data
Gesellschaft für Wirtschaftliche Strukturforschung (GWS) mbH
US Energy Information Administration
Québec
DDIPB, Registre forestier, MFFP
Énergir (Route bleue)
Institut de la statistique du Québec
MDDELCC
MFQ: Conference Board
Private communiqué
Statistique Canada
São Paulo
Sao Paulo State Energy Plan PPE 2020
Energy Balance of the State of Sao Paulo 2017
ANEEL

Energy Matrix of the State of São Paulo 2035
JUNIOR J.U. 2014
Energy Balance of the State of Sao Paulo 2017; ANEEL - BIG
SEADE Foundation
Climatempo
IBGE
OANDA
Global Rates

Shandong

Shandong Development and Reform Commission
Shandong Statistical Yearbook 2011
Shandong Statistical Yearbook 2016
Statistics on Installed Capacity of Wind Power in China in 2005-2007
中国山东省新闻网
凤凰新闻
山东工业技术
山东水文局
山东省新能源和可再生能源中长期发展规划2016-2030
山东省统计年鉴
山东省节约能源十二五规划
山东能源网

Upper Austria

AMS
Austria`s National Inventory Report 2016
Biermayr et al 2017
Energieleitregion OÖ 2050
Energie in Österreich
Energiestatus 2016
Eurostat
Goldbrunner J. 2012
IG Windkraft
Initiative gas
Joanneum Research
Konjunktur- und Wirtschaftsreport
Land Oberösterreich
Landesgesetzblätter
Öberösterreich Zahlen & Fakten Jahresausgabe 2017; 2015; 2013; 2011
Ökostrombericht 2017
OÖ Energiebericht 2012 -2016
OÖ Energiesparverband
Ratschan et al 2015
Richtlinie Oö. Windkraft-Masterplan 2017
STATcube – Statistische Datenbank von STATISTIK AUSTRIA
Statistik Austria
Stromkennzeichnung 2007 -2017
Studie WWF 2010
windkraft - Masterplan 2017 Ausschlusszonen

Western Cape

IPPPP Provincal Report Volume 3. Western Cape

Provincial

Centre for Renewable and Sustainable Energy Studies

GreenCape Market Intelligence Reports - Energy Efficiency; Energy Services; Renewable Energy 2015 – 2018

Western Cape Provincial Economic Review and Outlook 2005 – 2017

Western Cape Municipal Economic Review and Outlook 2010 – 2017

Statistics South Africa

www.microhydropower.net

WWF ZA Industrial scale solar heat in South Africa 2017

GreenCape Solar Heat for Industry Brochure

SOLTRAIN Solar Thermal Roadmap South Africa

6 ANNEX 3: Regional regulatory frameworks (selection)

Québec

In November 2009, the Gouvernement du Québec set its GHG emission reduction target to 20 % below its 1990 level by 2020. According to the Suzuki Fundation, this is the most ambitious target in North America. This target was taken to 37,5 % below the 1990 level by 2030, in November 2015.

Georgia

In the State of Georgia the use of renewable energy is voluntary. The government does not mandate the energy mix. Public, private, philanthropic partnerships which utilize state assets to test innovative technologies and prove business models in the areas of renewable energy, transportation and sustainability. The Ray (www.theray.org) an 18 mile highway designated for experimenting and evaluating new technologies. The following trade organizations promote and raise awareness of the renewable energy and sustainability in Georgia.

- Solar Energy Association
- Clean Cities of Georgia
- Green Chamber of the South
- Center for Transportation and the Environment
- Georgia Recycling Coalition
- Southface

Upper Austria

Since the mid-1990s, there have been strategies to stimulate energy efficiency, renewable energy and other innovative energy technologies in Upper Austria that generated measurable results in energy generation and demand as well as a significant number of innovative projects. Already with the energy concept adopted in 1994, specific goals were defined up to the year 2000, which included both the consumption and the supply side. With the concept "Energy 21" adopted in 2000, this energy strategy was continued.

The starting point for the new energy strategy was the Upper Austrian Energy Strategy regarding energy generation in 2030. This strategy was planned to be implemented until the year 2030 and is now being expanded by the new equally climate and location-oriented *Upper Austrian Energy Strategy 'Energie-Leitregion OÖ 2050'*.

The vision of this strategy is the establishment of Upper Austria as region with regard to the improvement of energy efficiency, the application of new technologies (Upper Austria as the first "smart region" of Europe), as well as an international technology leadership in selected core areas of energy and environmental technology.

The revised energy strategy comprises five equal-ranking objectives in the areas:

- energy efficiency / renewables
- supply security

- competitiveness / profitability
- innovation / location / research and development
- acceptance / interest representation

The objective of energy efficiency and renewable energy comprises (1) continuous improvement of energy-related greenhouse gas emissions with a reduction in emission intensity (GHG to GRP, base year: 2014) by 25 to 33% by 2030 and by 70 to 90% by 2050; (2) continuous increase in energy efficiency (final energy to GRP) with a reduction of energy intensity by 1.5 to 2% p. a.; (3) continuous improvement of heat intensity, reduction of energy use per m^2 by 1% p. a.; (4) improving mobility by increasing the share of public transport (in comparison to private transport), by increasing the use of alternative mobility concepts and by increasing the efficiency of car fuel consumption per 100 km in the corridor of 0.5 to 1% p. a.; (4) further increasing the share of renewables in electricity consumption while maintaining current security of supply and using efficiently renewable energy potentials in Upper Austria between 80 to 97% by 2030.

The Western Cape

The Western Cape government has set an ambitious goal of becoming the 'Green' Economic Hub of the African continent and introduced a number of strategic frameworks to achieve this goal. It was the first of South Africa's provinces to develop a Sustainable Energy Strategy and it has also launched a Green Economic Strategic Framework that targets job creation in the sector and building a strong environmentally conscious economy in the province. To support these objectives the province is actively building institutional capacity and creating a conducive policy environment. In particular, GreenCape, aWestern Cape government funded and industry- led initiative established in 2010 to support investors, has seen considerable expansion. GreenCape provides support to renewable energy IPPs to unlock the potential for renewable energy production in the province.

7 ANNEX 4: Regional R&D landscape (selection)

Upper Austria

Energy and Environment Research Center Wels (University of Applied Sciences Upper Austria)

This R & D focus encompasses the combination of eco-energy and environmental technology topics in the research fields solar energy / hydrogen, building optimization / solar mobility as well as waste gas, waste air and wastewater treatment. All projects focus on the ethical handling of the world's resources. The projects range from basic research to the optimization of operations in application laboratories right through to company foundations. All stages of a production chain are covered e.g. from the optimization of the raw materials / biomass, fermentation conditions to the control of the end products. High-temperature (SOFC) fuel cells and the area of energy-efficient construction and building ecology are further research areas. It is possible to rely on an excellent set of instruments with hydrogen, fuel cells, a thermal and photovoltaic laboratory, construction physics and climatic engineering laboratory, bio- and chemical laboratories, photocatalysis, biogas, sewage and environmental engineering and process engineering laboratory with complete analytics and equipment. The latest simulation tools and analytics can be used for R&D tasks (impedance, FTIR, UV / vis, GC, GC MS, ICP HPLC, IC, infrared camera, blower door equipment, hotbox, etc.) on a pilot plants scale in waste air purification, dedusting as well as exhaust air purification for R & D tasks. In addition to outdoor measuring stands, various solar simulators (up to 1.5 x 2.5 m2) are available for photovoltaic and solar thermal developments. A 17 kWp photovoltaic system with all currently available types of solar cells, solar recharging station and interlinking with electrolysis and fuel cell is also used in R & D projects.

Energiesparverband (Upper Austrian Energy Saving Agency)

In Upper Austria, about 9,000 energy consultations and assessments were carried out in 2016 by the OÖ Energiesparverband (Upper Austrian Energy Saving Agency). The energy advisory program for companies as part of the country's environmental initiative was continued. Consultation and information activities were also carried out by the chambers, provincial services and companies.

The dissemination of energy information is carried out with various instruments by numerous institutions and companies. In addition to measures such as lectures, seminars, brochures and trade fairs, various information channels are also used. For example, the energy-saving fair attracted 100,000 people, a PV program for kindergartens and a solar energy storage initiative in the country or, for example, LED and electrical appliance campaigns as well as actions for low-income households were carried out. With the Energy Academy, there is a comprehensive education and training program in the field of energy with more than 30 seminars.

Energieinstitut at the Johannes Kepler University of Linz

The Energieinstitut at the Johannes Kepler University Linz is a highly distinguished project partner whenever multidisciplinary knowledge of more than one scientific field is essential for energy-related research topics. The institute's three departments cover Energy Economics, Energy Law and Energy Technology. Only the combination of these core disciplines allows comprehensive analyses and accounts for all aspects of future-oriented energy topics. Researchers of the Energieinstitut analyze the economic effects of energy-related policies, discuss the most recent developments in the European energy legislation and evaluate strategies for CO_2 abatement schemes as well as measures aimed at promoting energy efficiency and supply security goals. The three disciplinary departments closely interact and collaborate on a series of topics and projects:

Energy Economics *Department of the Energy Institute, Johannes Kepler University Linz*

Topics: Macroeconomic assessments of different energy issues, Energy Supply Security, Smart Metering, Smart Grids, Smart Regions, Smart Cities, Energy Efficiency and Climate change mitigation strategies, Energy storage, Behavior, Engagement and Acceptance

Energy Technology *Department of the Energy Institute, Johannes Kepler University Linz*

Topics: Technology Development and Assessment: Second generation Biofuels, Biorefinery technology development: First implementation in Austria, Life cycle assessment based on ISO 14040/14044

Energy Law *Department of the Energy Institute, Johannes Kepler University Linz*

Topics: Data protection and national energy legislative, Smart Metering and privacy, Smart grid research, privacy issues.

Apart from highly distinguished research in various (inter-)national projects, the practical applicability of the efforts is a key focus of the Energieinstitut. This interdisciplinary orientation allows the Energy Institute to not only publish highly recognized contributions on various energy issues, but also enables us to be reputable keynote speakers at international conferences and roundtable discussions. The Energieinstitut holds close relationship with partners ranging from scientific institutes, universities and companies of all sectors. The scientific results of multiple projects and studies conducted by the Energy Institute have been the driving force for innovative solutions in the energy business. The Energy Institute at the Johannes Kepler University Linz is involved in multiple industry-related projects and conducts highly sophisticated, user-orientated research with partners from Upper Austria, Austria, the European Union and North- and South-America.