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

SWOT analysis of the role of renewable energy in RLS regions' energy transitions

April 2020

The RLS-Energy Network is a scientific network which conducts joint research and exchanges under the framework of the political forum called the Regional Leaders' Summit (RLS). It was initiated as a result of the 6th RLS meeting in São Paulo in 2012. It was agreed amongst the participants that the development of renewable sources of energy is a crucial issue that requires extensive research. Due to their unique geographical composition spanning over four continents, and in accordance with their research profiles, the RLS regions represent a strong potential in this field. Together, the RLS regions can cover all aspects of energy, from production to usage, monitoring to efficiency. The RLS-Energy Network is used as a means to bring together complementary strengths in energy research to be shared and further developed in a joint effort. These efforts, guided by a joint roadmap, will generate insights which may be useful for further developments, including policy. 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. These results may be achieved through: ▪ Regular exchange of scientific information between universities, research centres, industry, and public bodies within and between the regions. ▪ Identification of bi-and multilateral funding opportunities within and outside of the network. ▪ Joint research activities and joint participation in international research programs by the regions.

Regions can play a key role in the global energy transformation. RLS regions have made significant developments during the past years; others have established ambitious plans. In this context, the RLS-Energy Network has produced a report identifying and analysing strengths, weaknesses, opportunities and threats (SWOT) to analyse the role of renewable energy deployment in RLS regions' energy transitions. The report is organized into four sections. Section 1 offers information on the RLS Energy Network and its roadmap, the Regional Renewable Alliance. Section 2 gives a brief overview about energy transitions and builds the connection to the RLS regions. In Section 3, the SWOT analysis is undertaken. Section 4 provides a summary and gives recommendations for RLS regions' policymakers and the research community.

The SWOT was prepared by the Energieinstitut at the Johannes Kepler University (JKU) Linz and was financially supported by the Upper Austrian Government. Sebastian Goers was the coordinator and main author of this report. Fiona Rumohr (Bavarian Research Alliance) co-authored the report.

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The SWOT analysis builds on the Monitoring Report which was presented to the Heads of Government at the 9th Regional Leaders Summit in Québec in May 2018. The present analysis represents a key example of the connection between the scientific and political levels of RLS-Sciences. In this context, the RLS-Energy Network's lead scientists would like to thank the RLS-Sciences regions' political coordinators - Kristina Beck, Michael Hinterdobler, Sebastian Röhrig (Bavaria), Mary Waters (Georgia), Alexandra Berranini (Québec), Andrey Brito (São Paulo), Margot Nazzal (Upper Austria) and Roderick Thyssen (Western Cape) - and the RLS-Sciences administrative coordinators - Véronique Baril (Québec), Guo Xiaohong (Shandong) and Christian Kolarik (Upper Austria) - for the direct exchange on energy transitions in the RLS region during the RLS-Energy Network Workshop and the Québec Network on Smart Energy meeting on November 19th, 2019 in Québec City.

This study, together with the Monitoring Report on Renewable Energy in the RLS Regions (May 2018), formed the basis for the scientific publication:

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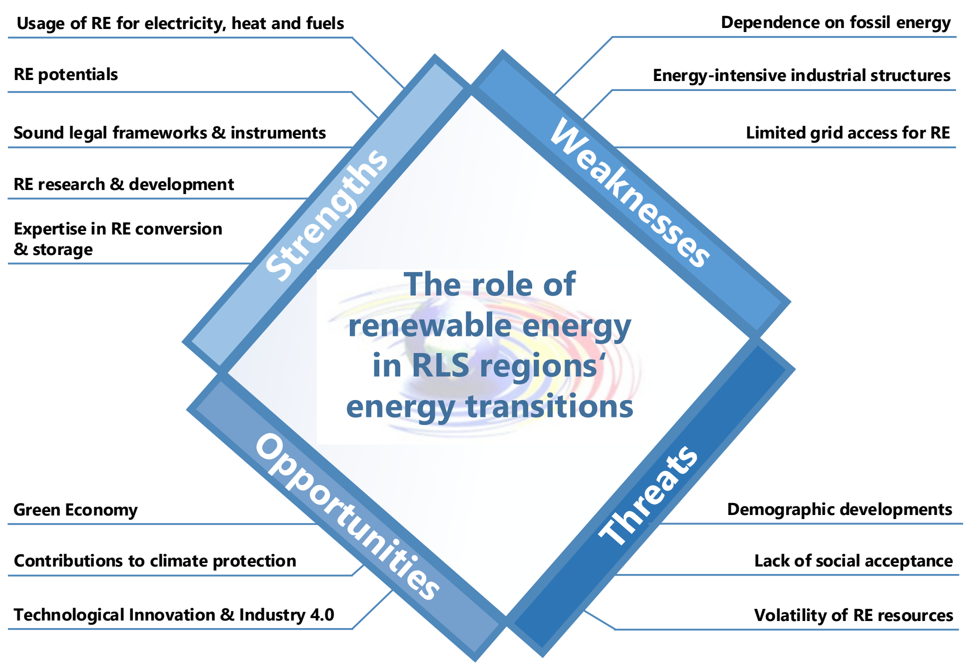
Summary

At the 9th RLS Conference in Québec City in May 2018, the heads of governments and representatives of the political level of the partner regions Bavaria (Germany), Georgia (USA), Québec (Canada), São Paulo (Brazil), Shandong (China), Upper Austria (Austria), and Western Cape (South Africa) signed "The Québec Joint Declaration on Energy Transition". This declaration highlighted the political commitment at the regional level, with a goal for the regions to become leaders in energy transition by 2030. It referred specifically to renewable energy and energy efficiency with the further aim of building a ''new, strong, low-carbon economy''. In this context, the RLS-Energy Network has produced a report detecting and exploring strengths, weaknesses, opportunities and threats (SWOT) to analyse the role of renewable energy deployment in RLS regions' energy transitions. The current SWOT analysis reveals that the current usage of renewable energy for electricity, heat and fuel production, existing renewable energy potentials, sound legal frameworks and instruments to support renewable energy, ongoing research and development activities and the expertise in renewable energy conversion and storage strengthens the role of renewables within RLS regions' energy transitions. Further, deployment of renewables promises multiple benefits, ranging from economic growth and job creation to the mitigation of climate change and technological innovation.



However, to be impactful, the energy system transformation requires an overall approach, engaging all levels of the society – from governments to stakeholders from the public and private sectors. Hence, conclusions and recommendations for policymakers, for R&D and with regard to green economy and social acceptance issues are derived.

1 Roadmap: Regional Renewable Alliance

The roadmap, the Regional Renewable Alliance (RRA), established a permanent scientific group under the umbrella of the Regional Leaders' Summit (RLS). The partner regions Bavaria (Germany), Georgia (USA), Québec (Canada), São Paulo (Brazil), Shandong (China), Upper Austria (Austria), and Western Cape (South Africa) launched a scientific partnership that combines state-of the-art conversion and storage technologies and substantial resources of wind, hydro, solar and biomass resources.

1.1 Motivation

The transition of the world's energy systems towards carbon-neutrality, with a significant increase of renewable energy, is a global trend with outstanding dynamics. Furthermore, the high cost and restricted sources of fossil fuels, in addition to the necessity to diminish greenhouse gasses emissions, have strengthened the role of renewable resources in energy - based economies. Renewable energy resources provide a vast potential to satisfy the world's energy demand and will have a significant share in the future global energy portfolio.

The seven RLS partner regions of Bavaria, Georgia, Québec, São Paulo, Shandong, Upper Austria and the Western Cape are leading expert stakeholders in their countries, regions and continents with unique growth rates and exemplary technical, scientific and, in particular, renewable energy resources. Further, 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 the regional energy transitions and future markets are not only the efficient and cost effective conversion of renewable energy sources 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 countries of the consortium members host all of the relevant energy sources and have already established large capacities at exemplary growth rates in the last years. The roadmap evaluates how renewable energy resources are currently being used in the RLS partner regions and aims at displaying the regions' scientific developments to improve the use, future prospects, and deployment of renewable energies.

1.2 Objectives and current results

The roadmap for the Regional Renewables Alliance started with a **preparatory phase**. This first stage targeted the most promising technologies and implementation strategies of the RLS regions' energy transitions in order to prepare an implementation and demonstration phase. The preparatory phase created and widened networks, personal contacts and it is promoting the exchange of knowledge, technologies and human resources between the partner stakeholders. Workshops and conferences are bringing key players together and defining rules and funding schemes for the roadmap's final **implementation and demonstration phase of new joint R&D projects** between the RLS partner regions.

In order to facilitate the preparation of joint transnational research and innovation projects and to promote the joint development of key technologies for supporting the RLS regions' energy transitions, the following actions were undertaken:

- Investigation of renewable energies' status quo and potentials (Work Package 2, "Monitoring Report")
  - → ***Release of 1st Monitoring Report at the 9th Regional Leaders Summit, Québec, 2018***

    https://www.rls-energynetwork.org/news-and-events.html

    https://www.rls-energynetwork.org/uploads/5/5/4/4/55448469/rls_energy_network_-_rra_monitoring_report_may_2018.pdf
- Implementation of an "Energy systems analysis" and a "Regional science and technology map" of the partner regions (Work Packages 3 and 4) and
  - → ***Direct RLS activities and events with participation of RLS Energy Network researchers***
    - ***iSEneC 2016 (Nuremberg, July 2016)***
    - ***"Journée de la recherche" (Montreal, April 2017)***
    - ***WindAc Africa 2017 (Western Cape, November 2017)***
    - ***Upper Austrian / Bavarian Stakeholder Workshop, Forum Econogy (Linz, December 2017)***
    - ***ClimEx workshop (Québec City, May 2018)***
    - ***Meeting with the Hydrogen Research Institute (Québec City, May 2018)***
    - ***Workshop at the 9th RLS Conference (Québec City, May 2018)***
    - ***Masterclass in 'Power to the Molecules ' (Linz, March 2019)***
    - ***Workshop ' Green Gas ' (Nuremberg, May 2019)***
    - ***RLS-Energy Network meeting (focus on renewable energy conversion and storage, climate-energy-nexus, energy transitions, smartness of energy systems) (São José dos Campos, May 2019)***
    - ***RLS-Energy Workshop and the Québec Network on Smart Energy: International collaboration in energy research (Québec City, November 2019)***

    https://www.rls-energynetwork.org/news-and-events.html

- Cooperation on training courses, scholarships and summer schools (Work Package 5)

  → ***Inaugural international summer school on renewable energy of the RLS-Sciences Renewable Energy Network, Québec, 2018***

  http://www.frqnt.gouv.qc.ca/en/espace-presse/calendrier-d-evenements/evenement/international-summer-school-on-renewable-energy-of-the-rls-energy-network-6bgnwa4w1519754663937

  → ***RLS-Energy Network participation at the Young Energy Researchers' Conferences of the World Sustainable Energy Days, Upper Austria, 2019***

  https://www.wsed.at/en/reviews/wsed-2019.html

  https://www.rls-energynetwork.org/news-and-events.html

  → ***RLS-Energy Network participation at the Young Energy Researchers' Conferences of the World Sustainable Energy Days, Upper Austria, 2020***

  → https://www.wsed.at/en/programme/young-energy-researchers.html

  → https://www.rls-energynetwork.org/news-and-events.html

The objective is to 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.

Figure 1: Preparatory phase and implementation and demonstration phase of the RLS-Energy Network's roadmap Regional Renewables Alliance

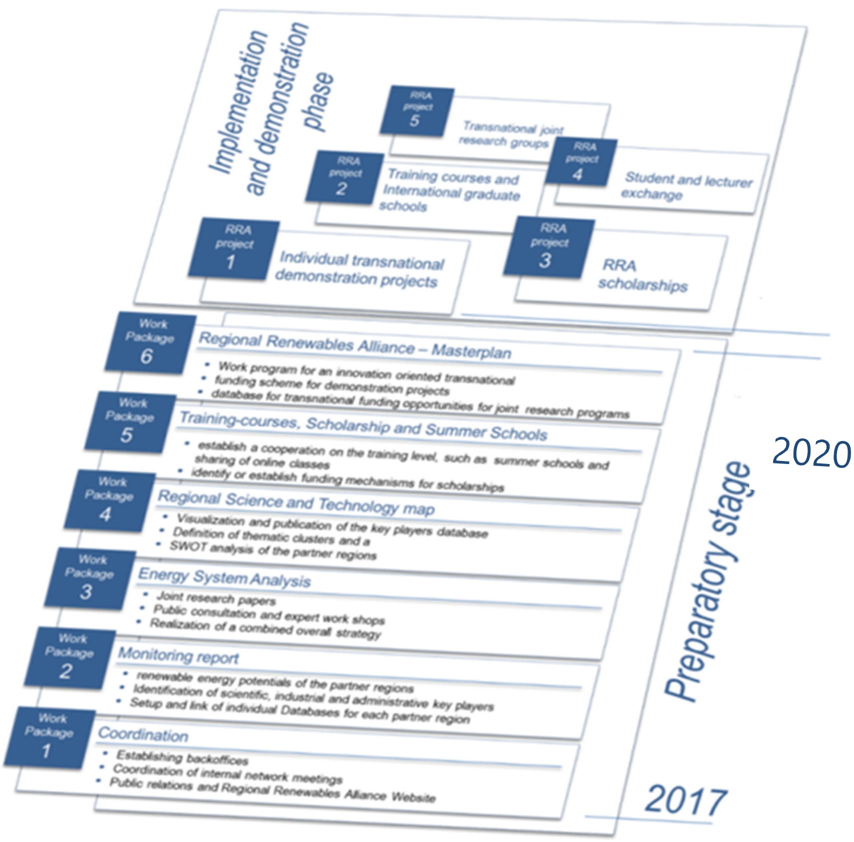


Table 1: Work packages of the RLS-Energy Network's roadmap Regional Renewables Alliance (status as of March 2020) – preparatory phase

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 **- completed -**	**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 **- in progress -**	**Energy System Analysis** 3.1 Research papers 3.2 Public consultation and expert workshops 3.3 Development of overall strategy
N° 4 **- in progress -**	**Regional Science and Technology Map** 4.1 Visualization and publication of database with key players 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 funding 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

2 Energy transitions in the context of RLS

2.1 Theoretical framework

Sustainability Transitions can be defined as ''long-term, multi-dimensional and fundamental transformations of large socio-technical systems towards more sustainable modes of production and consumption'' (Markarda et al., 2012). However, sustainability has no universally agreed upon definition, and is a normative concept; all sustainability transitions, regardless of scale or system, will involve value choices and trade-offs. Geels (2010) shows that, in navigating decisions about a collective future, "sustainability transitions will be full of debates about the relative importance of various environmental problems, which entail deep-seated values and beliefs". In this framework, the intersection between science and policy becomes increasingly important, and "public authorities and civil society will therefore be crucial drivers for sustainability transitions" (Geels, 2010). While science can provide information about the likely outcomes of particular choices or pathways of society, it is important to acknowledge the role of the political and civil society actors in such transitions, particularly in light of these value trade-offs.

The energy transition can be argued to be an example of a sustainability transition, specifically a transition of a socio-technical system. Socio-technical systems, which are made of established technologies, "highly intertwined with user practices and life styles, complementary technologies, business models, value chains, organizational structures, regulations, institutional structures, and even political structures", tend to undergo "incremental rather than radical changes" (Markarda et al., 2012). The high level of interconnectivity, coupled with existing lock-ins and path dependencies, mean that navigating sustainability transitions and changes to socio-technical systems must address "sunk investments, behavioural patterns, vested interests, infrastructure, favourable subsidies and regulations" (Unruh, 2000). In order to create relevant information for societies navigating these transitions, the systems must therefore be addressed in research from an interdisciplinary perspective.

2.2 Regional Leaders Summit and RLS-Sciences

The Regional Leaders Summit (RLS) is a multilateral political forum of seven partner regions: Bavaria (Germany), Georgia (USA), Québec (Canada), São Paulo (Brazil), Shandong (China), Upper Austria (Austria), and Western Cape (South Africa). Since 2002, the heads of government of these regions have met every two years for a political summit. These summits offer the RLS regions an opportunity for political dialogue. On April 12th, 2012, on the occasion of the Sixth Regional Leaders Summit in São Paulo, the RLS Member States adopted a Final Declaration which included the following commitment (Item 12):

> ''*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.''

This was the impetus for the creation of the RLS-Energy Network. The RLS-Energy Network served as the pilot project for RLS-Sciences, which was established in 2016. Upon the establishment of RLS-Sciences, four themes- including energy- were identified as having the highest potential for cooperation among the parter regions. These four themes developed into the four RLS-Sciences projects. RLS-Sciences is a scientific and research network operating under the framework of RLS. RLS-Sciences seeks to leverage the unique composition and strengths of the RLS network to support scientific research within and between the RLS regions. It works to generate and support academic, scientific, and technological exchanges, and the initiation of multilateral research projects.

At the 9th RLS Conference, the heads of government and representatives of the political level signed "The Québec Joint Declaration on Energy Transition". This declaration highlighted the political commitment at the regional level, with a goal for the regions to become leaders in energy transition by 2030. The document refers specifically to renewable energy and energy efficiency with the further aim of building a ''new, strong, low-carbon economy''. The declaration references not only the economy to be changed as a result of energy policies, but health and quality of life as well. The political leaders mandated the RLS-Energy Network to undertake work to support such a transition, identifying three main tasks. First, the sharing and exchange of expertise and information regarding renewable energy and energy efficiency, including expanding the dialogue around these topics (MRIF, 2018). Second, to ''identify opportunities for cooperation between the regions'', and third to, ''suggest actions energy leaders can take'' before the 10th RLS Conference in 2020 (MRIF, 2018).

2.3 RLS-Energy Network and the Regional Renewables Alliance

The RLS-Energy Network established the Regional Renewables Alliance in order to jointly conduct 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 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 favourable 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. The Regional Renewables Alliance aims to develop human and knowledge resources within the network, and to undertake research, pilot, and demonstration projects to improve and create energy storage and generation technologies. In this framework, a joint roadmap was developed in 2016 to guide these efforts. The roadmap brings together researchers to produce knowledge about the seven RLS regions, train young researchers and young professionals within an international and interdisciplinary framework, and develop the conditions to generate joint research projects.

The efforts and results generated from the RLS-Energy Network can support energy transitions in the RLS regions, through interdisciplinary knowledge production and training, as well as targeted exchanges from the different regional and academic perspectives brought by the network's partners.

3 SWOT analysis

3.1 Methodology

A SWOT analysis is a structured planning method used to evaluate the strengths (S), weaknesses (W), opportunities (O), and threats (T) involved in a project or in a business venture. It involves identifying the objective of the business venture or project and recognizing the internal and external factors that are advantageous and disadvantageous to accomplish that objective. See Weihrich (1982), Hill and Westbrook (1997) and Valentin (2001) for a detailed description of the SWOT analysis methodology. SWOT analysis is often used as part of a strategic or business planning process, but can be useful in understanding an organization or situation and decision-making for all sorts of scenarios.

The degree to which the internal environment of the undertaking matches with the external environment is expressed by the concept of strategic fit:

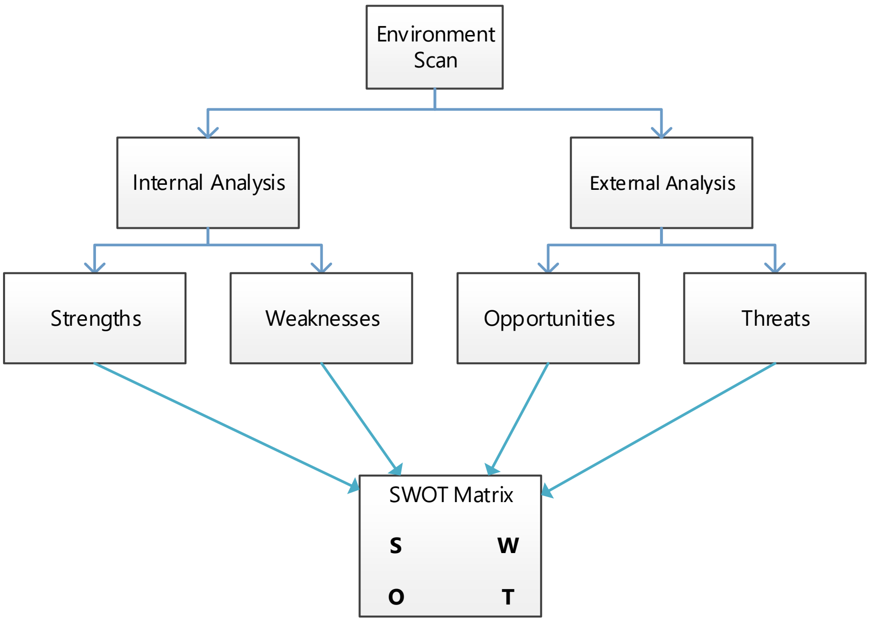
- ***S**trengths:* characteristics of the project that give it an advantage over others
- ***W**eaknesses:* characteristics that place the project in a disadvantageous position relative to others
- ***O**pportunities:* elements that the project could exploit to its advantage
- ***T**hreats*: elements in the environment that could jeopardize the project

Hence, the SWOT analysis involves systematic thinking and can offer a comprehensive diagnosis of factors which influence a new product, technology, management or planning. Drawing from Kahraman et al. (2008) and Görener et al. (2012), the SWOT analysis builds the outcome of an environment scan as displayed in Figure 2.

Identification of SWOTs is important because they can inform later steps in planning to achieve the objective. The 'SWOT' itself is not only a data collection tool/method – it is a (subjective) assessment of data which is organized by the SWOT format into a logical order that helps understanding, presentation, discussion and decision-making.

It should be noted, that the SWOT comprises no methods of analytically defining the importance of the factors or of evaluating the decision alternatives with regard to the factors (Kangas et al. 2003). Recent studies link the SWOT with the analytic hierarchical process (AHP) concept in order to compare more detailed elements and provide a quantitative basis in the strategic planning process. AHP is an effective decision-making technique primarily when subjectivity is present and it is appropriate to solve problems where the decision factors can be structured in a hierarchical way into sub-sections (Saaty 1980).

Figure 2: Framework of SWOT analysis



Source: Own compilation based on Kahraman et al. (2008) and Görener et al. (2012).

In our approach, we perform the SWOT analysis with the assistance of a matrix. At first, there is a blank matrix with four divisions (strengths, weaknesses, opportunities, threats) as displayed in Table 2.

Table 2: Blank SWOT matrix

Internal **strengths**	Internal **weaknesses**
Positive - *helpful for achieving the objective*	Negative - *harmful for achieving the objective*
External **opportunities**	External **threats**
Positive - *helpful for achieving the objective*	Negative - *harmful for achieving the objective*

Source: Own compilation.

Users of SWOT analysis need to ask and answer questions that generate meaningful information for each category (strengths, weaknesses, opportunities, and threats) to make the analysis useful and find their competitive advantage(s). The objective in the SWOT analysis being undertaken here is to identify the role of renewable energy within the energy transitions envisaged by the RLS regions. Supportive questions for identifying relevant content for each section are displayed in Annex I.

These questions were classified via an exhaustive literature review of available SWOT analyses with regard to renewable energy implementation in different regions of the world (see Annex II) and in consultation with scientific and policy expert stakeholders from the seven partner regions through strategic conference calls and meetings of the RLS-Energy Network.

Filling in the sections to answer the questions can be done by interviews with experts, brainstorming, data analysis and literature reviews. We rely on the RLS-Energy Network's Monitoring Report which illustrates data and information on renewable energy with regard to the regulatory framework, status quo, potentials and research and development activities in the RLS regions. Geographic, climate, demographic, macroeconomic and national context data complement the database.

In Table 3, related arguments are summarized and categorized according to their significance, starting with the most significant argument. The listings of arguments, as well as their ranking, are subjective; however, they nevertheless reflect the collected data and information revealed during the monitoring process of renewable energy in the RLS regions.

3.2. Results

The present SWOT analysis focuses on contributions that renewable energy can make to the energy transitions of the respective RLS regions. It should be noted that the analysis is aggregated and does not target individual regions. Thus, depending on the region, there may be deviations with respect to the internal and external analyses.

Regions can play a key role in the global energy transformation. RLS regions have made significant developments during the past years; others have established ambitious plans. They are already making individual contributions to the processes of building sustainable and low-emission energy systems.

The present analysis is not so much a question of defining singular steps, but of unifying regional visions with regard to global transformation and thus further accelerating it. Through multilateral structure and multi-level governance within the RLS-Energy network, best practice approaches can be presented holistically and they can help to assess how regions can learn from each other.

Table 3: SWOT analysis for the support of renewable energy (RE) within the RLS regions' energy transitions

Internal **strengths**	Internal **weaknesses**
- Usage of RE for electricity, heat and fuels - RE potentials - Sound legal frameworks & instruments for RE - RE research & development - Expertise in RE conversion and storage	- Dependence on fossil energy - Energy-intensive industrial structures (which require stable energy supply historically supported by fossil fuels) - Limited grid access for RE
External **opportunities**	External **threats**

- Green economy
  - Employment (green jobs)
  - Economic growth (green economy)
- Contributions to climate protection
- Technological innovation & Industry 4.0
	- Demographic developments
	- Lack of social acceptance
	- Volatility of RE resources

Source: Own compilation.

3.2.1 Internal analysis

3.2.1.1 Strengths

3.2.1.1.1 Usage of renewable energy for electricity, heat and fuels

A central strength is that the RLS regions, as they seek to move towards a cleaner and more sustainable energy mix, exhibit an intensified use of renewable energies. The regions are very diverse in terms of their population, size and their economic, social and political characteristics, and therefore in their energy systems. The monitoring of data and information revealed that the RLS partner regions include all main renewable energy sources in their collective energy portfolio 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 systems and utilize them for electricity (see Table 4), heat (see Table 5 and Table 6) and fuel (see Table 7) production. This shows that the regional energy systems have common strengths as they advance in the deployment of renewable energy.

Table 4: Electricity generation in selected RLS partner regions, 2015

	Bavaria	**Québec**	**São Paulo**	**Shandong**	**Upper Austria**
	[2015]	**[2015]**	**[2015]**	**[2015]**	**[2015]**
Total (MWh)	**86.2**	**202.0**	**-**	**468.5**	**14.0**
Fossil	**29.6%**	**1.4%**	**3.3%**	**-**	**26.5%**
Renewable	**70.4%**	**98.6%**	**96.7%**	**-**	**73.5%**
Biomass	18.2%	0.9%	31.6%	-	6.9%
Hydro	23.4%	93.4%	65.1%	-	64.7%
Wind	5.8%	4.2%	0.0%	-	0.6%
Solar	23.0%	0.0%	0.0%	-	1.3%
Coal				*97.2%*	
Others				*2.8%*	

Notes: '-' : no data available during the monitoring process; rounded values
Sources: Own calculation based on Bradshaw and de Martino Jannuzzi (2019) and RLS-Energy Network Monitoring Report (2018)

Table 5: Installed solar thermal collectors and active generated annual heat in selected RLS regions, 2016

		Bavaria [2016]	Upper Austria [2016]
Total installed solar thermal collectors	*m^2*	6,295,500	1,429,000
Solar thermal collectors per 1,000 capita	*$m^2/1,000$*	487	1,000
Active generated annual heat	*GWh*	2,556	500

Note: '-' : no data available during the monitoring process; rounded values
Source: Own calculation based on RLS-Energy Network Monitoring Report (2018)

Table 6: Heat yield from biomass in selected RLS regions, 2014/2015

		Bavaria [2014]	Québec [2015]	São Paulo [2015]	Upper Austria [2015]
Solid biomass	*PJ*	112	6	951	42
Liquid and gaseous biomass	*PJ*	94	0	421	18
Total	*PJ*	205	6	1,372	60

Note: '-' : no data available during the monitoring process; rounded values
Source: RLS-Energy Network Monitoring Report (2018)

Table 7: Usage of biofuels for transportation in selected RLS regions, 2014/2015

		Bavaria [2015]	Québec [2014]	São Paulo [2015]	Shandong [2015]	Upper Austria [2015]
Total biofuels for transportation	*PJ*	18	10*	261	35	51
Share of renewable fuels	*%*	-		27	-	7.6

*Notes: * data for ethanol consumption; '-' : no data available during the monitoring process; rounded values*
Source: Own calculation based on RLS-Energy Network Monitoring Report (2018)

3.2.1.1.2 Potentials of renewable energy resources

In addition to the current status of renewable energy endowment and deployment, untapped renewable energy sources are also a strength for the supporting role of renewable energy in a regional energy transition. The availability of certain renewable energy resources allows for long-term planning with regard to the regional energy transitions. Within the monitoring activities, potentials for particular renewable energy sources were detected. As outlined in Verbruggen et al. (2010), the notion of renewable energies' potentials is not a well-defined concept. Following Verbruggen et al. (2010), most publications prefer theoretical, geographical, technical potentials and their assessment of policy relevant potentials is minimal. Within the Monitoring Report, a specific concept of renewable energy resource potentials could not be applied due to limited data availability. The displayed potentials (see Table 8) refer mainly to targets of particular renewable energy sources within regional strategies.

3.2.1.1.3 Legal frameworks & instruments for renewable energy

Several RLS governments need to reach specific national and regional targets for renewable energy, and have designed incentive programs to reach these programs. Accordingly, they have created research and development programs to help reach these targets (see Table 9). The reasons for supporting the development of renewable energy for governments and industry include contributing to national and local energy supply, the creation of additional employment and economic development, building a regional and national industry, and 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 on existing legislation and appear in roadmap documents. Some regions have specific goals or targets for renewable energy generally as well as for specific technologies.

3.2.1.1.4 Research & Development

Research & Development (R&D) plays a significant role in making renewable energy technology more cost-competitive and consistent. 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. Ambitious plans exist to expand renewable energy development. These plans will need specific and continued R&D to be accomplished. Achieving the planned objectives will require public and private R&D funding carefully targeting the topics that will most likely accelerate renewable energy deployment, including as resources, technology, operations, environmental impacts, and social-economic issues. Within the RLS regions, R&D activities in the field of renewable energy, its conversion, storage and transportation are taking place, and are presented comprehensively in the Monitoring Report.

Table 8: Existing potentials and targets of renewable energy resources

	Bavaria	São Paulo	Shandong	Upper Austria
Wind	-	*Installed capacity of* •+ 603 MW in 2030	*Installed electricity capacity* •14 GW in 2020 •23 GW in 2030	*Installed capacity of* •+ 30 MW in 2030
Solar thermal	-	-	-	-
Photovoltaic	*Installed capacity of* •+ 14,000 MW in 2030	-	*Installed electricity capacity* •10 GW in 2020 •25 GW in 2030	*Electricity production* •800 – 2,600 GWh in 2030
Biomass	-	*Total heat* •18,300 PJ in 2020 *Total electricity* •87 MWh in 2020	*Installed electricity capacity* •2 GW in 2020 •5 GW in 2030	-
Hydro	*Electricity production* •14,500 GWh in 2021	*Electricity production* •70,000 GWh in 2020 •73,000 GWh in 2030	*Installed electricity capacity* •1 GW in 2020 •8 GW in 2030	*Electricity production* •+ 488 GWh in 2030

Notes: '-' : no data available during the monitoring process; rounded values
Source: Own compilation based on Liu et al. (2017) and RLS-Energy Network Monitoring Report (2018)

Table 9: Policy frameworks

<u>Bavaria</u> Bavarian Energy Concept *Renewable Energy Law (national)*	**<u>Shandong</u>** Shandong province electric power development plan in the 13th Five-Year
<u>Georgia</u> Public, private, philanthropic partnerships that utilize state assets to test innovative technologies and test business models in the areas of renewable energy, transportation and sustainability.	**<u>Upper Austria</u>** Climate and location-oriented Upper Austrian Energy Strategy 'Energie-Leitregion OÖ 2050' Wind Power Master Plan *Green Electricity Regulation (national)*
<u>Québec</u> Politique énergétique 2030 (PE2030) Plan d'actions 2013-2020 sur les changements climatiques	**<u>Western Cape</u>** Renewable Energy Independent Power Producers Procurement *Program Integrated Energy Plan / Integrated Resources Plan (national)*
<u>São Paulo</u> São Paulo State Energy Plan - PPE / 2020	

Source: Own compilation based on RLS-Energy Network Monitoring Report (2018)

3.2.1.1.5 Expertise in renewable energy storage and system integration

Key technologies for a successful implementation of energy transitions are not only those for the efficient and cost effective conversion of renewables into electricity or heat. Storage of renewable energies 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.

Due to 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 mobility based on renewable energy will play an increasing role as the energy transition accelerates. This dynamic shift has served to highlight the need for numerous new technologies, market designs, business models and systems thinking at the energy sector level. Forecasts foresee that these will become cost-effective 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. As such, the role of battery energy storage systems for stationary and transport applications is gaining prominence.

Several studies, which are illustrating 100 % scenarios of energy supply of 100 % from renewables highlight the strong connection between power, gas and heat. This leads automatically to hybrid networks in order to “re-cycle” losses in one energy system as useable sources for another network.

Regarding the implementation of hybrid grids, new technologies have been developed that enable a much stronger link between the three grids mentioned earlier. Technologies like Power-to-Gas, fuel cells, Stirling engines or new heat pumps have been 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 have reached their former limits. 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 - when 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.

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

- Increased 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 enhances the security of supply. On the other hand, the increased 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 systems. The development of hybrid networks might be cost-effective in the long term because of the increased resource efficiency and high-quality, secure supply of energy. The cost reduction leads to more competitive companies and could eventually lead to potential cost reductions for end costumers.

Based on that, significant foundations for a resource-optimized energy supply for 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 (transitions from one grid to another) are available and work accurately. Such technologies and their components include, for example:

- Electrolysis plants for producing hydrogen from water
- Storage of hydrogen in gas storages
- Methanation as 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

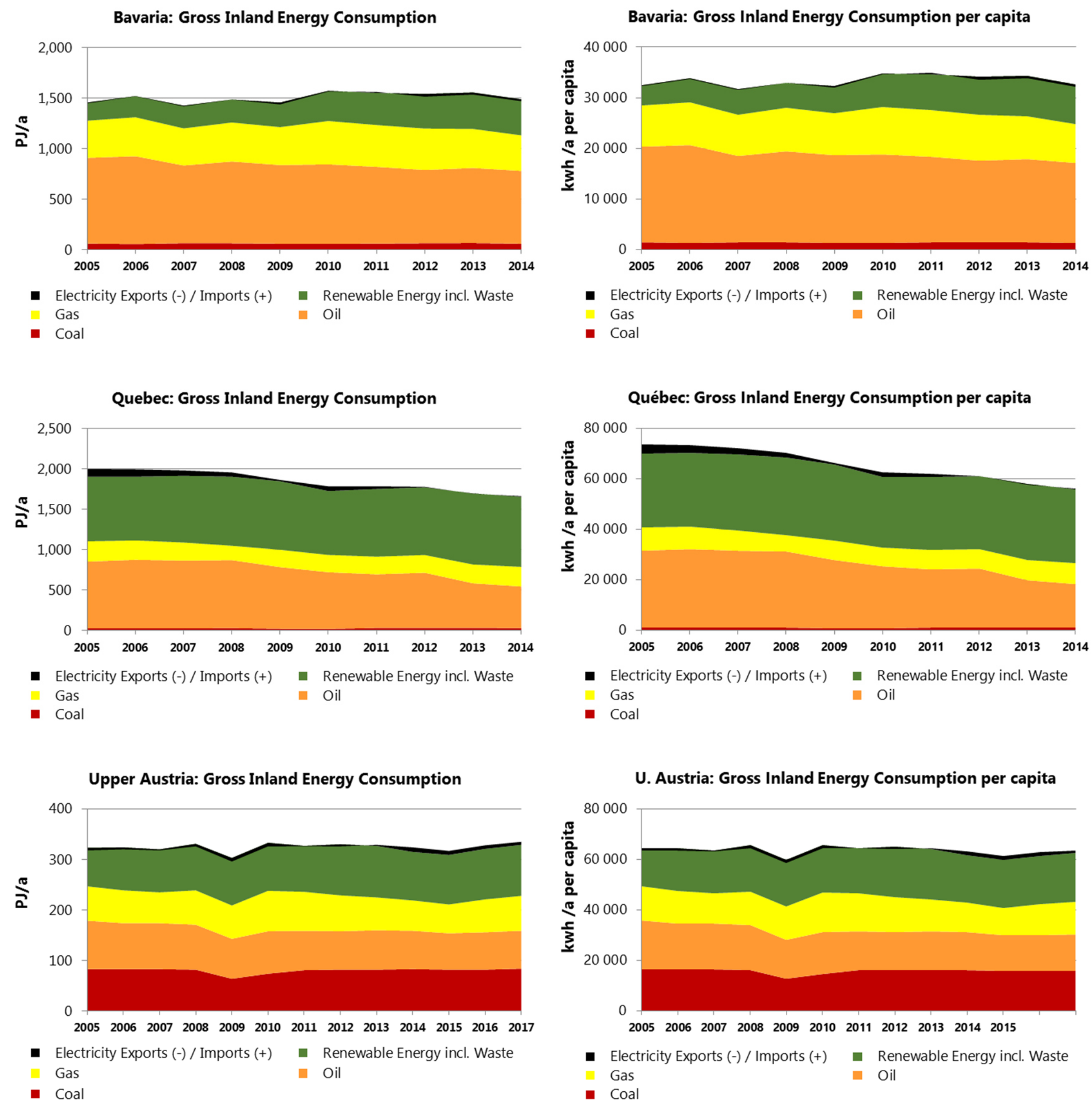
The development of these system components and the general progress of a new energy system is intensively stimulated and supported by research in the RLS regions.

3.2.1.2 Weaknesses

3.2.1.2.1 Dependence on fossil energy

Fluctuating oil and gas commodity prices have impacts on economies that import fossil fuels, and can badly affect their balance of payments and increase their vulnerability. Hence, energy security risks can be generated via energy market instabilities caused by unforeseen changes in geopolitical or other external factors, or compounded by fossil fuel resource concentration. Renewable energy can contribute to enhance security of supply when displacing fossil fuels. The examination of the gross energy consumption reveals certain levels of fossil energy dependence in selected RLS regions due to a share of fossil energy within their energy consumption (see Figure 3).

Figure 3: Absolute and per capita gross inland energy consumption in selected RLS regions



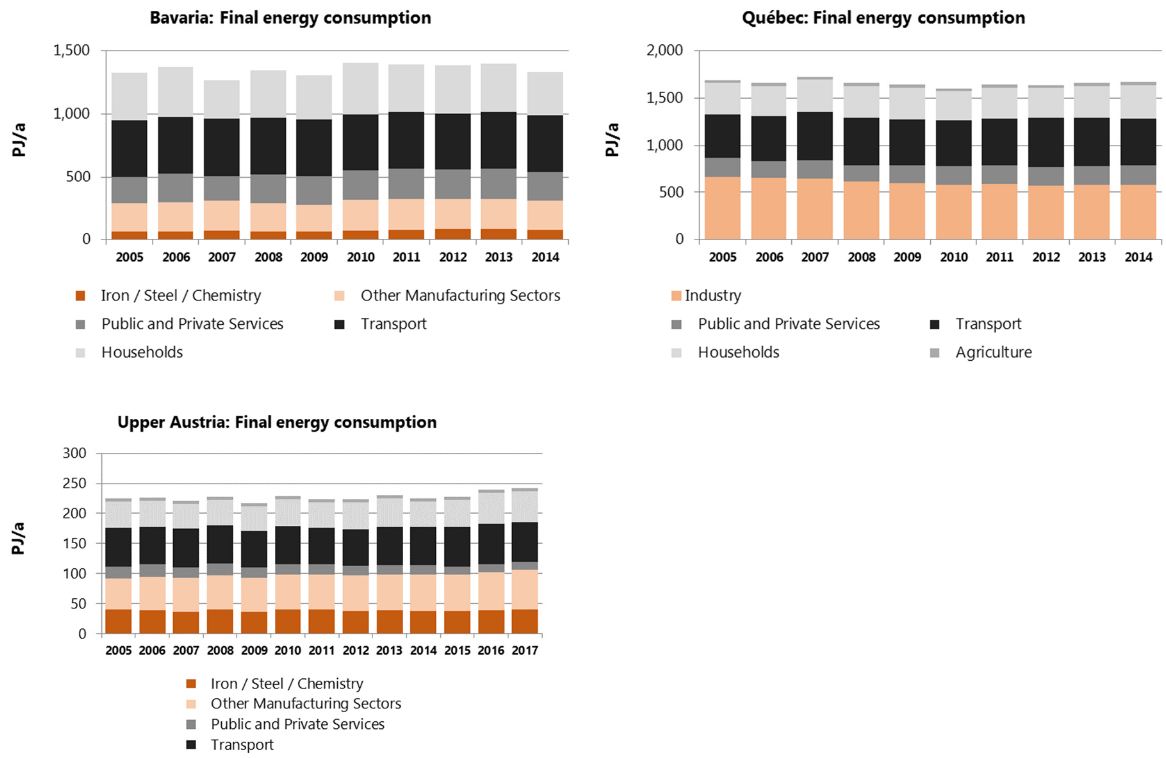
Source: RLS-Energy Network Monitoring Report (2018) and Dell (2019)

3.2.1.2.2 Energy-intensive industrial structures

Energy-intensive industries produce basic materials such as steel, cement, aluminum, fertilizers and plastics, and at present account for one-third of world-wide energy use. They contribute significantly to industrial processes which are responsible for the global emission of 37.1 billion tonnes of CO_2 in 2018 (Tolleffson 2018). Following Allwood et al. (2010), demand for manufactured goods is expected to at least double by 2050. Given the large gap between increasing demand for manufactured goods and the necessity for decreasing industrial CO_2 emissions, the implementation of low-carbon technologies in all energy intensive sectors is essential.

As displayed in Figure 4, industries contribute significantly to the final energy consumption of selected RLS regions. For example, the data for Upper Austria indicates a high share of the energy-intensive sector on final energy consumption.

Figure 4: Final energy consumption by sectors in selected RLS regions



Source: RLS-Energy Network Monitoring Report (2018) and Dell (2019)

As shown in Fischedick et al. (2014), the best available technologies can only diminish CO_2 emissions by 15–30% in energy-intensive industries, even if they are implemented on a large scale. Reductions beyond this implicate investments and central changes in the core processes used based on new 'breakthrough technologies' which will need further developments to become both technically and commercially feasible (Åhman et al., 2017).

As outlined in Nabernegg (2017), there exist various options to decarbonize energy intensive industries, including: (i) intensifying energy efficiency; (ii) switching from fuel combustion to electricity; (iii) substituting fossil fuels by renewables; (iv) a reduction in industrial process emissions by replacing raw material inputs or by a switch of the process itself; (v) product innovations; and (vi) carbon sequestration and reuse.

3.2.1.2.3 Limited grid access for renewables

While small penetrations of renewable generation on the grid can be smoothly integrated, accommodating major electricity generation from renewable sources will require new approaches to extending and operating the grid. The variability of renewable resources, due to characteristic weather fluctuations, introduces uncertainty in the generation output. Although aggregation over large areas mitigates the variability of individual assets, there remain uncertainties in renewable generation that are greater than the relatively predictable uncertainties in demand that the grid deals with regularly at present. Greater uncertainty and variability can be dealt with by switching-in fast-acting conventional reserves as needed on the basis of weather forecasts on a minute-by-minute and hourly basis, by installing large scale storage on the grid or by long distance transmission of renewable electricity enabling access to larger pools of resources in order to balance regional and local excesses or deficits. As renewable penetration grows, storage (see Section 3.2.1.1.5) and transmission will likely become more cost effective and necessary.

3.2.2 External analysis

3.2.2.1 Opportunities

3.2.2.1.1 Green economy

Economic growth and employment are currently on top of the political agendas of the RLS regions. The Green Economy is an economic system oriented towards ecological sustainability, economic profitability and social inclusion that does not exceed physical limits in the medium and long term and secures employment. To achieve this, the transformation of the economic system into a sustainable economy that is both competitive and sustainable needs to be environmentally and socially compatible as well. This "greening" of the current economic system is a first important step towards ecological, economic and social sustainability and achieving social objectives (OECD, 2011).

The major theme of the green economy is economic activities aimed at preserving and restoring the ecological system. Products and services of a green economy are (i) environmentally friendly and sustainable, (ii) based on renewable energies, (iii) include environmentally friendly fuels and modes of transport and (iv) are energy efficient. Further, the following criteria apply to the processes by which these products and services are produced: (i) energy-efficient production, distribution and design, (ii) reduction of energy, materials and water consumption through high efficiency and (iii) change from CO_2-rich to CO_2-poor technologies.

In order to achieve the medium- to long-term climate objectives, an immediate and permanent decoupling of economic development and greenhouse gas emissions is necessary. Such a decoupling, which also creates sufficient employment (see Section 3.2.2.1.2), is difficult to achieve without a fundamental transformation of the energy, economic and social system. By implementing the strategies of the Green Economy, using a targeted and intelligent mix of environmental framework conditions, long-term, ecologically oriented employment relationships can be created or maintained.

As displayed in Table 10, the data for Upper Austria in 2016 in the area of environmentally-oriented production and services show an environmental turnover of € 6.6 billion.

A fact-based knowledge of the driving forces behind green growth is necessary in order to be able to push this forward with targeted instruments in the fields of business, research, labor markets and innovation. This information must be collected and evaluated on a regular basis. Internationally recognized and comparable indicators (such as the share of eco-taxes in total tax revenue or material and energy productivity; OECD, 2014) should be used to assess whether a development towards green growth is taking place.

Table 10: Turnover in the green economy and resource management sector in Upper Austria

		2008	2009	2010	2011	2012	2013	2014	2015	2016
Total turnover	***m €***	**7,418**	**7,409**	**7,362**	**7,686**	**7,775**	**8,211**	**6,196**	**6,202**	**6,563**
Relative to GRP (nominal)	*%*	15.0	15.5	14.9	14.7	14.4	13.6	13.5	10.6	10.8
Environmental services	*m €*	2,578	2,671	2,470	2,480	2,243	2,504	1,986	1,942	1,903
Environmental goods	*m €*	3,386	3,282	3,415	3,619	3,777	3,961	2,629	2,672	2,912
Related goods	*m €*	*329*	*337*	*317*	*357*	*379*	*448*	*579*	*574*	*573*
Environmentally friendly goods	*m €*	*3,057*	*2,945*	*3,099*	*3,262*	*3,398*	*3,515*	*2,050*	*2,099*	*2,339*
Environmental technologies	*m €*	1,454	1,456	1,477	1,587	1,756	1,746	1,581	1,588	1,748
End-of-pipe technologies	*m €*	*432*	*338*	*298*	*349*	*418*	*511*	*365*	*345*	*412*
Integrated Technologies	*m €*	*1,022*	*1,118*	*1,179*	*1,238*	*1,338*	*1,235*	*1,216*	*1,243*	*1,336*

Source: Own compilation based on Statistik Austria (2018)

3.2.2.1.2 Green jobs

Renewable energy has a verified impact on job creation effect. The positive effect on job creation of renewable energy is a consequence of long and diverse supply chains, labor intensity, and high net profit margins (ILO, 2019; UNEP, 2011; WWF, 2009). The International Renewable Agency (IRENA, 2018b) classifies three employment categories:

(1) Direct employment comprises jobs which are generated in the renewable energy sector, without considering the employment generated in the value chain of other manufacturing industries.

(2) Indirect employment classifies jobs which are created in secondary sectors of activity, which are not directly linked to the renewable energy sector yet contribute to its main activities.

(3) Induced employment is generated in other sectors of activity, which are not linked to the main and secondary renewable energy sectors and their corresponding value chains.

This employment results from the increase in the income of workers in sectors directly or indirectly related to renewable energies (e.g., jobs created in unrelated service sectors such as leisure).

Organisation for Economic Co-operation and Development's (OECD) work on SMEs, entrepreneurship and innovation (OECD, 2019) indicates that there will be a requirement for new types of skills to match novel categories of employment, as industry is shifts to a low-carbon economy. The number of green and silver jobs is estimated to increase and there will be a noticeable change towards business services jobs in advanced economies. These high-level green skills will be required to adapt to the green transformation of the economy. Green skills comprise specific skills to adapt products, services or operations due to climate change.

Of course, as the demand for energy from renewable sources grows, a corresponding decrease in the demand for oil, coal, and gas can be expected. However, studies demonstrate that renewable energy projects can counterbalance job losses from a decline in extractive industries and can in turn create a net employment expansion (OECD, 2017). As stated by Ortega et al. (2015), the employment being generated can be measured as gross jobs (the number of total jobs being generated) or as net jobs (jobs created in one sector minus those destroyed in other sectors which use competing generation technologies).

Renewable energy is a major key for the undergoing energy transitions in the RLS regions and is being extended continuously. The development of those markets has led to an increase in the number of related jobs. Exemplarily, current data of green jobs and renewable energy employment for Upper Austria and Bavaria is displayed in Table 11. For Shandong, the renewable energy equipment manufacturing industry will provide more than 300.000 jobs (Liu et al., 2017).

Table 11: Renewable energy (RE) jobs in Bavaria / Green jobs in Upper Austria

RE jobs in Bavaria	2016	Green jobs in Upper Austria	2016
total *[employees]*	50,650	green jobs – total *[employees]*	35,572
Wind *[employees]*	12,920	Relative to total employees *[%]*	5.6
Solar *[employees]*	8,740	Environmental services *[employees]*	11,164
Bioenergy *[employees]*	21,270	Environmental goods *[employees]*	17,727

Source: Own compilation based on Ulrich and Lehr (2016) and Statistik Austria (2019).

3.2.2.1.3 Contributions to climate protection

Renewable energy plays a key role in the decarbonisation process of energy systems and the resulting mitigation of climate change effects. Demand for energy and related services, particularly to support social and economic development and advance human welfare and health, is growing. All societies have need of energy services to meet basic human requirements (e.g. lighting, cooking, space comfort, mobility, communication) and to serve productive processes. Since approximately 1850, global use of fossil fuels (coal, oil and gas) has increased to control energy supply, leading to a rapid growth in CO_2 emissions. Recent data confirm that consumption of fossil fuels accounts for the majority of global anthropogenic GHG emissions (IPCC, 2011).

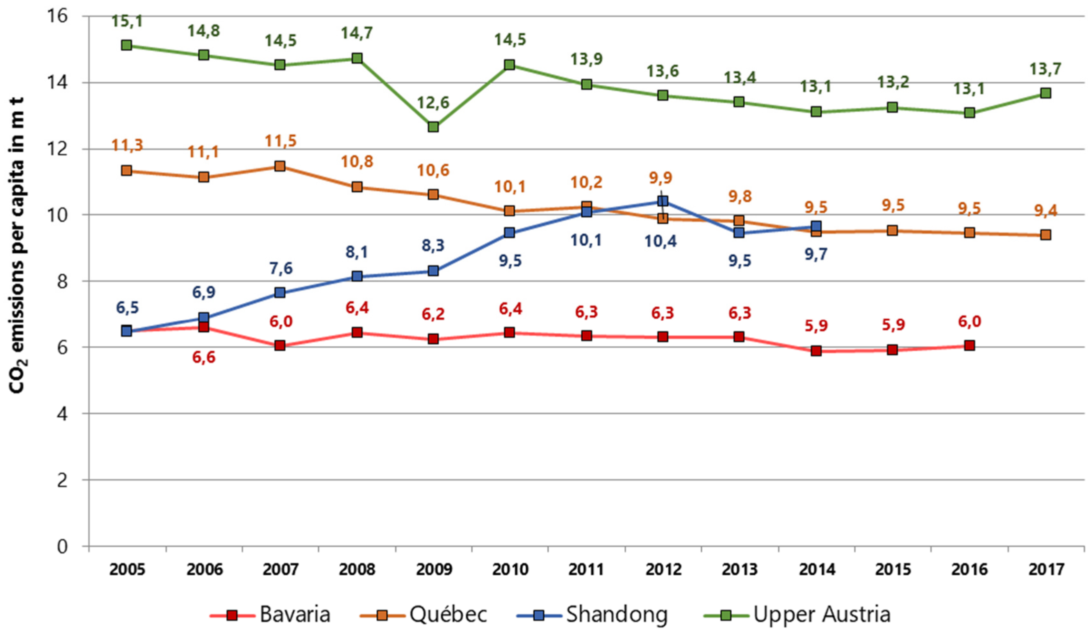
There are multiple options for lowering GHG emissions from the RLS energy systems (see Table 12 and Figure 5) while still satisfying the energy demands. Besides options such as energy conservation and efficiency, fossil fuel switching, nuclear energy and carbon capture and storage, the deployment of renewable energy is a major strategy.

Table 12: CO_2 emissions in selected RLS partner regions

		2005	**2010**	**2015**	**2016**	**2017**
Bavaria	*m tCO_2*	81	81	76	78	-
Québec	*m tCO_2*	87	81	79	79	79
São Paulo	*m tCO_2*	89	-	-	-	-
Shandong	*m tCO_2*	598	905	-	-	-
Upper Austria	*m tCO_2*	21	20	19	19	20

Notes: '-' : no data available during the monitoring process; rounded values; Upper Austrian data refers to energy-related emissions
Sources: Own compilation based on Dell (2019), Ministère de l'Environnement et de la Lutte contre les changements climatiques (2018) and RLS-Energy Network Monitoring Report (2018).

Figure 5: ***CO_2 emissions per capita in selected RLS partner regions***



Sources: Own calculation based on Dell (2019), Ministère de l'Environnement et de la Lutte contre les changements climatiques (2018, RLS-Energy Network Monitoring Report (2018) and Statistique Canada (2019).

3.2.2.1.4 Technological innovation & Industry 4.0

Technological innovations, which comprise for example higher efficiencies of solar photovoltaic modules and wind turbines, have played a central role in speeding up the implementation of renewables in the electricity sector. As indicated in IRENA (2017, 2018a), next generation biofuels and renewable hydrogen produced via electrolysis may allow renewables to spread into sectors such as aviation, shipping and heavy industry.

Further, innovations in digitalization and energy storage are also allowing for new possibilities (IRENA, 2019a). New digital technologies, such as smart grids, the internet of things, big data, and artificial intelligence are being applied in the energy industry, helping to raise efficiency and accelerate the use of renewable energy within emerging smart generation and distribution systems. As discussed in Section 3.2.1.1.5, new energy technologies are also being established for energy storage supporting variable renewables such as wind and solar. Batteries, comprising those in electric vehicles, are expected to become an important storage tool. Electricity can also be stored in thermal form using boilers, heat pumps or chilled water. For longer-term storage, there are other options, including compressed air energy storage or hydrogen.

Industry 4.0 could support identifying new means of dealing with major global challenges, such as the lack of clean energy access and economic progress and climate change. As pointed out in UNIDO (2017), the sustainable energy transition and Industry 4.0 share central characteristics that can be combined to implement a sustainability transition: both are stimulated by technological innovation, rely on the progress of new appropriate infrastructures and regulations and provide possibilities for new business models. The new technologies in the framework of Industry 4.0 may offer increased utilization of renewable energy in manufacturing, abatement of carbon emissions, enhanced energy-use, increased productivity and cost savings at a large scale.

Following UNIDO (2017), a wide-ranging change in manufacturing, production, energy efficiency, and renewable energy can be achieved by two development concepts: “transforming” and “leapfrogging”. Transforming towards Industry 4.0 includes modernizing existing industrialized systems with Industry 4.0 technologies that offer more sustainable solutions. Standardization, partnerships, and liable regulations can be enabled to maximize the economic, social and environmental possibilities of Industry 4.0. Alternatively, leapfrogging may offer an opportunity to push forward industrialization in developing regions without running the risks of historical development paths. Regions that are less developed can develop, for example, smart factories or decentralized microgrids, among other examples of leapfrogging possibilities (UNIDO, 2017).

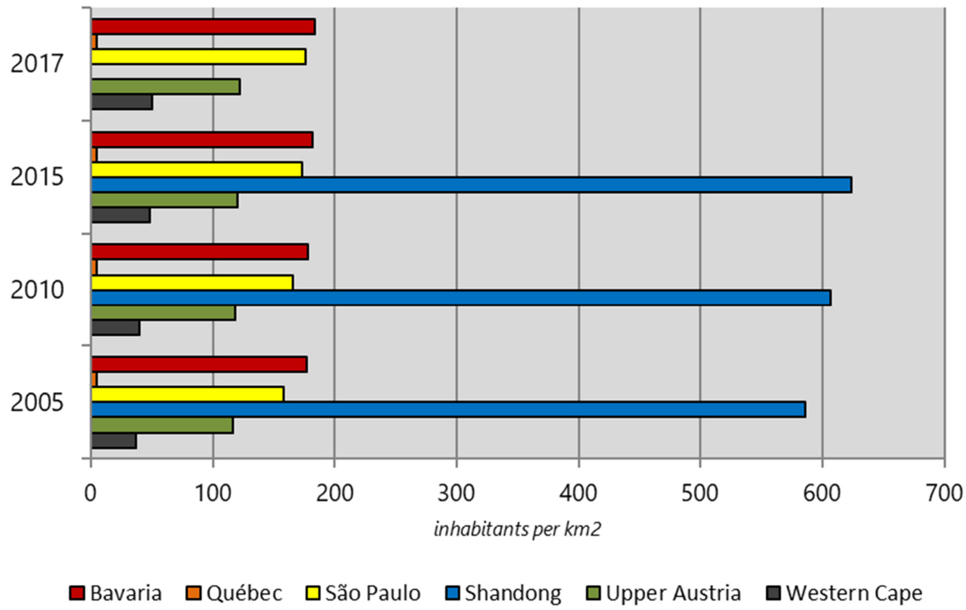
In general, the concept of Industry 4.0 is relevant to any industry sector. Nevertheless, it could be argued that the energy industry is one of the most affected or directly influenced industrial sectors in the RLS regions. This stems from the fact that the Industry 4.0 concept takes place simultaneously to the time when the energy industry is experiencing a transition over the next few years. The RLS regions’ energy transitions require a smart and flexible energy system with the ability to exchange energy and information to assist with the balancing of an increasing demand for energy. It is not just the digitalization of the energy system but in fact an overhaul of the system’s infrastructure as it becomes more decentralized and decarbonized, supported by technology (see Section 3.2.1.1.5).

3.2.2.2 Threats

3.2.2.2.1 Demographic developments

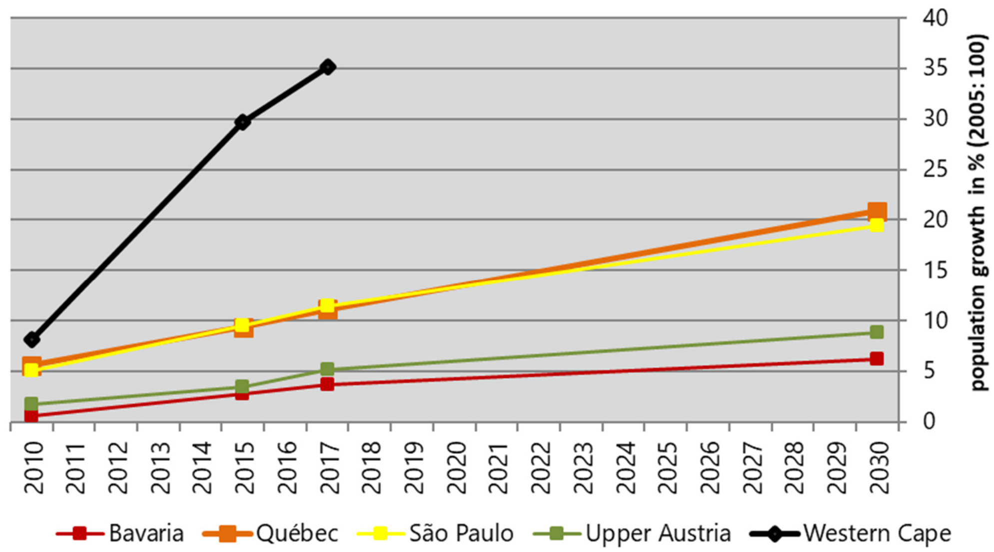
Demand for energy in RLS regions may increase rapidly in the future due to population and economic growth (especially in emerging market economies). Energy security concerns can arise as more consumers require ever more energy resources.

Figure 6: Demographic development in RLS regions, 2005-2017



Sources: Own calculation based on Bradshaw and de Martino Jannuzzi (2019), RLS-Energy Network Monitoring Report (2018) and Statistique Canada (2019).

Figure 7: Demographic development in RLS regions, 2010-2030



Source: *RLS-Energy Network Monitoring Report, May 2018* and *Statistique Canada (2019).*

3.2.2.2.2 Lack of social acceptance

In addition to technical and economic characteristics, it is crucial to examine the social aspects that impact the acceptance of renewable energy generation technologies by societies. Technologies that are technically and economically reasonable may not be well applied due to the lack of awareness of the technology. Public resistance could then interrupt or hinder the operation of sustainable technologies and renewable energy projects. This could obstruct the achievement of environmental and societal goals, such as decreasing CO_2e emissions.

All electricity production technologies include negative impacts, even if these impacts might be smaller than with other technologies. As renewable energy plants are being installed decentrally in various locations more and more, there may be conflicts with local communities (Azarova et al., 2019; Cohen et al. 2016a; Cohen et al. 2016b). Hofmann and van der Gaast (2014) explain that the acceptance for renewable technologies, such as wind energy developments, can be low, as they include local externalities such as visual effects on the landscape, noise, shadow flicker, and impacts on the local ecosystem, as well as general arguments that wind energy is inefficient or too expensive. As a low acceptance level can seriously slow down the development of renewables, it is vital to take this into account in the planning in order to decrease the probability of resistance.

Acceptance is a concept that includes a response to something which is offered externally. The social or public acceptance is generally defined as a positive attitude towards a technology or measure, which leads to supporting behavior if needed or requested, and the counteracting of resistance by others (see Hitzeroth and Megerle, 2013, and Huijts et al., 2012, as cited in Hofmann and van der Gaast, 2014). Assuming that the successful implementation of low-carbon technologies and processes profoundly depends on their social acceptance, it is essential to have clear understanding of the elements that affect public attitudes. Hofmann and van der Gaast (2014) classify these elements as follows: (i) awareness of climate change and knowledge of the technology (such as renewable energy), (ii) fairness of the decision-making process; (iii) overall evaluation of costs, risks and benefits of a technology; (iv) local context and (v) trust in decision-makers and other relevant stakeholders.

With regard to (iv) and (v), recent studies by Kollmann and Reichl (2015) and Azarova et al. (2019) find that broader issues of trust in governmental bodies can also have impacts on their effectiveness as opinion leaders in improving acceptance and participation in energy transitions. Specifically, Azarova et al. (2019) investigate whether stated support from political opinion leaders at the local, national, and EU levels can intensify the acceptance of renewable energy systems. For Switzerland, the authors detect a positive impact from support of the local government. If a Swiss mayor was said to back up a particular alternative energy technology, the probability that the recommended renewable energy community project is favored increases by 2.2%.

Finally, the current RLS regions' energy transition induce the necessity of a reconsideration of ethical dilemmas on how to distribute the benefits and costs of scarce energy resources among the citizens. In this context, the concept of energy justice (Heffron and McCauley, 2017; Jenkins et al., 2016) should also be mentioned.

Energy justice provides a framework by which decisions can be made with regard to energy policy, energy distribution, energy security and climate change. As an alternative to focusing just on variables such as economic growth (see Sections 3.2.2.1.1 and 3.2.2.1.2), energy justice theory considers moral aspects on how such decisions might affect individuals now and in the future. It reflects environmental impacts, and also accounts for the social and environmental costs that those decisions might generate. The energy justice framework explicitly and normatively addresses aspects identified in sustainability transitions, namely the value trade offs and associated consequences of those choices.

As outlined in Allen et al. (2019), this concept reflects different effects on health and wellbeing of fossil fuel-based energy, inequalities in access to renewable energy, environmental racism, and disproportionate impacts of climate change on vulnerable populations and women. Energy justice focuses on how issues of climate justice, fairness and equity can be incorporated into energy systems' transitions (Newell and Mulvaney, 2013).

3.2.2.2.3 Volatility of renewable energy resources

Mitigating climate change will require incorporating large quantities of highly alternating renewable energy sources in future electricity markets. Such high amounts of energy supplied from RE sources pose significant challenges to existing energy systems as the economically most viable and carbon free RE technologies (i.e., wind and solar) are highly volatile in their output. A future low-carbon energy system which relies on a large share of volatile renewable energy will likely face the challenge of substantial periodic mismatches between energy demand and supply. The most prominent and encouraging strategies to barrier volatility comprise pumped-storage plants, demand management, double structures retaining conventional plants as back-ups as well as grid expansion to other regions.

4 Summary & recommendations for RLS regions' energy transitions

4.1 Summary

Research was conducted to understand the strengths, weaknesses, opportunities and threats associated with the deployment of renewable energy in order to make energy transitions in the RLS regions happen. In the context of multi-level governance, RLS regions confronted with regional realities are already setting up cutting-edge technology innovations, defining some of the most ambitious renewable energy targets and investing in a clean technology infrastructure. This leads to regional development and market growth, and may further speed up the transition to a low carbon economy. It is not so much a question of defining singular steps, but of unifying regional visions with regard to global transformation and thus further accelerating it. Through multilateral structure and multi-level governance within the RLS-Energy network, best practice approaches can be presented holistically and help to assess how regions can learn from each other. The joint collaboration on the regional level can drive stronger action that results in change nationally – and even internationally.

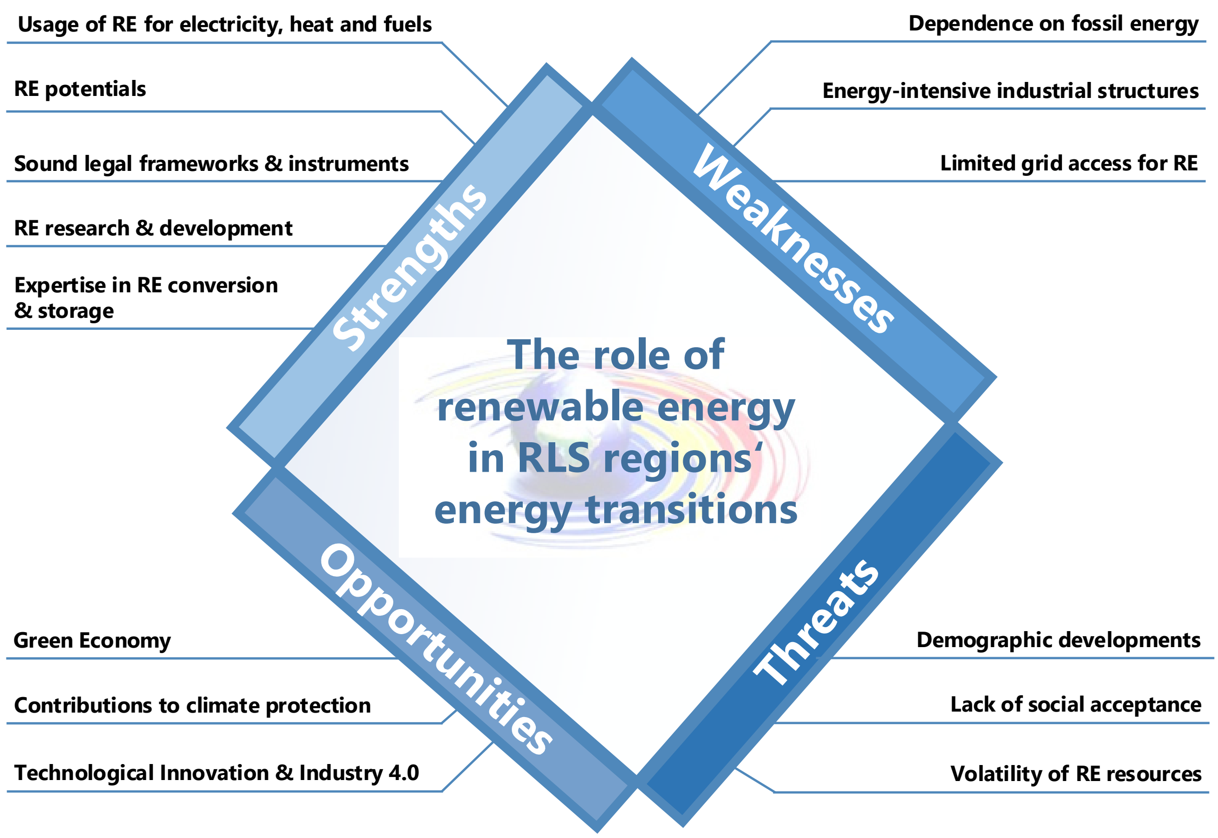
First, recent concepts of energy transitions with regard to the regional level were summarized. Second, the hypotheses and questions were identified via an extensive literature review of SWOT analyses with regard to renewable energy and consultation with scientific and policy experts of the RLS regions. Finally, we evaluated the internal and external characteristics of renewable energy deployment to support energy transition in the RLS regions via data of the RLS-Energy Network's Monitoring Report and current scientific findings on renewable energy in the RLS regions.

The SWOT analysis reveals that the current usage of renewable energy for electricity, heat and fuel production, existing renewable energy potentials, sound legal frameworks and instruments to support renewable energy, ongoing research and development activities and the expertise in renewable energy conversion and storage strengthens the role of renewables within RLS regions' energy transitions. These findings coincide with the fact that the share of renewables in final energy consumption continues to increase globally with some technologies developing very fast. Following REN21 (2018), the average growth rate of modern renewables over the past decade amounted to 5.4 %. Further, at the end of 2018, global renewable generation capacity amounted to 2351 GW (IRENA, 2019b), which implies an increase in renewable capacity of 7.9% during 2018. These developments reflect the political agreement on the goal to further develop renewable energy, while also indicating significant support from the private sector.

On the other hand, the fact that fossil fuels still hold a significant share in gross inland energy consumption, energy-intensive industrial structures continue to be supported by fossil fuels and grid access is limited for renewables may constitute weaknesses. The evaluation of external factors revealed that the deployment of renewable energy in order to facilitate energy transitions may lead to opportunities for implementing or further strengthening regional green economies, contributing to mitigate climate change, increasing public interest and inducing technological innovations. However, demographic developments and the volatility of renewable energy resources may threat the significance of renewable energy in RLS regions' energy transitions.

Our qualitative research shows that political implications and R&D have a big influence on the deployment of renewable energy with regard to efficiency and cost-effectiveness. Social awareness and acceptance also have a positive impact on the deployment of renewable energy. As highlighted in Azarova et al. (2019), the type of energy production included in a local energy community project has to be cautiously selected in accordance with local choices to guarantee that the local energy transition will have large support from affected citizens. Further, the results underline the need to consider not only the technical or operational framework of a project, but also the country-specific political and group norms (Azarova et al., 2019). Those political bodies in which the public has more confidence can be preferred to lead towards energy transition, which may increase acceptance and participation within some national contexts. In order to increase the acceptance of renewable energy community projects, Azarova et al. (2019) recommend that educational programs and advertising campaigns could be implemented for less accepting groups of citizens.

Figure 8: Internal and external factors affecting the role of renewable energy as a driver for RLS regions' energy transitions



Source: Own compilation.

4.2 Conclusions and recommendations for policymakers

The role of the RLS governments in guiding and managing regional energy transitions is highly important. The future will likely display an interesting and heterogeneous interaction between regional policies and their planned or already implemented future energy transitions.

Regional renewable energy targets and policies across the RLS partner regions vary extensively. On the one hand, the importance of climate action at the national, and hence at the regional levels, is increasingly translating into actions to support renewable energy. On the other hand, access to energy, energy security, and industrial development can be key reasons for renewable energy policy and actions. In all RLS partner regions, a focus on regional competitiveness, economic welfare and job creation often shapes policies. Among the political leaders of the RLS partner regions, there is broad agreement on these benefits and the promise brought forward by renewable energy.

Despite the significant progress made over the past decade and the growth in policy support, renewables have yet to reach their full potential and key barriers still constrain further development. These relate to technology, awareness and capacity, cost, finance, infrastructure and public acceptance, in addition to policy, regulatory, institutional and administrative barriers.

Substantial efforts are still required to scale-up renewable energy deployment (together with energy efficiency) to meet climate objectives. To this end, a combination of policy measures are needed, focusing on direct support (deployment), integration and enabling environment. Direct policy support for renewable energy has to be increased in the power and end-use sectors, which both account for large shares in final energy consumption as well as energy related CO_2 emissions.

In many regions, renewables continue to face competition from subsidised fossil fuel options. Meanwhile, enabling policies are needed to ensure effective operating conditions for renewables in energy systems and markets. As such, policy makers should ensure that renewable energy technologies can operate in the system on a level playing field with other technologies, facilitating innovation, supply and consumption of renewable energy in all end-uses.

In any area of energy use, no single instrument can fulfil the aims of all regions equally effectively. Policies must be selected with care and designed or adapted to reflect specific national and regional conditions. The long-term stability of targets and policies is key to ensuring investor confidence and sustained growth. Hence, the dialogue on best-practice examples of energy policies within the RLS-Energy Network adds value to the RLS regions energy system planning and governance.

At the same time, policies need to continuously adapt to changing market conditions, to achieve greater cost-competitiveness and improved integration of renewables into the system. To ensure that the energy transition accelerates, greater attention must be paid to the transformative impact of society, institutions, financing, ownership structures and the wider economy. This requires supporting effective participation by all stakeholders.

Finally, renewable energy needs to be integrated into the daily life of consumers and prosumers, as well as into the institutional framework, to allow them to be part of the overall energy transition. This step can be fulfilled via measures to encourage behavioral change (through raising awareness programmes) and policies to couple renewable energy technologies with livelihoods (in the access context).

4.3 Conclusions and recommendations for R&D

The RLS regions' energy systems, driven by regional energy transitions, could potentially enable the realization of a strong integration of renewables and could cover partially distributed, decentralized energy systems with embedded energy storage, demand side management, and the application of smart technologies. It may also likely contain a large role for electric and renewable hydrogen mobility charged from regional renewable energy sources. Energy transitions are also intricately linked to efforts to enhance energy efficiency of buildings, industries and transportation.

Further progress in the utilization of renewable energy technologies can serve as cost-effective and environmentally responsible alternatives to conventional energy generation. Technical and market potential exists to considerably intensify the current contribution of renewable energy sources to the RLS regions' energy demands in the long-term, resulting in employment and economic benefits and R&D investment.

The scientific RLS-Energy Network recognizes this opportunity and offers (in accordance with government energy institutions and agencies of the RLS partner regions) to provide support for their energy transition's efforts to exploit stronger near-term potentials via:

- Analysing opportunities for renewable energy and working in consultation with industry to identify R&D and market strategies to meet technological goals
- Conducting R&D in cooperation with industry to develop and commercialize technologies
- Encouraging the use of renewable energy technologies by possible consumers, including utilities
- Providing technical support and advice to industry associations and government programs that are encouraging an increased use of renewable energy.

With regard to the Regional Renewable Alliance's demonstration and implementation phase from 2020 on, the following points should be addressed:

- Research priorities of the RLS-Energy Network should be established in consultation with society, governments and industry to reflect their energy transition requirements.
- The research should include a variety of stakeholders in the energy industry, such as private sector firms, utilities, regional governments and other departments.

- The research results should be transferred through sponsorship of workshops, seminars and conferences, as well as the publication of scientific and technical reports.
- The generation of renewable energy for heat, electricity and transport is interconnected through storage, monitored through smart meters, and changed through voluntary shifting of demand. Digitalisation, energy storage and demand response are the solutions to helping future energy systems maintain balance as we move away from separate energy consumption.

4.4 Conclusions and recommendations with regard to Green Economy issues

Alternative economic approaches, which change the current connection between economic growth and fossil energy consumption, are required in the long term to accomplish the necessary decarbonisation of the society regardless of growth limitations. The aim of the Green Economy is to support and form this transformation via technological, social and economic innovations. The possibilities for this include many fields of action, such as the careful use of energy, raw materials and other resources, alternative consumer behaviour up to and including towards sustainable mobility and infrastructure in RLS regions.

Hence, growth and employment should focus above all on those sectors that can make significant contributions to a green economy and the associated socio-ecological transformation. In order to achieve these objectives, a comprehensive green economy strategy should be drawn up and an implementation plan should be drawn up. Monitoring on the basis of less reliable indicators (e.g. on the basis of existing OECD recommendations) should also regions to check whether the objectives of a comprehensive green economy strategy are being achieved.

In the regional RLS environmental technology industries, successful export initiatives should be continued. Long-term, ambitious environmental and climate policy objectives should be defined at national and international level in order to create suitable framework conditions for companies in the environmental technology industry.

Existing and proven promotional and educational instruments, especially in the field of research and development, should be continued to a greater extent in order to further promote the environmental economy and the environmental technology industries. In order to exploit the opportunities offered by digitisation for a more resource-efficient, climate-friendly economy, corresponding research priorities should be set and innovations promoted.

4.5 Conclusions and recommendations with regard to social acceptance

Bearing in mind that the realization of renewable energy projects depends to a huge extent on their social acceptance, it is crucial to evaluate the social implications of deploying and diffusing certain renewable energy technologies. With regard to renewable energy project planning and development, societal acceptance should be considered by the project developers, as well as related local and regional RLS government policy makers. Participation of the regional community in organizing and development, or even (co-) ownership, may induce higher social acceptance (Hofmann and van der Gaast, 2014). Further, policymakers should consider social acceptance as one of the determining factors in the predictability of clean technology investments. Social acceptance levels may be influenced through, for example, information and transparency rules, campaigns and support mechanisms.

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Annex I

Table: SWOT matrix with questions

Internal **strengths / weaknesses**
– Are high amounts of fossil energy resources existent and used within a region? – What are the natural conditions for the development of a given type of renewable energy resource? – Do potentials for renewable energy production exist? – For a given type of renewable energy, how much of its usable potential is already being utilized? – Does the development of a given type of renewable energy resource generate interest for investors/local authorities? – What is the public opinion the citizens within a specific region about a given type of renewable energy? – Do renewable energy investments provide profitability? Are subsidies provided? – Is the production/usage of renewable energy cheaper compared to fossil energy (coal, oil, natural gas)? – Will the development of a given type of renewable energy generate new jobs? – How does a given type of renewable energy impact the environment? – Are the regional politics and set of regulations attracting renewable energy developments? Is there a clear political target for expading renewable energy within the region? – Is there an existing industry which strongly depends on fossil energy? – Is expertise for the production of renewable energy provided within the region? – Does energy related research focus on renewable energy production and usage?
External **opportunities / threats**
– Is the current national regulation having a positive impact on the development of the renewable energy sector? – How secure is the supply of fossil and renewable resources? – Does cooperation with other states/counties/regions for the further deployment of renewable energy exist?

Source: Own compilation based on literature review (see Annex) and consultations with stakeholders from the science and policy of the RLS-Energy Network.

Annex II

Literature Review - application of SWOT analysis in the context of renewable energy

The following table gives a comprehensive overview about undertaken SWOT analyses in the context of renewable energy for different regions worldwide in the scientific literature.

Table: SWOT analyses in the context of renewable energy – literature review

Author(s)/ Year of publication	Title	Methodology	Focus of SWOT analysis	Key Findings
Adibfar A. (2016)	SWOT Analysis for **Iran**'s Wind Farms	Conducted SWOT was analysed and examined by working croups - Committee of professionals from ministry, energy organization, investment companies, and members of parliament and university professors.	Wind farms	The abundance of inexpensive fossil fuels constitutes one of the most decisive factors why wind farms remain undeveloped in Iran. Other significant factors are the economic impediments, governing rules and regulations.
Aydin B. (2014)	SWOT Analysis of Renewable Energy	Literature review and implementation of a SWOT analysis	Renewable energy sources in general	The interest on renewable energy will continue to increase. States should foster renewable energy to compete with fossil fuels.

Author(s)/ Year of publication	**Title**	**Methodology**	**Focus of SWOT analysis**	**Key Findings**
Chen W.-M. , Kim H. & Yamaguchi H. (2014)	Renewable energy in **Eastern Asia**: Renewable energy policy review and comparative SWOT analysis for promoting renewable energy in **Japan, South Korea**, and **Taiwan**	Literature review and implementation of a SWOT analysis	Renewable energy policies in **Japan, South Korea** and **Taiwan**	The analysis shows a capacity for additional renewable energy deployment in Japan, South Korea and Taiwan, and highlights the necessity of increased cooperation between the three countries to strengthen their domestic and regional renewable energy sectors and compete in the global renewable energy market.
Dong Q. (2014)	A Study on Renewable Energy Generation in **China** - Focus on Distributed PV Power Generation	Literature review and experts opinions for implementation of a SWOT analysis	Developing Residential Grid-connected Photovoltaic Power Systems in **China**	Results are a reference for governments, contractors and other stakeholders in providing insights into the barriers, advantages and possible approaches of promoting residential grid-connected photovoltaic power systems in China.
Fertel C., Cahn O., Vaillancourt K., Waaub J.-P. (2013)	**Canadian** energy and climate policies: A SWOT analysis in search of federal/provincial coherence	Literature review and implementation of a SWOT analysis	Energy security, energy efficiency, technology and innovation	The analysis reveals that there is a lack of consistency in the Canadian energy and climate strategies beyond the application of market principles. Furthermore, in certain sectors, the Canadian approach amounts to an amalgam of decisions made at a provincial level without cooperation with other provinces or with the federal government.

Author(s)/ Year of publication	**Title**	**Methodology**	**Focus of SWOT analysis**	**Key Findings**
Inglinski B., Piechota G., Inglinska A., Chichosz M., Buczkowski R. (2015)	The study on the SWOT analysis of renewable energy sector on the example of the Pomorskie Voivodeship (**Poland**)	Development of questions and indicators for implementation of a SWOT analysis Information was collected from renewable energy producers by surveys, literature sources, the strategy for the development of renewable energy sources as well as legal acts and regulations.	Renewable energy in Poland on the example of Pomorskie Voivodeship	The further development of the renewable energy sector strongly depends on the Act on renewable energy sources, legal regulations, more effective financial support for new investments, introduction of guaranteed certificate prices, public education, and the strategies of investors and decision-makers in the field of renewable energy.
Khader A., Idris M. (2016)	SWOT Analysis of Solar Energy In **India**	Literature review and implementation of a SWOT	Solar energy usage in **India**	The demand for power is increasing day by day in India and solar energy could be a solution for deficit power.
Lupu A. G., Dumencu A., Atanasiu M. V., Panaite C. E., Dumintrascu G., Popescu A. (2016)	SWOT analysis of the renewable energy sources in **Romania** – case study: solar energy	Literature review and implementation of a SWOT	State of the art, potential and future prospects for development of renewable energy in **Romania**	The analysis concluded that the development of solar energy sector in Romania depends largely on: viability of legislative framework on renewable energy sources, increased subsidies for solar R&D, simplified methodology of green certificates, and awareness raising in the public and for investors, nd decision-makers

Author(s)/ Year of publication	Title	Methodology	Focus of SWOT analysis	Key Findings
Markoska N., Taseska V., Pop-Jordanov J. (2009)	SWOT analyses of the national energy sector for sustainable energy development	SWOT analysis is developed in a participatory approach (bottom-up component), complemented with a study of the existing relevant strategic and planning documents, legislation and statistics (top–down component).	Energy sector in **Macedonia**	The progressive adoption of European Union (EU) standards in energy policy and regulation as the most important achievement in the domestic energy sector.
Paliwal R. (2006)	EIA practice in **India** and its evaluation using SWOT analysis	SWOT analysis based on authors' own experiences during field visits, professional's views (i.e., government officials, consultants and managers) revealed during informal talks, and semi structured interviews and available literature on the subject.	Indian EIA systems constraints, potentials and challenges	The opportunities are realised as increasing public awareness, initiatives of environmental groups and business community and forward thinking to integrate environmental consideration into plans and policies.
Paschalidou A., Tsatiris M., Kitikidou K. (2016)	Energy crops for biofuel production or for food? - SWOT analysis (case study: **Greece**)	Literature review and implementation of a SWOT analysis	Cultivation of crops for biofuel production or for food	The dilemma of using “energy crops for biofuel production or for food” depends on a variety factors.

Author(s)/ Year of publication	Title	Methodology	Focus of SWOT analysis	Key Findings
Tavana M., Pirdashti M., Kenedy D., Belaud J.-P., Behzadian M. (2012)	A hybrid Delphi-SWOT paradigm for oil and gas pipeline strategic planning in **Caspian Sea basin**	Implementation of a hybrid model with SWOT and Delphi methods	Evaluation and selection of alternative transnational export routes from the **Caspian Sea basin**	The framework developed in the study can potentially lend itself to many practical applications.
Terrados J., Almonacid G., Hontoria L. (2005)	Regional energy planning through SWOT analysis and strategic planning tools. Impact on renewables energy development	Elaboration of a problem tree and an objective tree; SWOT analysis	Regional energy planning	SWOT analysis has proved to be an effective tool and has constituted a suitable baseline to diagnose current problems and to sketch future action lines.
Wyns T., Khatchadourian A. (2015)	Situational analysis of **EU** Renewable Energy legislation	Literature review and implementation of SWOT and TOWS analyses	How could the **EU** renewable energy policy be reshaped after 2020 as to further enhance renewable energy deployment?	Suggestions for a stronger and/or improved interaction of a reviewed renewable energy directive with other parts of EU energy law

Source: Own compilation.