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1. EXECUTIVE SUMMARY

Saxony-Anhalt is a region with a lot of farming land and some metropolitan areas around Magdeburg, the capital city, and Halle (Saale), where most of the economic activities are located. In Saxony-Anhalt are operating a high amount of wind farms, photovoltaic plants and biomass fired power plants. However, electric and thermal power is also generated using fossil sources like coal and natural gas. In order to move forward in decarbonising the power system y, it is necessary to installed new power plants based on renewable energies and/or repowering the old one. Therefore, measures to assure the on-going energy transition have been identified and and their impact on the decarbonisation of the land has been quantified.Those measures target five different fields of actions: energy economics, buildings, traffic, industry and economy, agriculture/land use / forestry/ food. They have been suggested through meetings with stakeholders (industrial, academic and policy makers) which are directly engaged in the decarbonisation process. These measures focuse on creating a better use of incentives aiming to support green projects, to decrease the related bureaucratic machine and to better integrate the population in the decision making processes. As consequence of the suggested measures, energetic scenarios have been modelled and simulated. The aim is to draw up a road map which could be able to address stakeholders in their energy planning actions .The results of the simulated scenarion have pointed out that the power generation by coal power plants located in Saxony-Anhalt mostly limits the success of the actions for the decarbonize of land Saxony-Anhalt. The generation of heat by electric driven heat pumps as well as the electrification of the transportation might offer a high contribution to reach the fixed targets of CO2 emission by 2030. However, in order to supply these loads new power plants based on renewable energy source must be installed. This report gives an indication of required actions that should be taken in consideration for decarbonising the land Saxony-Anhalt and reach the fixed targets by 2030.

2. INTRODUCTION

2.1. Status quo summary

The land Saxony-Anhalt is located in the east part of Germany. In Saxony-Anhalt live about 2.2 Million of inhabitants. The capital city is Magdeburg. There are 218 municipalities, only three of them have a population higher than 50.000 inhabitants: Magdeburg, Halle and Dessau-Roßlau.

Figure 1 Map of Germany and Saxony-Anhalt

The regional population development is negative. Since 2000´s about 400.000 inhabitant have leaved the federal state. The average size of households (1.9 persons) is also lower than the national value (1.99 persons).

In the last years, the regional economy has improved. It has affected the average income of the regional households. However, there is still a negative gap between the regional and the national values. The service sector gives the highest contribution to the economy of the region. Industry and construction sectors are, respectively, in the second and third place.

The infrastructures in Saxony-Anhalt are well developed. People and goods are transported using waterways, highways and railways. Even if the airport "Leipzig-Halle" is geographically located in Saxony, it is also considered as one of the airways´ infrastructures of Saxony-Anhalt.

The energetic infrastructure consists of electric networks, natural gas (pipelines and caverns) and heat districts. These entire infrastructures are well developed. Some of them (i.e. the electric network) is going to be further developed to better integrate the electric power generated by renewable energy sources.

The total energy demand in Saxony-Anhalt is estimated to a value of 143.834 GWh.

About 55% of the generated electricity is produced by renewable energy sources.

In Saxony-Anhalt, the generation by renewable energies plays an important role. By considering the electricity and the thermal energy, renewable energy generate about 43% of the total generated energy. In the electric sector, the share reaches 55%. Wind energy results to be the most used resource; indeed it covers about 34% of the entire generated electricity.

The amount of the CO_2 emissions, based on the energy consumption, is estimated to an amount of 25,4 million of tons . The pro capita CO_2 emissions are about 11,5 tons.

2.2. Current development trends

Due to the energy transition and the associated goal of a resource efficient usage of products, the Government of Saxonian developed research field that are going to be focused on. Research is done on the areas of smart energy, regenerative energies and biomass. In detail this includes net and energy management, modular energy systems and energy services. As part of the renewable energy systems photovoltaic, green hydrogen, hydropower plants and energy storage. The area of biomass includes biotechnological material and energy conversion. Beside those future markets the research of universities and research facilities focus on electric-mobility, bio energy research, fuel cell technologies and technologies for the use of low-temperature waste heat in order to reduce the CO2-emissions. [1]

2.3. Development potentials

One key factor of the development strategy in Saxony-Anhalt is the focused on the research activities. Universities and research centres dedicate huge resources to find new sustainable solutions enabling the sustainable development of the federal state Saxony-Anhalt.

The regional innovation strategy Saxonian-Anhalt 2020 (RIF ST 2020) sets the focus on five main markets for the innovation development in this region:

1. energy, machinery and plant construction, resource efficiency (EMAR)
2. chemistry and bio economy
3. mobility and logistics
4. health and medical technology
5. food and agriculture [2]

For the first topic EMAR following fields of action were defined:

Renewable energies

- electricity storage
- energy production from fossil fuels
- photovoltaics
- energy efficiency

with the following lead projects:

- lead project coupled plants
- pilot project river-electricity
- lead project PVT-based electricity/heat generation
- lead project three-phase generator

The topic 'chemistry and bio economy' covers the development and realisation of Chemistry 4.0. in a circular economy. This is necessary for the upcoming energy transition and finding alternatives for energy consuming chemical industry. Reducing CO2 emissions by creating a circular usage of carbon is relevant here. Therefor following steps need to be taken:

- electricity-based electrolysis for the production of "green" hydrogen and gradual substitution of hydrogen produced from natural gas and oil derivatives of fossil origin, in particular for hydrogenation in fuel production
- specialty fine chemical products with higher added value based on biomass
- gasification of plastic waste with the developments of the Fraunhofer project *Carbontrans*
- synthesis gas production with the water-shift reaction from CO2 for emission-free methanol production

Lead projects are:

- HYPOS – Hydrogen Power Storage & Solutions East Germany
- construction of a real laboratory to demonstrate the carbon cycle economy at the location in Leuna

The third points mobility and logistic aims to develop the location of the regions Magdeburg/Halle as ITS competence region for intermodal and networked mobility solutions and services. [1]

3. MISSION STATEMENT

3.1. Key energy priorities and priority matrix

The main priorities within the energy transition pointed out by the Saxonian-Anhalt Government are located in the areas of:

- energy economics,
- buildings,
- transportation,
- industry and economy,
- agriculture/land use/forestry/food.

Those areas represent to most energy demanding and the highest CO2-emitting branches in Saxony-Anhalt. A scale with six-levels from A to F has been suggested. By using such a score scale the effects of identified actions on the decarbonisation of the land has been evaluated. . All not evaluated measures are given an F since those measures refer to more preparing actions. [1]

Table 1: Priorities of measures in the field of actions [2]

Priority	Measures in the field of action
A	energy economics
B	buildings
C	transportation
D	industry and economy
E	agriculture / land use / forestry / food
F	not evaluated measures

3.2. Measures to set within the priorities and estimated timeframes

3.2.1. Description of measures covered by the respective priority

For the energy economy, three main priorities have been identified (see Table 2). Such priorities focus on the generation of heat, to the generation of electricity and to the planning new flexibility options. In Saxony-Anhalt, the heat represents one of the most demanded energy sources. New heating districts which are supplied by efficient technologies, like the combined heat and power (CHP), as well as the use of energetic wastes might massively contribute to make the heat generation more sustainable. The electric power generation by renewable energy sources (RES) should further be supported. Wind, sun and biomass might offer a high contribution to cover the electric demand. However, their volatile generation (mostly true for wind and sun) needs that new flexibility options must be identified, quantified and exploited. Thereby, energy storage systems, acive participaion of large and medium consumers to the energy balance processes, the power-to-x technologies (heat pumps, electrolyzers) need to be further integrated. The energy system should be holistically considered. Electric grid, gas network, high and low enthalpy grids as well as the transportation system should be able to interact.

Table 2: Measures within the priority energy economy [1]

A	Energy economy
A1	expansion of heating network and combined heat and power generation
A 1.1	expansion of heating network and increasing the share of renewables
A 1.2	support of combined heat and power generation (CHP)
A 1.3	use of waste heat
A 2	expansion renewable energies
A 2.1	expansion wind power
A 2.2	expansion photovoltaic (open space)
A 2.3	maintaining the status quo in bioenergy plants
A 2.4	decentralised energy supply/substitution of energy sources
A 2.5	citizen participation and involvement
A 3	flexibility options
A 3.1	optimisation of electricity grid operation
A 3.2.	support of flexibility options
A 3.3	support power-to-X solutions

In Table 3 the measures corresponding to the building sector are listed. This sector especially focuses on building insulation, plant efficiency, ventilation techniques and consumption behaviour to reduce heating and hot water consumption. Nonetheless also the building related heat supply for the sectors industry, trade and services is referred to. The measures B2 aim to increase the renovation rate of the existing buildings. A key goal is to improve the energy efficiency of the equipments, e.g. lightning and electrical appliances. Another aspect that will be focussed on is the living in quarter neighbourhoods as part of the settlement development [1].

Table 3: Measures within the priority buildings [1]

B	Buildings
B1	Sustainable urban structure
B 1.1	climate protection and energy efficiency in urban development
B 2	climate friendly construction and living
B 2.1	energetic building refurbishment
B 2.2	strengthening construction and refurbishment with ecological building materials
B 2.3	using climate friendly heating, cooling and electricity applications
B 2.4	monitoring and optimisation in the implementation of climate protection measures
B 2.5	consulting services for users and owners

B 2.6	roof-mounted photovoltaics (tenant electricity for Saxony-Anhalt)
B 2.7	climate protection in churches and rooms used by churches
B 3	Role model function of the public sector
B 3.1	energetic refurbishment of public properties
B 3.2	use of renewable energies in public properties
B 3.3	increasing energy efficiency in public properties
B 3.4	public amministrators as initiator and promoter

The transportation sector has the highest consumption of fossil energy sources. It includes not only the passengers, but also the goods transportation. In order to reduce the energy consumption different measures have been formulated. The digitalisation might offer to reduce the traffic congestion as well as to avoid the transportation of persons (i.e. through home working or home schooling). Other measures focus on thee bundling of the transportation system through micro hubs, on the promotion of carbon neutral transportation systems (i.e. cycles or pedestrian) and on the promotion of sharing models. Renewable energies can also be integrated into the transportation sector. Indeed through the electrification of the transportation system and/or through the conversion of green energy into gas (i.e. hydrogen or methane), power generated by RES can be easily used to supply the mobility of persons and goods.

Table 4: Measures within the priority traffic [1]

C	Transportation
C1	Avoidance of traffic congestion
C 1.1	avoidance of traffic congestion through digitalisation
C 1.2	reducing traffic through shorter distances
C 1.3	avoidance of traffic through shorter goods transport
C 1.4	integrated urban development
C 1.5	transport bundling through micro hubs
C 2	Shift to efficient transport methods
C 2.1	promotion of cycling
C 2.2	promotion of pedestrian traffic
C 2.3	shifting everyday traffic from cars to public transport
C 2.4	shifting leisure and recreational traffic to public transport
C 2.5	link between different modes of transport
C 3	Mobility management and better use of capacity
C 3.1	mobility management in companies
C 3.2.	car-sharing
C 3.3	using autonomous driving for public transport (incl. car-sharing/taxi)

C 3.4	stabilisation of the traffic flow
C 4	change of energy source
C 4.1	electrification of the largest possible parts of the railway network
C 4.2	electric mobility for cars and commercial vehicles
C 4.3	alternative drives in public transport
C 4.4	strategy for regenerative gas mobility
C 5	vehicle Efficiency
C 5.1	economical driving style
C 5.2	promoting new and environmentally friendly technologies (efficiency)

The field of action for industry and economy is mainly defined by the emissions by combustion processes as well as emissions through industrial processes. In Saxony-Anhalt, 50 energy-intensive industrial facilities are already subjected to the Emission Trading Scheme (ETS). These include plants for ceramics, pulp, refining oil smelting of iron or steel and many more. However, a huge energy saving potential has been identified in non-ETS facilities. The synergy among different facilities might contribute to increase the energetic efficiency and to adopt procedures based on circular economy. The digitalization of the processes and the adoption of solutions based on "Industry 4.0" also have the potential to optimize the industrial processes with the focus to reduce the energy and resources demand. Table 5 summarizes the main measures for the industry and economy sector.

Table 5: Measures within the priority industry and economy [1]

D	Industry and Economy
D1	increase in operational and inter-company energy efficiency
D 1.1	overarching measures for cross-cutting technologies
D 1.2	increasing the use of industrial and commercial waste heat
D 1.3	mobility and logistics management in companies
D 2	increasing the material and resource efficiency
D 2.1	increasing the material and resource efficiency as well as circular economy
D 2.2	substitution of energy-intensive materials and processes
D 3	information transfer, networking and research and development
D 3.1	optimisation and expansion of energy consulting services for SME
D 3.2.	expansion of networks for the exchange of experiencer
D 3.3	continuing and further developing of qualification and R&D support programmes for climate protection and energy efficiency
D 4	digitalisation/ industry 4.0
D 4.1	using the potential for savings in the area of information and communication technology (ICT)

D 4.2	energy efficiency through automation and digitalisation

The measures for the agriculture, land use, forestry and food are listed in Table 6. In the land Saxony-Anhalt 85% of the area is used as farmland, it represents the highgest land usage among the German Federal States. However, compared with the other Federal States, in Saxony-Anhalt there are few animal farms. Therefore, 77% of the GHG-emission, are caused by the cultivaion activities. The highest part of emissions is caused by mineral fertiliser, farm manure applications and crop residues in soil. These produce the most N2O emissions and raise the quantity of Nitrogen. Therefore, the measures E1 have been set in order to build a low-emission cultivation and reduce Nitrogen and other GHG's in air and soil. In addition, E2 refers to the CH4-emissions produced in the livestock farming. Besides it, the use of biomass and biogas for energy activitites also represents an important measure for limiting the GHG-emissions in the agricalure sector. In parallel, the increase of wood based maerials might contribute to reduce the usage of energy-intensive materials like concrete or aluminium.

Table 6: Measures within the priority agriculture/ land use/ forestry/ food [1]

E	Agriculture / land use / forestry / food
E1	Low-emission cultivation of agricultural soils
E 1.1	gentle soil management
E 1.2	efficient use of mineral fertilisers
E 1.3	emission optimised application of organic fertilisers
E 2	Low-emission livestock farming
E 2.1	optimised and nutrient-adapted feeding methods
E 2.2	low-emission keeping methods/ stable construction systems for the future
E 2.3	increased use of manure in biogas plants
E 2.4	covering existing slurry and fermentation residue storage
E 3	energy saving, energy efficiency and decentralised energy supply
E 3.1	reduce energy consumption
E 4	conservation and enhancement of carbon sinks
E 4.1	maintain permanent grassland
E 4.2	maintain the humus content of soils used for agriculture and forestry
E 4.3	reinforce forests
E 4.4	secure productive and climate-stable forests
E 4.5	increase structural elements
E 4.6	protect and rewet peatlands
E 4.7	reduce the use of peat as plant substrate
E 5	supply of biomass for material and energy use
E 5.1	promoting renewable wood-like raw materials

E 5.2	increasing the material use of wood
E 6	climate-friendly diet
E 6.1	reduce food waste
E 6.2	climate-friendly shopping and eating habits

3.2.2. Assignment of measures to the dimensions of the Energy Union and Identification of affected target sectors

Technical-ecological and economic criteria have been identified for evaluating the impact of the selected measures (see Table 7). Among the technical criteria, the energy efficiency, the security of supply and the research & development innovation have been considered. For the ecological criteria, the effect on the decarbonisation and the energy efficiency have been taken in consideration. The market integration evaluates the impact on the economic criteria. As depicted in Table 7, the identified measures mostly effect on the decarbonisation processes, the market integration and have a high R&D innovation.

Table 7: Assignment of measures

dimension / target sector	Decarbonisation	Energy efficiency	Supply security	Market integration	R&D innovation
Transportation	C1 C2 C3 C4 C5	C2 C5	C3	C1 C2 C3 C4 C5	C3 C4 C5
Buildings	B1 B2	B1 B2	B3	B3	B1 B2 B3
Energy	A1 A2	A3	A1 A2 A3	A1 A2 A3	A1 A2 A3
Industry	A1 A2	A3 D1 D2 D4	A1 A2 A3 D2	A1 A2 A3	A1 A2 A3 D1 D3
Agriculture	E1 E5	E3 E5	E4	E4 E6	E2

4. MISSION MAPPING

4.1. Classification of priorities by expected impact and effort

Through the direct interaction with the stakeholders which operate in Saxony-Anhalt four more actions have been identified. These actions might further contribute to speed up to the decarbonisation of the Saxony-Anhalt. The four actions focus on:

- Better integration of the local population in projects
- Better incentive support for the projects instead of bureaucracy
- 1 GW electrolyzer capacity for green hydrogen production
- Extension of the existing H2 grid

The discussions at the stakeholder meetings about the needed measures led to the following result in expected impact and effort.

a) Regarding the measure ‘better integration of the local population in projects’ the result were set as:

Impact: high

Effort: medium

b) For the measure ‘better incentive support for the projects instead of bureaucracy’ it is:

Impact: high

Effort: low

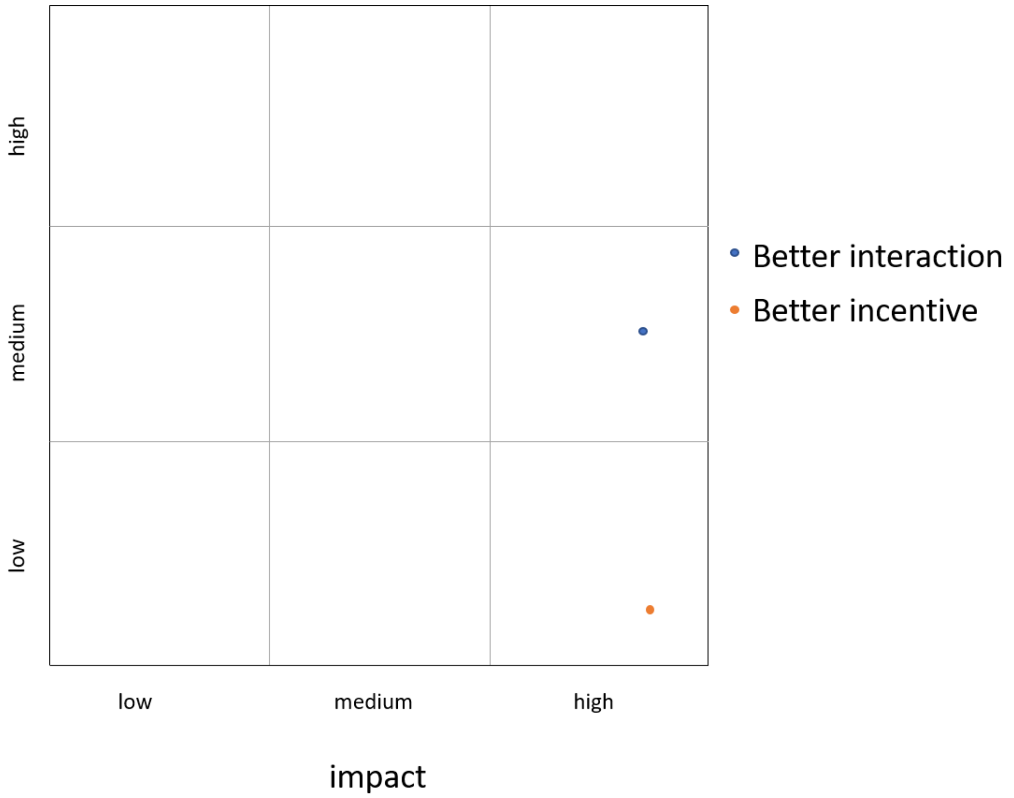


Figure 2: Matrix of corresponding impact and effort for each focused measure

c) Measure ‘1 GW electrolyzer capacity for green hydrogen production’

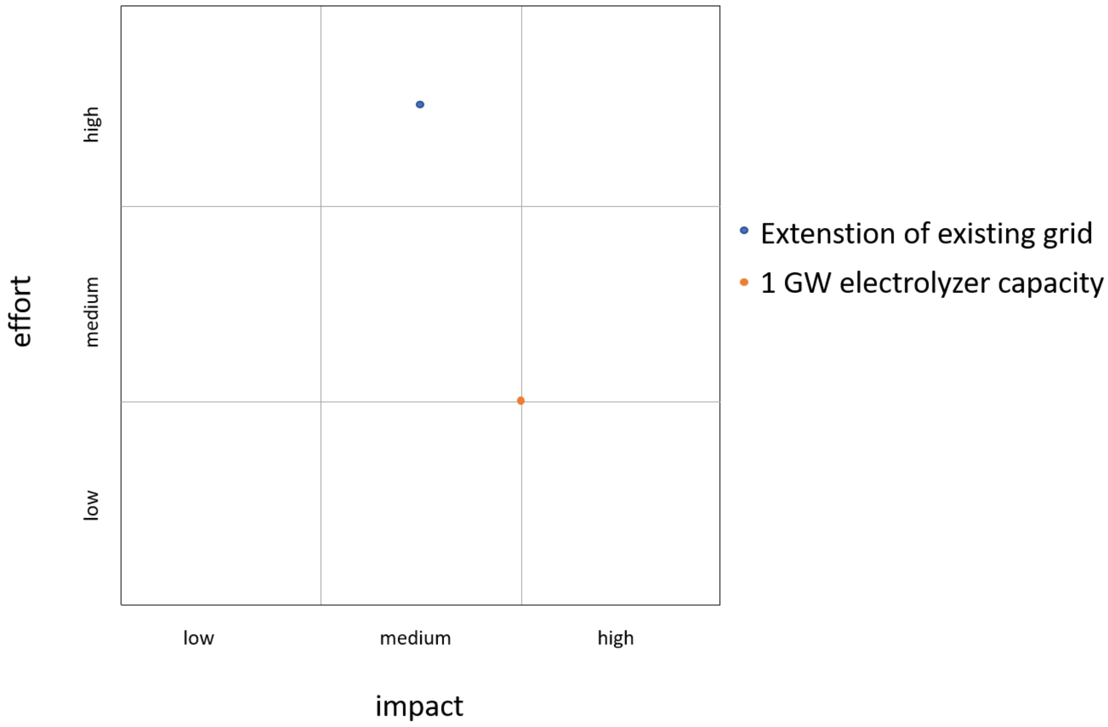
Impact: medium to high

Effort: low to medium

d) Measure: ‘Extension of the existing H2 grid’

Impact: medium

Effort: high


effort
high
medium
low
low
medium
high
impact
Extenstion of existing grid
1 GW electrolyzer capacity

4.2. Mapping of measures corresponding to priorities

The direct engagement of the population in the decision making processes might be determinant for speeding up the bureaucratic procedures related to new RES based power plants. One way to increase the acceptance in the population is to show them the effects that a RES based power plant might have on their life. In the last years, virtual reality (VR) tools have been developed to better explain how a RES based projects (i.e. wind farms or photovoltaic plants) impacts on the landscape and which measures might be planned to mitigate that impact [3]. VR solutions address this need and combines disciplines of energy and land-use planning in one model area. This produces an interdisciplinary view of the planning area, which integrates the design of energy and land-use plans. VR enables users to access the planning area directly. Representations of virtual 3D objects include not only their visual features, but also the corresponding parameters for land-use and energy planning. Figure 3 shows an example of virtual reality application for an energy planning project at logistic and industrial centre Rothensee in Magdeburg.

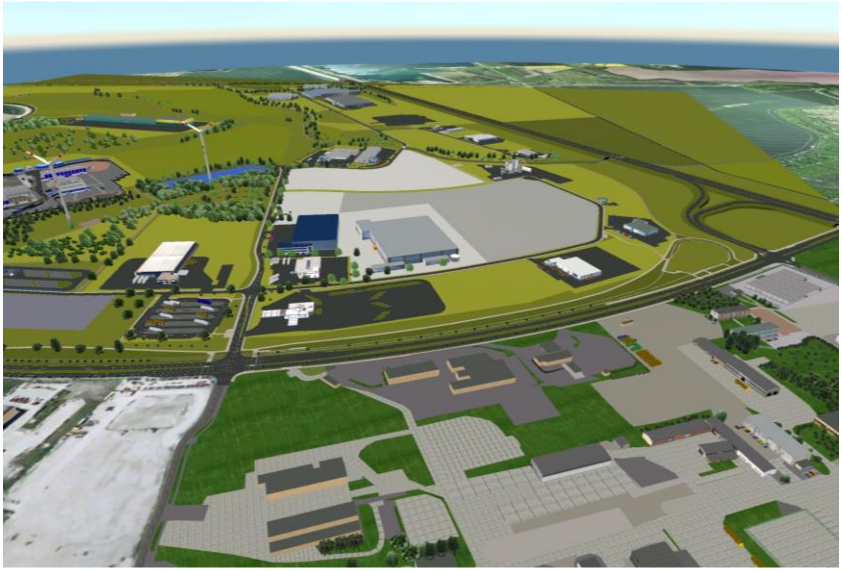


Figure 3: Bird's –eye view of the virtual terrain model of Industry- und Logistic centre Magdeburg Rothensee (ILC), Germany [3]

4.3. Mapping of internal and external factors promoting or threatening priority/measure achievement (SWOT)

In order to visualise the resulting efforts and impacts an EI-matrix will show the distribution of measures.

a) Starting with the measure 'better integration of local population in project' the following strengths can be identified:

- higher involvement of local population,
- easy to realise ,

In addition, weaknesses also occur. Among them, the following weakness has been pointed out:

- energy consultant and other employees need to be trained in order to inform the population in the appropriate and needed way.

As external factors, different opportunities might be created. They can be identified as following:

- higher identification of population with new measures,
- higher acceptance of new measures/ changes,
- population takes more responsibility for their own behaviour,
- measures also show applicability in personal life.

Similar to the weakness, the threat related to the opportunities has been stressed as following:

- population may block votes due to their incompetence.

The average result is represented in Figure 4.

b) The second measure 'better incentive support for the projects instead of bureaucracy ' shows the following internal strength factors:

- high impact,
- already existing mechanisms.

As weakness the following point has been identified:

- part of the financial funding, instead to be totally used for the planned measurements is partially used also for consultation (i.e. costs due to the energy expert advices).

The following external opportunities have be recognized:

- insight from a different perspective,
- helps to implement new technologies and realise the transition to more energy efficient technologies/plants/applications.

The related threat has been recognized as :

- financial support might not be used for the supposed measure due to less controlling

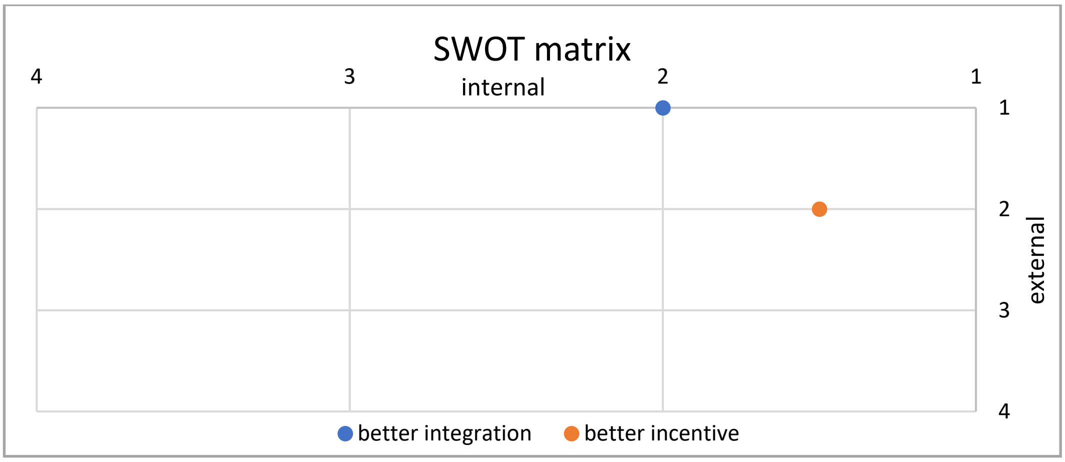


Figure 4: IE-matrix for measure 'better integration' and 'better incentive'

c) 1 GW electrolyzer capacity for green hydrogen production

The internal factors for strength are identified as:

- increase of flexibility options to be used for balancing the volatile generation by RES,
- possibility to use natural gas network for feeding the hydrogen.

The related weaknesses are listed as following:

- high capital might be required,
- for hydrogen production, high amount of water is needed.
- low energetic efficiency.

As external factors the following opportunities have been pointed out:

- possibility to increase the penetration of RES electric power generation,
- start up new business models based on green hydrogen,
- long time energy storage systems.

The threats are listed as following:

- for green hydrogen production, the technology is limited at the areas in which there is surplus of RES power generation,
- leak of companies with high expertise for large electrolyzers.

d) Extension of the existing H2 grid

The strength for this measure can be listed as following:

- possibility to supply green hydrogen to a larger amount of consumers (industrial and residential),
- transport for long distance green hydrogen,
- supply zones unfavourable for RES power generation.

The related weakness have been identified as following:

- higher investment costs if compared with natural gas grid,
- uncertainty to be able to use on market compressors for pushing hydrogen for long distance.

The external opportunity factors have been listed as:

- new job opportunities linked to the green hydrogen production,
- possibility to increase experiences and to develop competences which could be exporting to other lands and countries,
- to supply also the transportation sector, especially trains and trucks.

The threats have been identified as:

- more expensive than natural gas,
- need to dedicate incentive to H2 consumers,
- need to create dedicated infrastructures (i.e. caverns).

5. ACTION DEFINITION

5.1. Actions to take on policy level

5.1.1. Description of actions to promote priority implementation

a) In order to realise the measure ‘**better integration of the local population**’ new political standards and key factors need to be implemented. Those can be summed up to the following actions:

1. offer more referendums

This allows the population to decide which measures, projects, technologies, laws and so on they would like to realise in their area and gives the power to take action in the political process by especially giving them the opportunity to suggest their own projects etc.

2. promote new measures with a wider range

Promoting and informing the public through more and different medias like digital and printed newspapers, advertisements and info points that reach out to a wider range of people and the whole affected areas. But also explaining upcoming changes so that the acceptance increases since the knowledge behind it is provided.

3. provide easy access to information material regarding regional measures/ developments and trends

In order to increase the acceptance and likelihood of e.g. new power plants, the population needs to get easy access to information. The easier the access and the lesser the effort in gathering information the better and more satisfying the information are for citizens. Also, a virtual reality platform can help accepting new power plants

4. create information material on regional measures/ developments and trends

By creating information material for specific projects, laws or as a kind of further education citizens can increase their knowledge about climate change, current progresses in new technologies and studies. Thereby the acceptance of renewable energies and GHG -reducing technologies might increase in the population.

5. open up decision making meetings to public

Open up decisions making meetings gives the public more the feeling of being involved and no decision is made behind closed doors or laws needed to be hid from public.

6. create new ‘round tables’ to involve public and external parties

‘Round tables’ like ‘round table for energy & climate change’ may be the basis for new regularly happening meetings. They should be interdisciplinary and open for every citizen interested and motivated to participate. This way everyone can discuss upcoming projects or organise non-profit events etc.

b) Actions to realise the measure '**better incentive support for the projects instead of bureaucracy**' are also based on new political regulations for application, funding and tenders. Therefore, the listed bullet points need to be fulfilled:

1. increase promotion for supported projects

Events dedicated to potential stakeholders (i.e. SME, consumers, operators) need to be organized. Digital formats need to be also developed and shared among dedicated platforms.

2. increase information material for supported projects

After the wider promotion of funding programs and tenders the provided information must be increased to make sure that the thresholds are as low as possible and show the worthiness of such programs.

3. increase support for applications/tenders

The amount of paper works or questionnaires which need to be filled should be limited to the minimal one. Digital database should be used in which the majority of information are already stored.

4. clear out who is the right contact person for further questions

In order to ask for support during the application it is necessary to easily find out who might be the right person to contact, who is responsible for the present case, without a complicated and long-lasting research.

5. reduce application criteria

The previous points already sum up most of necessities of this action. Reducing application criteria leads to a higher willingness to use and apply for support and funding programs

6. easy understandable wording and clear structure

The needed paper work and application forms should have an easy understandable wording to lower the threshold as well as a clear structure so that barriers of providing or uploading documents is as easy as possible.

5.1.2. Description of actions to minimize negative developments

Since all those actions only improve the current situation and have no negative effect, there are no negative developments to be considered or actions needed to minimize negative developments, besides the exploitation and the wrong use of financial funding and support. Therefore, the right criteria still has to maintain an appropriate selection of projects and benefactors (i.e. private persons, SME etc.) that apply for funding programmes, but at the same time, keep the application as simple and attractive as possible.

5.2. Actions to take on technical level

5.2.1. Description of actions to promote priority implementation

Considering the mentioned measure, also actions at technical level, should be taken in consideration. Rearranging websites or online application forms are helpful as well as newsletters, flyers, digital platforms, webinar etc. Moreover, new user friendly solutions, like representation of the projects through virtual reality tools, need to be developed.

Another option for decarbonisation and maintaining the already existing amount of renewable energy power plants in Saxony-Anhalt might the method of repowering. It is based on removing old and less efficient wind power plants and replacing them by new more efficient ones. Since the rules for their location and the allowed/permitted areas have changed, some new plants might not be able to be rebuilt at the exact same place. Repowering generally reduces the number of turbines significantly, while modern turbine technology multiplies the yield. The federal association *WindEnergie-BWE* asks in a position statement 'for further operation, the market proceeds including the CO2 component should be used and regional marketing in various sectors should be facilitated' [4]. The potential of repowering is still high and could lead to a higher yield in energy power generated by wind turbines, but needs to be more promoted and achieved. [4] Figure 5 shows the development that could have been achieved by repowering the old wind power plants.

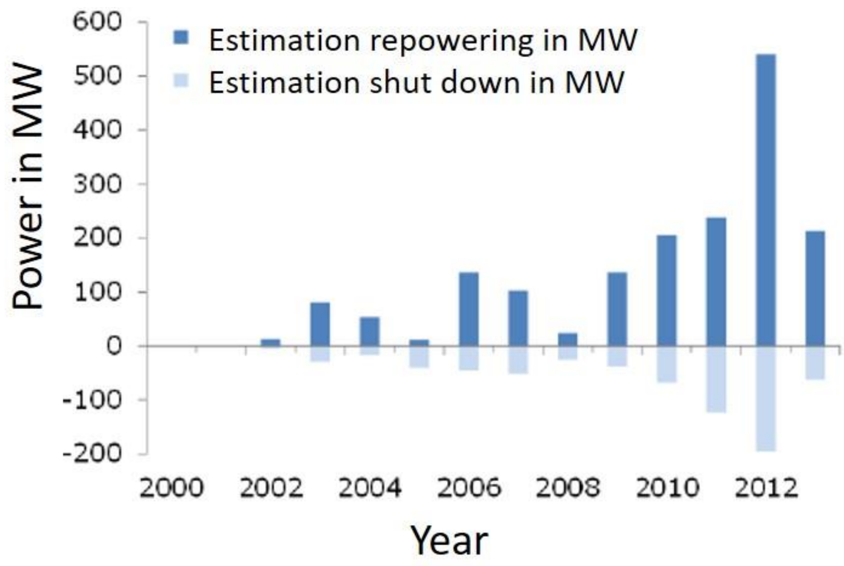


Figure 5: Development of the annual plant capacity with regard to decommissioning and repowering from wind energy in Germany

5.2.2. Description of actions to minimize negative developments

The already mentioned aspects of promoting and constantly repowering older wind turbines is a significant action to take in order to maintain and increase the amount of renewable energies in the future. In addition, pilot projects in which solutions with a technology readiness level (TLR) between 4 and 8, should be supported. The participation of local population, technical and economic stakeholders as well as research centres and academics is fundamental for minimizing negative developments. Furthermore, the dissemination of the results should be constantly and be as simple as possible.

5.3. Actions to take on financial level

5.3.1. Description of actions to promote priority implementation

The financial actions need to be adequately evaluated. From the economic point of view, the financial actions should make an investment on a sustainable solution (i.e. new heating system or passive cooling system) as attractive as the traditional one. Indicators, like i.e. pay-back-time or net present value, should be considered to estimate the needed financial actions to be dedicated for the implementation of sustainable solutions. These indicators should have similar or better values as those for traditional solutions.

5.3.2. Description of actions to minimize negative developments

Risk management should be used to minimize the possible negative developments which might occur during the realization of a project. Clear commitments to beneficiaries of funding should be formulated. It will ensure that the beneficiaries embed duties into the governance of the project. In addition, transparency and long term view should be foster and benchmark methodologies should be promoted.

5.4. Contribution of actions to the EU 2030 targets

The first two measures that are being focused on here also contributes to the actions set by the EU to achieve the targets of EU2030. Since only partially actively make an impact on those targets they still are necessary for the acceptance and further realisation of the decarbonisation and energy transition in Saxony-Anhalt. The better integration of the local population is a superior measure and its actions are in touch with every action in a different more general way. This also suits for the better incentive support for the projects instead of bureaucracy. The measures regarding the H_2-strategy also are in line with the EU 2030 targets. They even accelerate the achievements of those targets, since they directly focus on green H_2 gas and make fossil gas redundant.

6. SCENARIOS

6.1. Overview on actions and measures on the time scale

All the suggested actions aim to increase the power generation by renewable energy sources and to electrify, as much as possible, other energy sectors like transportation, heating and cooling. In this view, different scenarios have been formulated in order to estimate how defined actions impact on the energy plans of Saxony-Anhalt. The federal state Saxony-Anhalt has some climate goals which need to be reached till 2030. These are the same climate goals as the ones the German government defined for the whole country. The climate goals that are focused on for the simulation contain the reduction of the CO2 emissions by 55% till 2030, compared to the values of 1990. To reach these goals, there are different actions planned to reduce the CO2 emissions.

To calculate, how effective each action is, a calculation tool developed in MS Excel, for the purposes of PROSPECT 2030 scenario building is being used. The tool evaluates the generated CO2 emission based on chosen the power plant technologies (i.e. fossil or renewable based), the demanded energy for industry and residential users. Different forms of energies have been taken in consideration: electricity, thermal and transportation.

6.2. Short term scenario

The short term scenario targets the CO2 emission by 2030. Through the simulated scenarios, the actions plan effects to the CO2 emissions have been evaluated.

6.2.1. Base values and assumptions for the simulation

To keep the model as simple as possible, the focus was set on 2 main factors. Phase out of the solid fossil fuel-based electricity generation (coal) till 2040 and the change of the transport sector to electrically powered (e-mobility).

In Saxony-Anhalt, a plan aiming the phase-out of power (electric and heat) generated by coal has been already draft. This plan has been considered as backbone for the creation of scenarios. For the reduction of coal powered power plants, the action plan of Saxony-Anhalt plans to shut down one small power plant till 2030. The power plant Deuben, which has the power of 67MW_el produces 428.000 MWh per year, which is around 7% of the total coal powered electricity generation in Saxony-Anhalt. In addition to the electricity produced, the power plant also produces heat, which is distributed via district heating. As an assumption, also the value of 7% of the total district heat produced by coal powered power plants in Saxony-Anhalt is used, which needs to be balanced by the shutdown of the power plant Deuben. The planned change of the transport sector to e-mobility was calculated to 25% of the whole sector till 2030 [9]

With these two factors, two different demands need to be balanced:

1. Heat
2. Electricity

6.2.2. Balance of the missing generation

To simulate the mentioned actions, there are different possibilities to balance the missing heat and electricity to be generated.

6.2.2.1. Balance of the Heat

For the balancing of the missing heat from the shutdown of the power plant Deuben, two possible alternatives have been formulated. The first one, foresees the use of electric-driven low enthalpy heat pumps. The assumption considers that heat pumps are installed near the consumers. It does not take in consideration whether the heating system of the final user is suitable for low enthalpy heat supply. This alternative has been formulated since the technological maturity of high enthalpy heat pumps is still low. As consequence of this choice, the heating district which is actually in operation, can not be used.

The second alternative, considers natural gas fire boilers as technology to generated heat. In this case, the heating district might still be used, since such a technology allows to generated heat at higher temperature than low enthalpy heat pumps.

6.2.2.2. Balance of the missing electricity

The electricity demand which needs to be balanced consists of three different positions:

1. Missing electricity produced from power plant Deuben,
2. New electricity demand for driving heat pumps (from heat generation),
3. New electricity demand to supply the transport sector (through e-mobility).

To balance the electricity demand, it has been defined the expansion or repowering of the three most important renewable electricity generation technologies, which are dominant in Saxony-Anhalt:

1. Wind power (new plants or repowering),
2. Photovoltaics (new plants),
3. Biomass (new plants).

To get a good overview on the how large the expansion must be and how the investment costs are with the expansion of the different technologies, in total 7 different scenarios were defined to balance the electricity demand (see Table 8).

Table 8: Share to balance the electricity demand for the different scenarios

	Share to balance the electricity demand		
Scenario	Photovoltaics	Wind power	Biomass
1	0%	100%	0%
2	50%	50%	0%
3	100%	0%	0%
4	33%	33%	33%
5	0	50%	50%
6	50%	0%	50%
7	0%	0%	100

6.2.3. Declaration of the Scenarios

Combined with the two different ways to balance the heat demand, there are 14 scenarios in total.

The name of the specific scenario is composed of 3 Parts:

- The first part shows the year, for which the scenario is calculated
- The second part defines the heat generation via
  - Heat Pump: 1
  - Natural gas: 2
- The third part defines how the electricity demand is balanced (see Table 8)

The examples listed in Table 9 show how the scenarios are declared:

Table 9: Examples for the declaration of the scenarios

2030.1.1	• heat pumps to balance heat demand
2030.1.2	• natural gas boiler to balance heat demand

6.2.4. Sankey diagram

The impact of the planned actions can be easily evaluated by the use of Sankey diagrams. The Sankey diagram depicts the energy forms flowing from the sources to the end users. In this way, the most demanding sectors and the most consumed energy forms can be easily identified. For example, in Figure 6 the primary energy flows and the energy forms which are actually consumed within the federal state of Saxony-Anhalt is depicted. In order to compare the impacts of the identified actions, the representation of the status quo can be used as benchmark scenario.

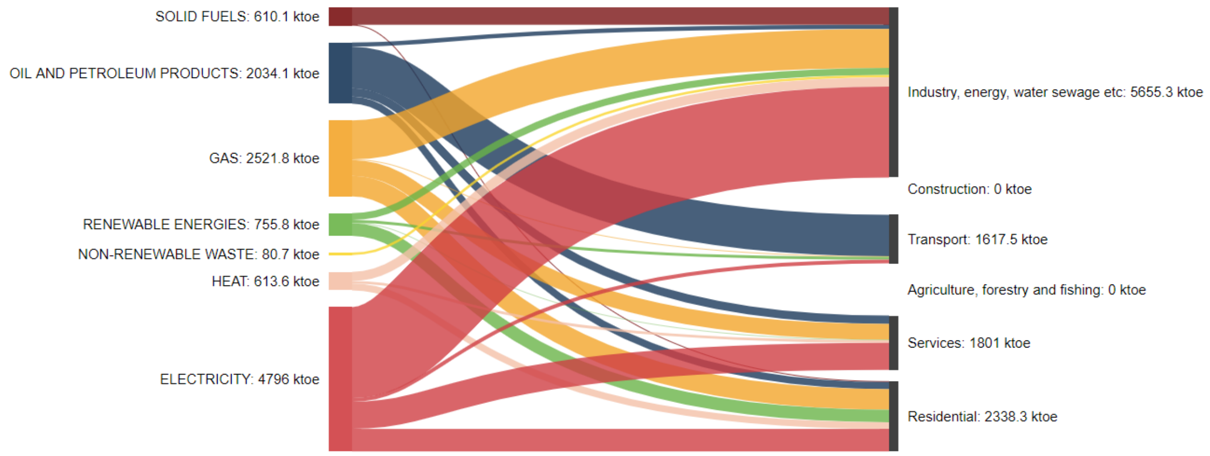


Figure 6 Primary energy forms and flows within the federal state of Saxony-Anhalt

The related CO2 emissions flows follow the same pattern of the primary energy flows (see Figure 7). In order to evaluate them, the emission factors listed in Table 10 have been considered.

Table 10 Emission factors

Sectors	Solid fossil fuels	Crude oil and petroleum products	Gas	Renewable energies	Renewable fuel for transportation	Non renewable wastes	Electricity	Derived heat
Values in ktoe	0.41	0.310	0.24	0.031	0.19	0.33	0.616	0.195

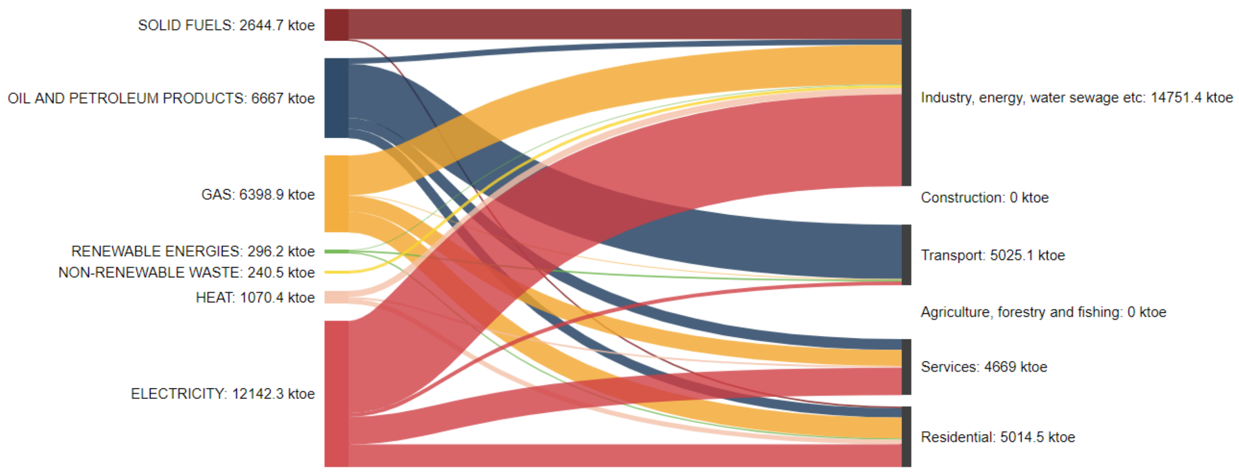


Figure 7 CO2 flows due to the primary energy consumption

6.3. Calculations

6.3.1. Calculation of the additional electricity demand

6.3.1.1. Scenario 2030.1

The phase-out plan from the power generation by coal sources foresees that the coal fired power plant in Deuben will be switched out by 2030. The power plant has an installed electric capacity of 67 MW. Its parameter of “full load hours” is about 6.400 hours. It implicates that the missing generated electricity is 427.980 MWh per year.

In addition, for residential purposes, coal is used for generating about 320.278 MWh of thermal energy. Electric driven heat pumps could be used for covering such a demand. The analysis considers that heat pumps with a coefficient of performance (COP) of 3.5 are installed near the demand and are operated at low enthalpy.

Related to the traffic sector, CO2 could be reduced if electric vehicles are used instead of vehicles using combustion engines. The analysis considers that the electric mobility will cover 25% of the transportation sector. Therefore, the electrification of the mobility will add 1.241.630 MWh of new electricity demand.

By considering the missing electricity generated by the power plant in Deuben, the new electricity demand for driving heat pumps and for supplying electricity to the transportation sector, about 1,73 GWh of electricity should be generated (see Table 11).

Table 11 summarizes the main values of the energy balance for the scenario 2030.

Table 11 Energy balance for scenario 2030.1

	Missing electricity generation in MWh	Missing thermal generation in MWh	New electricity demand for driving electric power in MWh	New electricity demand for suppling 25% of mobility in MWh	Additional amount of electricity to be supplied in MWh
Coal power plant Deuben	427.980				
Coal for heating room purposes in residential and service sectors		320.278			
Electric driven heat pump			91.508		
Electric mobility				1.214.630	
Electricity to be generated by RES based technologies					1.734.118

The impact on the CO2 emissions is depicted in Figure 8.

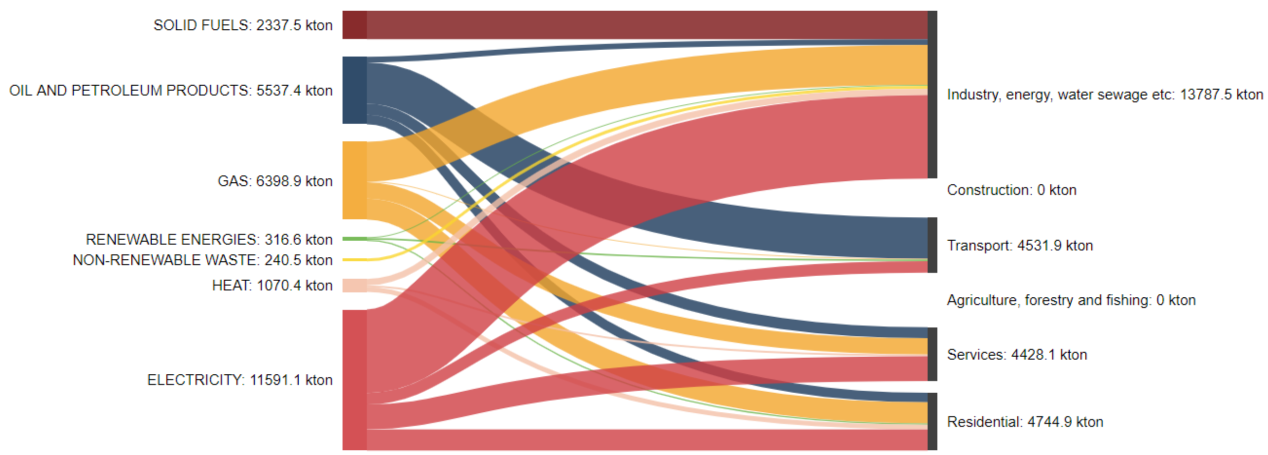


Figure 8 Sankey diagram of CO2 flows for the scenario 2030.1

6.3.1.2. Scenario 2030.2

Differently from the scenario 2030.1, in the scenario 2030.2 the missing generation of thermal energy is covered using natural gas fired boilers instead of electric driven heat pumps. Solar and wind energy are used to cover the missing electric power generated by the Duebel power plant.

The electricity to be generated is equally divided between photovoltaic technology and wind turbines.

Table 12 summarizes the main energetic values for the scenario 2030.2.

Table 12 Energy balance for the scenario 2030.2

	Missing electricity generation in MWh	Missing thermal generation in MWh	Thermal generation by gas fired boiler in MWh	New electricity demand for suppling 25% of mobility in MWh	Additional amount of electricity to be supplied in MWh
Coal power plant Deuben	427.980				
Coal for heating room purposes in residential and service sectors		320.278			
Natural gas fired boilers			320.278		
Electric mobility				1.214.630	
Electricity to be generated by RES based technologies					1.642.610

The impact on the CO2 emissions is depicted in Figure 9

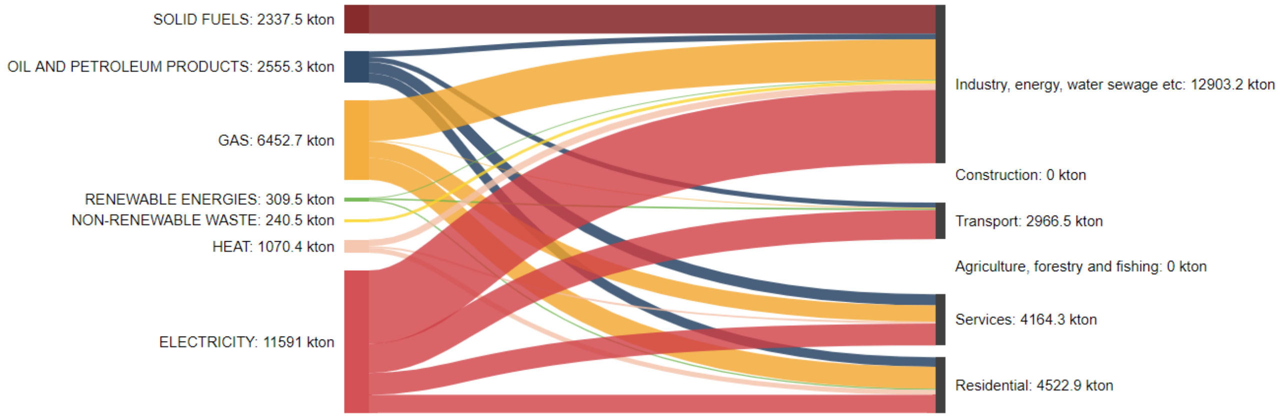


Figure 9 Sankey diagram of CO2 flows for the scenario 2030.2

6.3.2. Calculation of the needed expansion to balance electricity demand

A sensitivity analysis has been performed for calculating the needed power capacity to be installed to cover the increased electricity demand. Up to three technologies have been considered: wind turbines, photovoltaic plants and biomass. In the case in which two technologies are considered, the size of the required power capacity has been calculated by considering that the electricity to be generated is equally divided among the two technologies. Similarly is for the scenario in which three technologies are considered (see Table 8). Figure 10 and Figure 11 graphically summarize the obtained results.

Table 13: needed expansion of the different technologies for balancing electricity demand 2030.1/2030.2

	Expansion in %			Expansion in MW		
scenario	Wind farms	PV plants	Biomass fired plants	Wind farms	PV plants	Biomass fired plants
2030.1.	19,7	0	0	1001	0	0
2030.1.	9,8	44,0	0	500	992	0
2030.1.	9,8	0	56,8	500	0	227,4
2030.1.	6,5	29,0	37,5	330	654	150
2030.1.	0	88,0	0	0	1984	0
2030.1.	0	44,0	56,8	0	992	227
2030.1.	0	0	113,7	0	0	454
2030.2.	18,6	0	0	948,4	0	0
2030.2.	9,3	41,7	0	474,2	939,7	0
2030.2.	9,3	0	53,8	474,2	0	215,4
2030.2.	6,1	27,5	35,5	312,9	620,2	142,1
2030.2.	0	83,4	0	0	1879,4	0
2030.2.	0	41,7	53,8	0	939,7	215,4
2030.2.	0	0	107,7	0	0	430,8

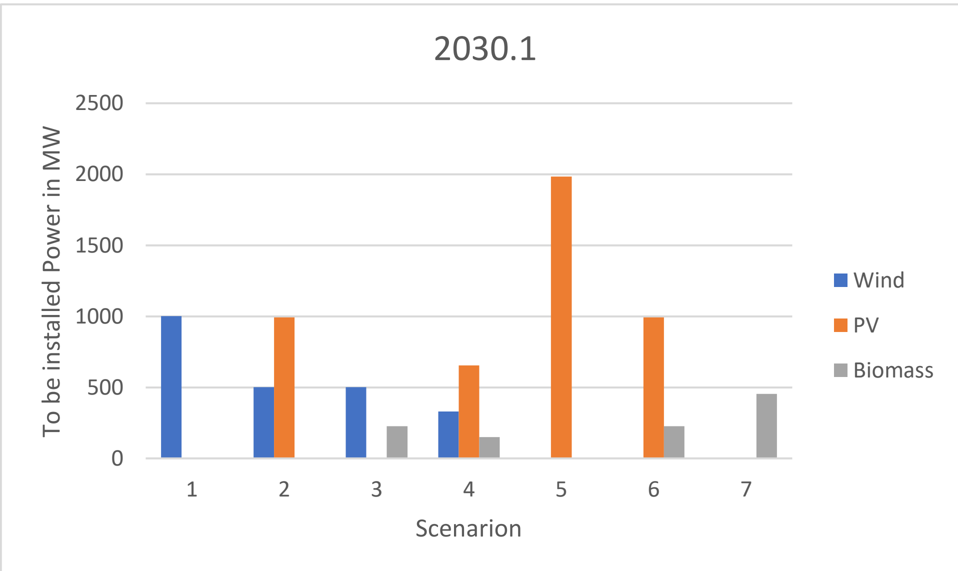


Figure 10 Power to be installed for the scenario 2030.1

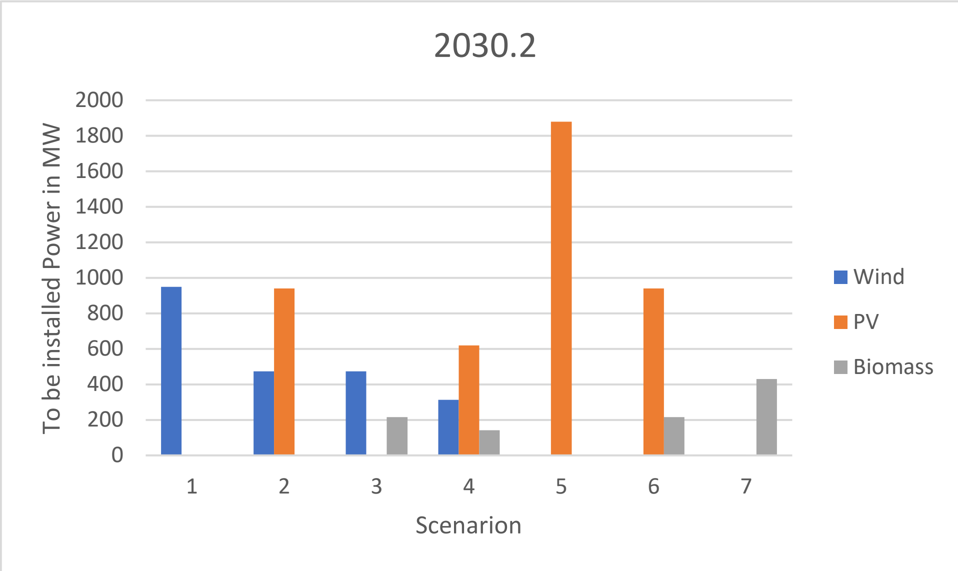


Figure 11 Power to be installed for the scenario 2030.2

6.4. Results

6.4.1. Economical results / investment costs

For the determination of the economical results of the scenario, the investment costs of all parts of the models are calculated. For the calculation, assumed values for full load hours and specific investment costs are needed. The specific investment costs do not include any costs for installation or needed ancillary costs (i.e. cost for construction new ways for transporting wind turbines). Table 14 shows the assumed specific costs for the considered technologies, while

Table 15 summarizes the main results for all analysed scenario. In addition, a ranking has been performed, which orders the best results in increasing way. From the economic point of view, the scenarios which foreseen to install additional power capacity using wind technology seems to be the most appropriate. However, it must be underlined that such a technology (similar to the photovoltaic plants) generate electricity with a volatile pattern. A huge generation of electricity by wind requires also high investment in creating new flexibility options (i.e. energy storage systems or power to X solutions). Besides it, it should be proven whether potential areas are available for installing the estimated additional capacity. A mix between biomass fired power plants and wind farms see also to be attractive. Indeed the needed investment costs are slightly higher than that in which only wind farms are foreseen. Higher are the needed investment costs for the scenario in which the additional demanded electricity is equally shared among wind, sun and biomass. On the other side, a solution in which only photovoltaic plants are considered is advised again. Indeed, the needed investment costs are the highest among all analysed scenario. In additional, also in this case, huge investment in adding flexibility capacity is necessary to balance the volatility of power generated by photovoltaic.

By considering the scenario in which natural gas boilers are considered for covering the missing heat generation of the coal fired power plant in Dueben, non-evident differences are shown. Indeed the results on the required installed capacity as well as required investment are very similar.

Table 14: Assumed values for calculation

Technology	Full load hours [h/a]	Specific investment costs [€/MW peak]
Wind	1732	700.000
PV	874	1.150.000
Biomass	3812	3.700.000
Heat pump	1.150	1.000.000*
Natural gas heating	1.150	140.000*

*[€/MWpeak_therm] - Assumption Fraunhofer Institute IFF

Table 15: Calculation of the investment costs to expand renewable power plants with ranking 2030.1/2030.2 (1= cheapest)

Scenario	Investment for wind farms in M€	Investment for photovoltaic plans in M€	Investment for biomass fired plants in M€	Total investment in M€	Ranking
2030.1.	700	0	0	700	1
2030.1.	350	1.140,8	0	1.491	3
2030.1	350	0	841,4	1191,9	2
2030.1.	231,3	1150,8	555,4	1.539,6	4
2030.1.	0	2.281	0	2.281	7
2030.1.	0	1.140,8	841,4	1.982	6
2030.1.	0	0	1.682,9	1682,9	5

6.4.1.1. Heat

For the calculation of the total investment volume, the investment costs for the generation of the heat via heat pump or gas heating are needed additionally. Using the heat demand from 6.3.1.1, the full load hours and the specific investment costs from listed in Table 14, the investment volume can be calculated.

Investment volume heat pumps (2030.1): **81 M€**

Investment volume gas heating (2030.2): **11 M€**

This value needs to be added to the total investment costs listed in Table 15.

6.4.2. Ecological results

The ecological results are metered considering the CO2 emission, which are calculated for both the considered scenarion and afterwards compared with the values from 1990, to see if the climate goals are reached. As benchmark, the CO2 emission in the year 1990 has been considered, which amounts to 49.522.ktCO2. Similar to the national CO2 targets, in Saxony-Anhalt a reduction of 55% compared to the emission of the year 1990, is aimed.

Table 16 shows the amount of reduction which could be reached if the scenario 2030.1 or 2030.2 are developed. In both the case, the reduction is lesser than 55%. Indeed, by adding the new capacity only through wind technology and using electric driven heat pumps for covering the missing heat generation of the coal fired power plant in Dueben, a reduction of CO2 emission of 48,9% is achieved. The choice of natural gas fired boiler worsens the results. Indeed, in this case the reduction will be 43,8%, which are 11,2% lower than the target.

Table 16: Calculation of reduction of CO2 emissions - scenario 2030.1/2030.2

Scenario	CO2 emissions calculated in ktCO2	Reduction in ktCO2	Reduction in %
Scenario 2030.1	25.322	24.199	48,9%
Scenario 2030.2	27.824	21.697	43,8%

6.5. Additional scenario to reach climate goals - 2030.3

An additional analysis has been performed to evaluate the needed actions which are necessary to reach the fixed CO2 target. Therefore a new scenario (2030.3) has been investigated. Among all the possible options, the expansion of the e-mobility in the transport sector seems to be the only one which might contribute the reach the target 2030[1]. The analysis of the scenario shows that a share of 91% e-mobility in the transport sector would be enough to reduce CO2 emissions by 55%. With this result, the climate aims to 2030 would be reached.

Table 17: Calculation of the reduction of CO2 emissions - scenario 2030.3

Scenario	CO2 emissions calculated in ktCO2	Reduction in ktCO2	Reduction [%]
Scenario 2030.3	22.295.244	27.226.756	55%

However, covering 91% of the transportation sector using electricity instead of fossil sources, will increase the demand of electricity which must be generated using renewable energy sources. Table 18 summarizes the energy balance for suppling 91% of the transportation sector through electricity.

[1] The switch-off of the second coal-fired power plant has been not considered.

Table 18 Energy balance for the scenario 2030.3

	Missing electricity generation in MWh	Missing thermal generation in MWh	New electricity demand for driving electric power in MWh	New electricity demand for suppling 25% of mobility in MWh	Additional amount of electricity to be supplied in MWh
Coal power plant Deuben	427.980				
Coal for heating room purposes in residential and service sectors		320.278			
Electric driven heat pump			91.508		
Electric mobility				4.421.252	
Electricity to be generated by RES based technologies					4.941.037

6.5.1. Calculation of the needed expansion to balance electricity demand

To calculate the needed expansion for balancing of the electricity demand, the same calculation as for scenario 2030.1 and 2030.2. have been used. Table 19 summarizes the needed expansion for wind farms, photovoltaic plants and biomass fired power plants both as percentage and as in GW. Figure 12 summarizes the results graphically. In comparison with the scenario 2030.1 and 2030.2, the additional capacity needed to reach the CO2 targets must be more than three times higher. By considering the needed investment costs (see Table 20), the generation by using only wind farms results to be the most attractive one. Adding new capacity using only photovoltaic technology should not be advised since it requires the highest investment costs.

Table 19 Needed expansion of the different technologies for balancing electricity demand 2030.1/2030.2

	Expansion in %			Expansion in GW		
scenario	Wind farms	PV plants	Biomass fired plants	Wind farms	PV plants	Biomass fired plants
2030.3.	56,2,6	0	0	2852,8	0	0
2030.3.	28,0	125,4	0	1426,4	2826,6	0
2030.3	28,0	0	162	1426,4	0	648
2030.3.	18,5	82,7	106,9	941,4	1865,6	427,7
2030.3.	0	250,8	0	0	5653,4	0
2030.3.	0	125,4	162,0	0	2826,7	648
2030.3.	0	0	324,0	0	0	1296

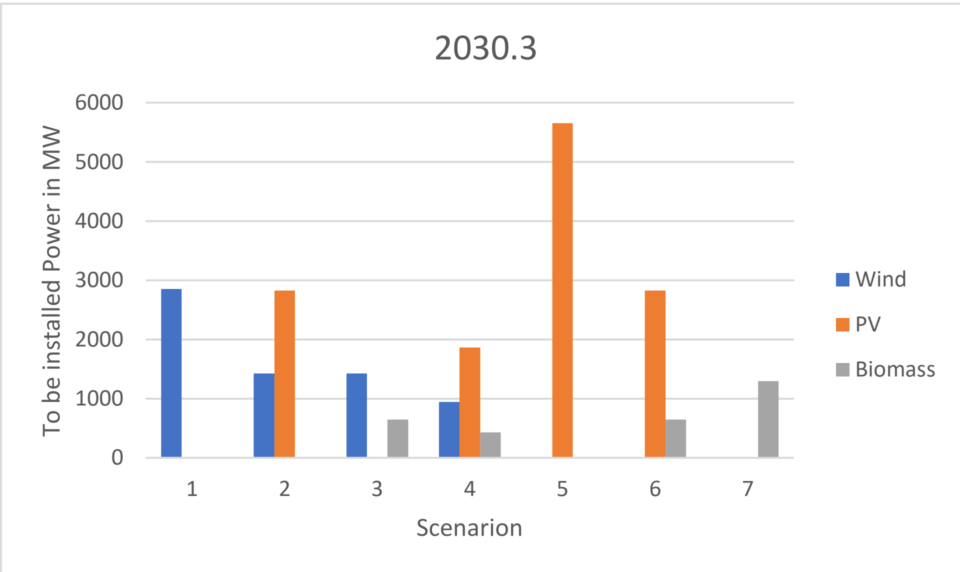


Figure 12 Power to be installed for the scenario 2030.3

Table 20: Calculation of the investment costs to expand renewable power plants with ranking 2030.3 (1= cheapest)

Scenario	Investment for wind farms in M€	Investment for photovoltaic plans in M€	Investment for biomass fired plants in M€	Total investment in M€	Ranking
2030.3.1	425,5	0	0	425,5	1
2030.3.2	212,7	1140,8	0	1353,6	3
2030.3.3	212,7	0	841,5	10540,2	2
2030.3.4	140,4	752,9	555,4	1448,8	4
2030.3.5	0	2281,7	0	2281,7	2
2030.3.6	0	1140,8	841,5	1982,3	6
2030.3.7	0	0	1682,9	1682,9	5

6.6. Conclusion

The results of the scenarios show that the planned actions of the state Saxony-Anhalt do not match with the climate targets of the whole country, which consist of reducing the emission of CO2 by 55% till 2030. One possible solution, for reducing theemissions by 55%, can be reached with the shift the supply to the transport sector from fossil sources to electricity. Indeed, through an electrification of the transportation sector of 91% a reduction of 55% can be reached.

It is important to point out, that the analysed scenario taken in consideration the national phase-out strategy from the use of coal to generate electricity and heat. Such a strategy foresees that the second large coal fired power plant operating in Saxony-Anhalt will be switched out after the year 2030.

The results also show that the difference of the CO2 emissions between balancing the heat with heat pumps (2030.1) and natural gas (2030.2) is 6% of the total amount of CO2 emissions (2.501 ktCO2), while the difference between the investment costs (without investments of the heat generating units) is only 0,6%. According to these results, it makes sense to change the generation of heat directly to heat pumps without the use of fossil fuels, because the rising demand of electricity effected from the heat pumps is not significant.

Problematic is, that the specific investment costs for heat pumps are more than 7 times higher than those for gas heaters. Therefore, it is currently much more expensive to switch to heat pumps. The difference between the total investment amount is 5,3% and in total 78.543.945€.

7. IMPLEMENTATION MONITORING AND KPIs

7.1. Evaluation periods

The evaluation of the right realisation and implementation of the required measures should involve a new 'Interministerial Working Group on Climate Protection' in order to assure a close cooperation of the Regional Energy Agency Saxony-Anhalt and scientific advisory boards (i.e. University of Applied Sciences Magdeburg-Stendal). Evaluations periods depend on the focused and on the adopted measures. Yearly reports should be drafted in order to adapt possible responses to the past measures which have not achieve the fixed targets.

7.2. KPIs for impact monitoring

Key performance indicators (KPIs) should provide measurable values for evaluating the implemented measures. They could depict technical, ecological and economic information which should be used to monitor the planned actions and evaluate them during the life time of the action plans. Examples of KPIs are listed in the following tables.

- **Technical KPIs:**

KPI	Description	Unit
Installed RES power	It depicts the total amount of installed RES power	GW
Energy Generation by RES	It depicts the yearly energy generation by RES in the	TWh/year
Ratio energy generation by RES to total energy demand	It depicts the ratio between the total energy generated by RES and the total energy demanded	%
Ratio electricity generation by RES to total electricity demand	It depicts the ratio between the total electricity generated by RES and the total electricity demanded	%
Ratio thermal energy generation by RES to total thermal energy demand	It depicts the ratio between the total thermal energy generated by RES and the total thermal energy demand	%
Amount of RES electricity not integrated into the electric grid	It depicts the amount of RES electricity which the electric system is not able to integrate	TWh/year
Amount of green hydrogen generated	It depicts the yearly amount of green hydrogen generated	TWh/year
Installed power capacity as energy storage system	It depicts the amount of installed power capacity as energy storage system	GW

Installed energy capacity as energy storage system	It depicts the amount of energy capacity as energy storage system	GWh
Average age of RES based power plants	It depicts the average age of all installed power plants which use RES	Year

- **Ecological KPIs:**

KPI	Description	Unit
Total CO2eq emission	It depicts the yearly amount of CO2 equivalent emitted	CO2eq/year
CO2eq emission pro capita	It depicts the yearly amount of CO2 equivalent emitted rated the total amount of population	CO2eq/(year* tot_population)
Ratio installed power capacity of RES to used surface dedicated to agriculture	It depicts the total amount of installed power based on RES rated to the total used surfaces which could be dedicated to the agriculture	GW/m^2

- **Economic KPIs:**

KPI	Description	Unit
Specific investment costs for power plant based on RES	It depicts the specific investment costs for different RES based technology	€/kW
Cost of generated energy	It depicts the costs to generate energy (i.e. electricity, thermal or gas)	€/kWh
Total needed investment	It depicts the total needed investment for a dedicated measure	€
Ratio investment to saved CO2eq	It depicts the ratio between the investment and the amount of saved CO2 eq	€/CO2eq

8. ASSESSMENT OF SUITING BUSINESS MODELS AND FUNDING SCHEMES

8.1. Existing business models for low carbon energy supply and improvement potentials

The existing business models are based on the financial support and possibilities provided by the German Law of Renewable Energies (*EEG*). That promotes the energy transformation in Germany and the regarding decarbonisation, energy efficiency, installation of renewables. Therefore, the business models can be divided by the way of producing or the source for consuming.

SME's and private households can be pure consumers by getting electricity from the grid and using gas from the nearest pipeline generated by any generation company or pure producers. Focusing on low carbon energy supply, the customer can choose to get *green electricity* from an energy supplier that sells energy generated by renewable energy sources like wind or solar power (model A). But they can also produce and use their own energy (model B). Therefore, funding of KfW exist, depending on the planned power, capacity, efficiency and investment height, in order to support the installation of self-owned energy systems. Other models support the generation of electricity and the feed of the surplus of electricity into the grid (model C), the generation of heat from biogas (model D) and the generation of heat from bio electricity (model E). Table 21 lists the different models and each (dis-)advantages and possibilities for improvement. Table 21 shows the advantages and disadvantages as well as possible improvement of the suggested business models.

Table 21: Advantages, disadvantages and possible improvements for different business models

Model	Pros	Cons	Possible Improvement
A	• no big investment needed • change of energy supply almost immediately possible	• no possibility to influence the electricity (mix) that comes out of power socket • still using partly carbon sourced heating/electricity • a lot of research necessary to find suitable companies • ~40% of green energy in the grid	• Increase the amount of green energy sources • Easier change of energy supply for customer (contracts, net supply, requirements etc.) • Local energy supplier and public utilities should set a good example and prefer using biogas & energy generated by renewables • First suggestion of supplier for new buildings should be one with low carbon energy supply
B	• direct control of way of energy source, production	• big investment in the beginning	• keep/ improve funding • simplify application

	• many different ways of generating electricity or heat possible • different systems can be combined • possibility to extend system from time to time	• storage system might be necessary (add. cost) • energy management system might be needed or helpful • amortisation takes up to 10-15 years • more complicated funding requirements	• spread awareness of benefits of energetical autonomy
C	• direct control of way of energy source, production • no storage system necessarily needed • shorter amortisation time	• decreasing feed-in remuneration	• not necessarily increase feed-in remuneration but increase of taxes for carbon sourced energy
D	• easy to use (already existing boiler might be used further) • increased funding	• depended on enough generation by bio power plants • limited amount of feed-in percentages	• reduce prejudices against bio mass power plants • increase possibility to set up small self-owned bio mass power plants
E	• increased funding • effective CHP usage	• depended on enough generation by bio power plants • transformation losses	• reduce prejudices against bio mass power plants • increase possibility to set up small self-owned bio mass power plants • increase CHP usage

8.2. Alternative business models and applicability

In order to move forward with energy transition and the necessarily decarbonisation more different business models, which take this into account, are needed. One possible way would be to allow and promote to build energy community networks or operate the systems as Net Zero Energy Systems [8]. By the energy community system neighbourhoods could share the electric power generated by renewable (i.e. photovoltaic power plants) or share the investment in building new flexibility options like energy storage systems, power to gas or power to heat plants. In this way not only, the generated electricity but also heat or gas could be shared and distributed between the community. The proximity to open fields and farming land could be used for self-funded bio mass and wind power plants. Communities and small networks like that could easily extend the implemented technologies according to their needs, for e.g. car-sharing points with electric cars could be provided if the community agrees on it. Especially the option to feed-in the surplus into the grid should be simplified. Related to the model of the Net Zero Energy Systems, it consists to generate electric power by renewable energy sources without feeding the electric grid if the generated power is higher than the demand. In order to operate such a system it is necessary to identify, plan and operate new flexibility options such as energy storage systems, energy converters (i.e. Power to gas) or to control the voltage (i.e. within DC manufacturing systems).

Another more future business model could be to generate H_2 and use it for fuel cells as well as to support its feed-in. The usage of is hydrogen is not yet implemented or common, but according funding and support schemes might create a higher incentive in research and development with the aim to result in a direct application and further installation.

8.3. Usable funding schemes: applicability and possible gaps to be filled

In Germany most, funding schemes are offered by the *KfW*, the Credit of reconstruction, and Federal Office of Economics and Export Control (BAFA). Other less common programmes are from Federal Ministry of Food and Agriculture (BMEL), Federal Ministry of Finance (BMF) and German Federal Foundation for the Environment (DBU). [5] These funding schemes are on national level and apply for private persons, commercial sector, industry and local authorities in total Germany. Regarding Saxony-Anhalt and the funding programmes there are currently none on regional level. At least none that are free for tender at the moment. Programmes like Saxony-Anhalt ENEGY or CLIMATE II are joint programmes of the EU and Saxony-Anhalt. Funding made available by the government of Saxony-Anhalt directly is *funding of electricity storages for photovoltaic roof systems*. The incentive is to support the installation of photovoltaic plants by offering funding schemes that enhance electricity storage systems. Regarding the funding of biomass, combined heat and power system there are still some gaps to be filled. Also, since the feed-in remuneration and funding of small photovoltaic cells are decreasing, there need to be alternatives or at least a compensation so that these applications are able to keep up with carbon sourced once. This would lead to decreasing the funding or raising the taxis of carbon sourced energy.

9. CONCLUSIONS

9.1. Summary of findings

Summarising all the findings lead to the result, that there are some important actions to take for Saxony-Anhalt. But still the already existing funding are a good start to support private persons, companies and local authorities during the energy transition. An overall improvement might be made by a better integration of the population, especially in rural areas. There is still a lot of possibility unused regarding biomass power plants, repowering of wind turbines and photovoltaic and combined heat and power technologies. Provide different ways of informing population also by using new technologies might lead to a higher acceptance and the will to support decarbonisation by themselves. Knowledge might be the key to increase the amount of installed power plants for renewable energies. By knowing about the consequences of staying with carbon sourced energies, the positive improvements and possibilities and eliminating prejudices the population might also want to be part of the energy transition.

Creating better incentive support for the projects instead of a high amount of bureaucracy, requirements and paper work is a target that concerns every aspect of German funding programmes. For most support schemes the approval of an energy consultant is needed before the application for funding. This leads to the fact that many possible target groups avoid using these support programmes. Furthermore, it reduces the amount of work for the office employees and reduce the working effort. This money can be used in different and more needed ways.

9.2. Challenges for the regional authorities

Implementing the mentioned actions should not lead to any challenges or problems. Reducing bureaucracy is a highly appreciated measure as well as a better integration of the population. Sure, there might be some weaknesses or threats by realising the developed bullet points. But with proper education and training these could be reduced pretty easily. By the time and with ongoing changes the amount of positive feedback will increase even more.

9.3. Expected impact on regional economy

A calculated impact through realising the measures above is difficult to forecast. Some key performance indicators are the raising amount of installed renewable energy and the increasing interest by the population either in participating politically in the decision making or by applying for support schemes. The economy probably will not be significantly influenced. The increasing impact might be determined in the rural area since there is still the highest possibility. By equalising the regulations for conventional generated energy and renewables the financial inequality could be evened out. This could lead to the case that companies using green energy are more competitive because they can adapt their costs and resulting prices.

9.4. Gaps to fill for proper implementation (technical, regulatory, financial)

Technical implementation can be easily made, only new technologies might require more research and development. Creating new information material (websites, flyers etc.) are already well-known media. The biggest change might be the increased amount of referendums and lesser bureaucracy. The already existing precautions need to be expanded. Referendums are already part of political structures, but not yet used in the way they will be, due to these measures. This will definitely require new restructuring of regulations and the awareness of politicians so that their politics can adapt. Financial gaps will only be needed to over come by increasing the funding and its height because of increasing application amount.

10. List of tables

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