Smart strategies for the transition in coal intensive regions

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Research & Innovation strategy in the field of energy for Southeast Region, Bulgaria

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Executive summary

This Research & Innovation (R&I) strategy aims to support the energy decarbonisation of the most coal-intensive Bulgarian region - South-Eastern Region (SER). The document provides an overview of the R&I approaches in the field of energy and the untapped potential for further regional development and investments. The Strategy considers the current situation in the region in terms of R&I, economy, and energy infrastructure. Additionally, it is aligned with the national and regional R&I and energy decarbonisation ambitions. Finally, based on a SWOT analysis, the Strategy's objectives, priorities, governance, and financing are defined.

The review of the educational and research situation in the region concluded that the current R&I activities in the region are very poor, due to the human capacity, work organization and monitoring, limited national funding, and low decentralization. The existing R&I in SER is weak in comparison to many other regions in Europe. Despite its key role in the country's energy generation and distribution, the region lacks a clear vision for the energy sector's development in compliance with the EU Green Deal's aims, as well as an advanced and long-term vision for regional energy development. Nonetheless, Bulgaria is trying to catch up to other coal-dependent European countries by developing a thorough regulatory framework for the promotion of R&I as well as substantial financing options for its development. Political will and substantial R&I policy advancement at national and regional level can be observed.

Based on analyses of TRACER project, several technologies are expected to play a key role in the energy future of the region – solar PV (both in large and small scale), hydrogen, batteries, waste incineration, smart grids, and digitalization of the energy system.

Considering these technologies, the R&I potential in the region, and the policy and financial environment, the Strategy identified several priority areas for energy-related R&I in SER. In the field of renewables, it is suggested that efforts are directed towards energy scenario modelling and socio-economic research focused on consumers, cost-benefit analyses, and policies. Another key priority is hydrogen, where R&I need to address both the technological development and socio-economic aspects ensuring positive attitude and supporting legal environment. The next priority is dedicated to smart grids and energy system digitalization – these will support the market liberalization and the flexibility of market players. The last priority are energy storage systems, where research efforts are necessary to assess the role they could play in the energy system and to support the planned batteries manufacturing in SER.

1 Introduction

1.1 R&I context in the EU and in Bulgaria

Over the last decade, R&I have become a key European policy priority aimed at supporting the enhancement of the EU's competitiveness and its industries and promoting high-quality research. These objectives of the Union are considered essential for achieving the ambitious targets for a clean, sustainable and prosperous economy. Moreover, the R&I sector is the main driver for fulfilling the European Commission's (EC) 6 goals in the domains of environment and climate, digitalization, employment, EU citizens' and values protection, international relations, democracy and rights.

In its "Strategic plan 2020-2024 - Research and Innovation" (EC, 2020) the EC ranks R&I among the most powerful European policies to boost the Union's economies and competitiveness on the global scale. The Plan foresees the creation of up to 320,000 new highly skilled jobs by 2040 and the leverage of approximately 11 euros of additional investments for each euro invested at the European level. Therefore, the R&I policy is considered to be an engine of the green and digital transitions in Europe in the next decades.

With the introduction of the Green Deal, the EU has declared its global target to fight climate change, being a driving force in developing renewables, and leading the world in energy-efficiency solutions for industry, transport, and buildings. To reach its overwhelming goals, however, Europe needs to invest in energy efficiency and renewable technologies, and the development of clean energy business models, embracing the new opportunities for innovative, cost-effective and environmentally friendly solutions in the context of a global energy transformation process. In 2016, the Commission presented its Accelerating Clean Energy Innovation strategy, where R&I are recognized as a driver for energy efficiency, turning Europe into a global leader in renewables, and boosting a fair deal for consumers. (EC, 2016) The comprehensive research, innovation and competitiveness strategy supports the objectives of the energy union and accelerates the transition to a low-carbon competitive EU economy.

Having as a background the ambitious targets set by the recent EU growth strategies, the coal-intensive regions in the EU, such as the Southeast Region (SER), appear to be struggling between decarbonisation plans and social resistance to energy transition. R&I activities are crucial for attaining social acceptance, legal and institutional framework, and technological development to support the desired energy transformation in the region.

As an EU member state, Bulgaria follows the course of setting the notion for R&I in the centre of its efforts to modernise and boost its competitive edge. Being aware of the fact that Bulgaria's innovation performance has fallen short of expectations, the country was advised by the EC to focus on creating favourable conditions for a R&I ecosystem, in order to help its own economy. With the introduction of the EU Green Deal, energy appeared to be among the priority R&I fields, since the sector will require a massive transformation. R&I appears to be crucial for delivering solutions for the upcoming energy system transition. It has a driving role in the further development of technologies for energy efficiency, renewable energy, energy storage, clean hydrogen, and circular economy.

To meet the EU's energy and climate goals for 2030, the EU member states developed integrated national energy and climate plans (NECP) for the period from 2021 to 2030, providing the basis for the national and regional R&I energy priorities until 2030 and 2050. The Bulgarian NECP aims at creating incentives and support for the introduction of new technologies to achieve an overall reduction in energy costs and impose new standards for energy efficiency and the transition to lower and more sustainable consumption of energy. The particular R&I objectives of NECP are as follows (ME, 2020):

- Implementation of highly efficient energy technologies;
- Construction of smart energy grids and energy storage;

- Supporting research in the field of nuclear energy;
- Exploring the possibilities for implementation of electrochemical sources of energy such as rechargeable batteries, hydrogen-based technologies and fuel cells.

1.2 Development of the Strategy: Overview of the process

The SER, being the host of Maritsa East - the biggest energy complex in South-Eastern Europe, is expected to be the most affected by the energy transition Bulgarian region, thus, it is in the greatest need of advancement in R&I in the field of energy. With the ambition to phase out coal in the upcoming decades, the region is expected to experience a significant shift in the energy mix, economic metamorphosis, social disturbances, and an increased level of unemployment. This leads to the need to re-design the R&I strategy in the field of energy and align it with the new reality in SER, Bulgaria, and Europe.

The current R&I Strategy is designed to assist the actors in SER in developing R&I framework supporting the transition towards a sustainable energy system. To ensure its sustainability, this Strategy establishes the necessary R&I structures and mechanisms.

This Strategy is based on a number of documents and activities, most notably:

- The Entrepreneurial Discovery Process (EDP), undertaken in the region within the framework of the TRACER project, consisting of semi-structured interviews, multi-stakeholder events, and analysis of their outcomes (Nikolaev A., Dineva M., 2021);
- The 2030/2050 energy projection for SER, developed within the TRACER project (Nikolaev A. et al., 2021);
- Outcomes from two meetings of the TRACER Working Group, co-organized jointly with the Interreg Europe project DeCarb;
- National R&I Strategy for Smart Specialisation;
- EU's SET-Plan;
- Outcomes from questionnaires distributed to national and regional R&I organisations in 12/2021 and 01/2022. The questionnaires aimed to obtain comprehensive, actual and reliable information on the R&I status and potential in the region;
- Interviews, mainly with researchers, but also with energy experts and business representatives, conducted in 12/2021 and 01/2022.

1.3 Definitions

1.3.1 Geographical and administrative division

For the purposes of the current Strategy and its territorial scope, it is important to distinguish between several geographical and administrative terms concerning the division of the territory:

- Yugoiztochen region (Southeast Region - SER), a NUTS-2 planning region in Bulgaria, covering 4 districts: Stara Zagora, Burgas, Yambol, and Sliven. SER is the central focus of the current analysis.
- Stara Zagora district, a NUTS-3 region, has a territory of 5.2 thousand sq. km and a population of 0.32 million (2019). The district of Stara Zagora consists of 11 municipalities, among them Radnevo and Galabovo, where the Maritsa East energy complex is located.

1.3.2 The Maritsa East energy complex

In order to grasp the importance of the upcoming transformation of the energy sector and its effect on the SER, it is necessary to understand the scale of the Maritsa East energy complex and its components.

Maritsa East is the largest energy complex in South-Eastern Europe, built on a site with significant lignite deposits. The complex, consisting of three lignite-fired thermal power plants with a total capacity of 3,035 MW, a mining company, enrichment plants, a briquette plant and its own railway system, generates about 40% of the electricity in the country (Ministry of Energy, 2020). The development of the thermal power and mining complex began in 1952. The Maritsa East mines and power plants are interdependent as the only market for coal are the power plants, while the power plants have no other supplier of coal but the mines.

Figure 1: Location of Maritsa East coal mining complex

2 Setting the context

2.1 Regional profile and specialisation

2.1.1 Geographic and economic indicators

The current Strategy focuses on the Southeast planning region (SER) in Bulgaria (NUTS2), which comprises four districts: Burgas, Sliven, Yambol and Stara Zagora with a total of 33 municipalities. The region has a total area of 19,664.2 sq. km (17.8% of the territory of Bulgaria) and a favourable geographical location with wide access to the Black Sea (224 km to the east) and a long border with Turkey to the south. Its crossroad position is a prerequisite for the development of intensive economic connections with other regions in Bulgaria and abroad. In 2020, the population of SER amounted to 1,020,187 people (NSI, 2021a) with an average density of 51,9 people per sq. km. The settlement network in the region consists of 486 settlements (26 cities and 460 villages). The connection with the Northeast and North Central regions is made through the low and convenient Stara Planina passes. The transport corridors No 8 and No 9, as well as the railway line Sofia-Burgas, pass through the region.

The economy of the SER is influenced by several factors. The first one is the strategic geographical location with access to the Black Sea - the port of Burgas with import-export cargo flow through it defines the increased share of foreign direct investments in the SER. Another important element in the regional economy is the large lignite basin located on the territory of Stara Zagora district as a huge source of energy resources - the Maritsa East energy complex. Foreign direct investment is also an important factor for the development of the region's economy and investment structure. A significant part of that investment is directed to the industrial and energy complex "Maritsa East". In terms of GDP, the region ranks third in Bulgaria with EUR 6,364 million in 2020 and EUR 6,226 GDP per capita (NSI, 2021b). The

average annual salary in the SER was EUR 7,077 in 2020 which was the third highest in the country (NSI, 2021c), mainly due to the relatively high wages in the lignite complex.

Zooming in on the Stara Zagora district, it has acquired the moniker "Bulgaria's energy heart" throughout the years. The district is strongly focused on lignite extraction and lignite-based electricity generation, contributing to about 30% of the regional GDP. The Maritsa East lignite complex is the key factor for the fast-growing economy of the region, and is important contributor to the district's relatively high wages and low unemployment. According to the National Statistical Institute (NSI), Stara Zagora district had EUR 8,299 GDP per capita in 2020, which was slightly less than the country's average (NSI, 2021b). The unemployment rate was 2.1%. What is more, this indicator has been decreasing in the last 5 years (NSI, 2021d). Nevertheless, if not properly managed, the envisaged energy transition puts at risk these positive developments in terms of economics, employment, and demography.

2.1.2 Educational structure with R&I potential

The educational network in the SER is relatively well developed. In total, there are 374 educational institutions, 53 of which are vocational schools. The education system also includes 3 universities and specialised universities (in Burgas and Stara Zagora). The number of students in the universities and specialised higher education institutions in the academic year 2020/2021 was 13,934, which was only about 6% of the total students in Bulgaria (NSI, 2021e).

Trakia University, a member of the International Association of Universities, is located in the Stara Zagora district. It is a multidisciplinary university with traditions in human and veterinary medicine, agriculture science, economics, techniques, etc. In 2011, the University broadened its scope and opened a new faculty dedicated to engineering and technologies in Yambol (FTT). The FTT Yambol aims at continuing the good traditions and practices in the field of engineering and technologies for improving the quality of education and stimulating scientific activity, and boosting R&I in the region. The FTT offers bachelor's programs in "Heat and gas supply", "Industrial engineering" and "Electrical engineering" and masters in "Energy efficiency", "Electrical engineering", "Heat and gas supply" and "Industrial engineering". FTT's scientific research in the energy sector may play an important role in the SER's economy in light of the forthcoming energy transformation.

Trakia University is a hosting structure of the newly established Institute for Sustainable Transition, which aims at contributing to the transformation of the agricultural model in the regions affected by the energy transition, as well as to meeting the goals for low carbon and carbon-neutral economy at a regional and national level. The Institute was founded as a joint effort of the Bulgarian Ministry of Education and Science, Ministry of Energy, Confederation of Independent Trade Unions in Bulgaria, Confederation of Labour "Podkrepa", Municipality of Stara Zagora, Trakia University, Technical University of Sofia, University of Mining and Geology "St. Ivan Rilsky" - Sofia, Bulgarian Chamber of Commerce, and the Association of Industrial Capital in Bulgaria. The transition of the SER towards a low-carbon economy, where in the next years the coal energy complex of Maritsa East should be transformed, needs careful socio-economic and technological analyses, development of new high-tech approaches, new educational directions combined with skilling and reskilling, which is the central focus of the Institute established in February 2021.

With its almost 60 years of history, "Prof. Dr. Assen Zlatarov" University in Burgas is among the oldest universities in Bulgaria. It consists of five faculties - of Technical Sciences, Natural Sciences, Social Sciences, Public Health and Health Care and Faculty of Medicine; three colleges - Technical, Medical and College of Tourism; and two departments - of Language Training and of Qualification and Professional Development of Pedagogical Specialists. The institution has demonstrated large potential as R&I driver, making it a key player in SER's R&I ecosystem.

Figure 2: Trakia University [Source: author's photography]

Another important regional R&I player is the Burgas Free University - a modern and innovative private university providing education and research in the following academic areas: Legal, Social and Economic Sciences, Humanities, Technical and Computer Sciences. It has established cooperation agreements with 36 universities and organisations in Europe, America, Asia, and Africa. The University has the potential to play a role in social sciences and humanities (SSH) energy-related research in the future.

The newly established in SER European Digital Innovation Hub Zagore (EDIH Zagore) unites the efforts of local authorities, businesses and their associations, and academia. The hub is intended to be a driving force behind R&I in SER, connecting institutions, businesses, and academia. The hub is meant to build crucial digital capacities in SER to support the regional industrial ecosystems and the green and digital transformation in the following decades. The main challenge the hub is facing is the overall change in the long-term established industrial traditions and business interdependencies of the SER's economy towards decarbonization and transition to clean energy technologies.

The expenditure on research and development for 2020 in SER was 23.05 million euros, which is about a 25% increase compared to 2015. About 75% of these expenses are being made from private companies, despite the unfavourable legislative environment in the field (NSI, 2021f). The number of personnel engaged in research and development had also gradually increased to 2,675 employees in 2020, in comparison to 2015 when the R&I sector employed 2,256 people (NSI, 2021g). Surprisingly, both indicators - expenditure on R&I and R&I staff - show the highest levels in Stara Zagora district, and not in Burgas, being the biggest city in the SER. About 56% of the R&I expenditures and about 61% of the employees in SER are generated in Stara Zagora district, which is mainly owed to the energy complex on its territory.

2.2 Southeast Region's energy and environment outlook

The National Recovery and Resilience Plan (CoM, 2022a) specifies 2038 as an indicative coal phase-out year. The European Commission and some national stakeholders, however, see this year, as not ambitious and the Bulgarian Government experiences pressure to either completely phase out or substantially reduce coal use for electricity generation until 2030. In relation to Art.22 (4) of Regulation (EU) 2019/943 of 5 June 2019, starting from 1st July 2025 the coal TPPs could rely only on energy trade (not on capacity services) and this would most likely lead to their insolvency. There is a chance, however, that TPPs are viable, if they operate only during the hours with very high electricity market prices.

Coal briquettes are currently used in 2 district heating companies (DHC) and in a small number of households in SER. The DHC in Sliven is currently preparing its complete switch to natural gas and, in the long-term, plans to install a 10 MW biomass-fired heat boiler. The DHC in Galabovo is expected to stop operation before 2030 (Nikolaev I., 2022). The use of coal briquettes in households is expected to continue its sharp decline in the next few years (Mihaylov T., 2021).

Natural gas is not expected to play a significant role in electricity generation after coal phase-out. The draft NRRP included a project for the construction of gas infrastructure to supply natural gas to Maritsa East complex, so that some of the coal capacities could be replaced by combined cycle gas turbines. However, this project was cancelled in January 2022 and is not present in the final Plan.

The Burgas District Heating Company is expected to continue consuming the same amount of natural gas until 2030 (Nikolaev I., 2022). Additionally, it is likely that there is a promising potential for new gas-fired CHPs in Burgas and Stara Zagora districts (ME, 2016). Furthermore, it is expected that the trend of increased gasification in households, industry and service sectors would continue until 2030 and beyond, in line with the priorities of the draft Sustainable Energy Development Strategy of the Republic of Bulgaria (ME, 2021) and the NECP (ME, 2020). All above projections, however, are highly uncertain in light of the recent increase in gas and carbon prices, and the geopolitical risks associated with the gas imports from Russia.

Due to the small untapped wind potential in Stara Zagora district, it is unlikely that wind energy projects will receive special support through their inclusion in the Territorial Just Transition Plan of Stara Zagora. It can therefore be assumed that wind energy in SER would rather develop at the average rate for the country, in proportion to the untapped technical potential in each region. This would result in an increase of the wind power capacity in SER from 121 MW in 2020 to 215 MW in 2030 and about 1,200 MW in 2050 (Nikolaev A. et al., 2021).

The southern part of SER, in which Maritsa East lignite complex is located, has significant solar energy potential and many believe that large-scale solar PV plants are an excellent opportunity for the post-mining development of the Maritsa East area. The large-scale solar PV capacity in SER, amounting to 421 MW in 2020, is projected to increase to 1,262 MW in 2030 and 1,826 MW in 2050 (Nikolaev A. et al., 2021). Additionally, small-scale (domestic) solar PV and solar thermal installations are expected to substantially develop in SER, in line with the stimuli laid down in the NRRP (CoM, 2022a).

According to the NECP, in Bulgaria, both the electricity and heat production from biomass will grow during the period 2020-2030 and most of that growth would come from the newly built biomass CHP plants. Biomass is expected to have a declining share in individual heating in SER, as users are expected to switch to cleaner and more comfortable alternatives. Although larger (community-based or industrial) biomass heating and CHP projects are expected to increase, it is not likely that they will reach a notable share in the 2030 energy balance of the region (Nikolaev I., 2022). Finally, no new hydropower generation capacity is expected in SER, as almost the entire technical potential is utilized (Mihaylov T., 2021).

There is a consensus that the intermittent renewable electricity (such as solar PV and wind) capacities in SER need to be combined with electricity storage and/or production of green hydrogen from the excess electricity. Both technologies are considered very promising for the region after 2030, when the costs are expected to go down (Nikolaev A., Dineva M., 2021). This is in line with the draft Energy Strategy, whose priorities include electricity storage systems and power-to-gas (hydrogen and methane) technologies (ME, 2021). The new NRRP includes battery storage projects, where the batteries are produced on the territory of Maritsa East complex (CoM, 2022a). It is likely that a large part of these batteries will be used in the complex, in relation to the expected high intermittent capacities there in the near future.

According to the NECP (ME, 2020), Bulgaria intends to enable the integration of hydrogen in its energy and mobility systems. The expected annual final hydrogen consumption is 34 GWh in 2030 and 256 GWh in 2040, all of which would be in the transport sector. The hydrogen will be produced by electrolysers using renewable electricity. On the other hand, according to EUCO3232.5, in 2030 the hydrogen consumption would be much higher - 0.8 TWh/a in the low scenario and 1.4 TWh/a in the high scenario (FCH 2 JU, 2020). Bulgaria's Minister of Economy launched the process to prepare a new Innovation Strategy for Smart Specialisation 2021-2027, with the aim to further explore the deployment of electrochemical sources such as hydrogen and fuel cell technologies.

In the final NRRP, the Bulgarian government added two major energy projects (CoM, 2022):

- Waste incineration installations in the ex-coal fired TPPs in Maritsa East complex, expected to use 55,000 t/year waste (Stara Zagora Municipality, 2022); and
- Installation of 400 MW geothermal capacities on six locations, but none of these sites is on the territory of SER.

Another important direction that would remain a top priority until 2050 is the energy end-use efficiency. The more and more stringent building codes and the increasing demand for passive buildings are shifting the market towards innovative building materials, automation, heating and cooling systems. Additionally, the high energy prices combined with the subsidies offered by the Bulgarian government are a strong motivation for households to undertake building renovation. Prosumers and energy communities are still not popular and insufficiently supported by the legislation, but the activation of citizens seems inevitable, in order to capture the viable small-scale energy production opportunities. Finally, smart grids coupled with smart metering systems will support the development of generation based on intermittent RES and distributed generation.

2.3 Southeast Region's current energy related R&I landscape

The new challenges towards the decarbonisation of the national economies need high-performance R&I with improved access to excellence in innovative technologies. This is still missing at both national and SER level. Therefore, there is an urgent need to tackle the current R&I fragmentation and lack of enough R&I personnel.

Despite the high concentration of energy business in the SER, the region remains rather focused on technologies linked to coal extraction and processing. The R&I in the field of energy technologies supporting SER transition experiences additional problems due to the lack of a clear strategy for the energy transition in the region. The main challenge for 2030 and 2050 is how to preserve the region as an energy centre, despite the coal phase-out. A growing concern is that technological R&I may be slowed down by poor regional policies and lack of funding, associated with brain drain of well-educated specialists in new high-tech niches.

Almost unanimously, the respondents to the questionnaire, distributed for the purpose of the current Strategy, claimed that at present, there are very limited R&I activities in SER, but their potential is huge. Among all R&I organizations in the region (see section 2.1), the respondents identified the Trakia University and its Institute for Sustainable Transition and Development (ISTD) as the main driving force of the R&I sector in the region.

Besides academia, the private sector is also a driver of the R&I in the field of energy in SER. Prof. Zheko Ganev, an internationally recognized scientist in the field of quantum electronics, author of a number of patents and scientific reports in physiochemistry and electrochemical integrated technologies, manages an innovative company. He claims that there is an environmentally friendly way to extend the life of coal-fired power plants in the Maritsa East complex without changing their current operation. The proposed technology transforms chemically the TPPs' carbon emissions to methane that could be used for energy and non-

energy purposes. The presented technology, however, is not yet confirmed as a working solution for efficiently reducing the coal emissions in Maritsa East energy complex.

An important catalyst of the transition processes in the SER is the non-governmental and non-profit sector, particularly active in the field of public awareness raising and transposing of European and national legislation on a local level. Although not working directly in R&I, the local NGOs were the pioneers in introducing innovative concepts, such as “just transition”, “clean energy”, and “low-carbon economy” and within a number of EU-funded projects many studies have been implemented. Solar PV, wind, and biomass technologies are relatively mature. For these technologies, in Bulgaria there is a well-developed technical expertise for installation and maintenance. The R&I in the field is moderate and concentrated in research bodies and companies outside SER.

An important component of the transition is the introduction of hydrogen as an energy carrier for grid balancing, fuel for transport, raw material in industry, and for export. The SER is a partner in the Hydrogen Valley Platform. An important feature of the Valley’s philosophy is that hydrogen works in synergy with (or reuse of): renewables generation, gas infrastructure, electricity grid, batteries, industrial production, etc. A regional hydrogen program is under development (short-term: 2026, medium-term: 2030, and long-term: 2050), demonstrating interoperability and synergies between production, storage & distribution and end-use applications, ensuring sectoral integration. In addition, the National Hydrogen Roadmap, currently under development, envisages the first hydrogen hub to be built in the Maritsa East energy complex.

This is in line with the Hydrogen Valley regional concept, in which the emphasis is put on the integrated system-level approach towards (Vladikova D., 2021):

- Production of renewable (solar and later on – wind and geothermal) energy, for which the mining land of more than 240 km^2 would be partially recultivated. Part of it can be used for solar PV parks (15 GW till 2030 and at least 30 GW till 2050).
- Production of hydrogen through electrolysis powered by regional renewable (PV) energy: 600 MW electrolysers by 2030 and above 2 GW by 2050;
- Distribution and storage: for regional mobility – with tube trailers; for industrial applications (ammonia production) – hydrogen pipeline to NEOCHIM by 2030; for export via a pipeline connecting Maritsa East with the Greek hydrogen pipeline by 2050;
- Hydrogen mobility – 30 buses and 10 trolleys locally retrofitted for Stara Zagora by 2030; regional hydrogen transport for 2050 with > 60 buses, 50 trucks and 30 vans;
- Industrial feedstock for ammonia production in Dimitrovgrad: 300 MW electrolysers by 2030 and 1 GW by 2050;
- Electricity grid balancing via 100 MW electrolysers;
- Gas grid injection for 1 GW gas turbines after 2030;
- Hydrogen for 1 GW hydrogen gas turbines by 2050;
- Hydrogen for export, using above 1 GW electrolysers by 2050;
- Electrolysers production of 500 MW/year by 2030 and 2 GW/year by 2050.

Hydrogen deployment needs strong RTDI efforts at both national and EU levels. The newly established Department of Hydrogen Technologies and Energy Systems at ISTD has the mission to coordinate this process in two directions: (1) R&I and (2) education and training with an emphasis on skilling and upskilling following technological development. R&I cover both low and high technology readiness levels (TRL) thus ensuring activities needed for accelerated market deployment combined with preparation for the next-generation technologies. An emphasis is given on hydrogen mobility with the development of expertise and introduction of integration of hybrid system “fuel cell/battery”. This direction will open a niche for investments in the production of hydrogen-electric vehicles in Bulgaria (Vladikova D., 2021).

The second high TRL development is hydrogen production from wastes which is a prospective niche taking into consideration that there are wastes from the local agriculture production. In relation to the next generation of technological developments, a new niche is the proton-conducting solid oxide cells with the application for clean and dry hydrogen production and extraction of hydrogen from natural gas mixtures. With respect to education and reskilling, ISTD entered the European network for education TeachHy which develops the first Hydrogen Masters Degree Program covering all aspects – from production to application with 20 modules that can be used also for reskilling. The program may be used in other regions since only 30% of the education will be face-to-face while the other 70% will be online. (Vladikova D., 2021)

The different application niches are developed to demonstrate the overall energy and economic efficiency and resilience of the integrated system.

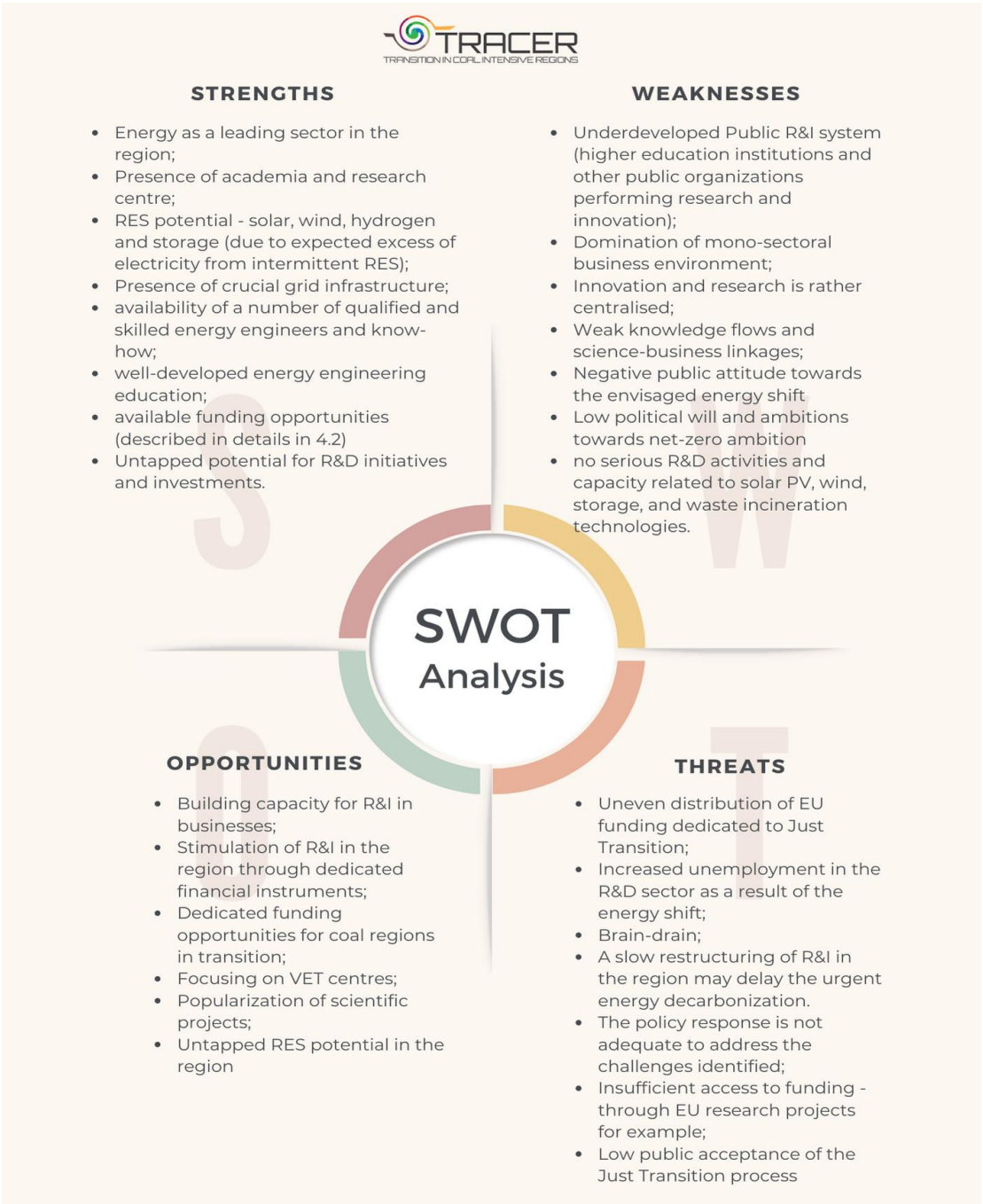

Figure 3: SWOT analysis of R&I potential in Southeast Region

A thorough SWOT analysis was performed based on the findings of the workgroup meeting and interviews with stakeholders in the SER region. The R&I in energy and environment has a very good basis and opportunities to build ambitious vision for 2030 and 2050. In the analysis below are shown the most important aspects that encourage or hinder the decarbonisation process and the transition to clean energy with a specific emphasis on R&I potential.

3 R&I in Energy and Environment: Vision for 2030 & 2050

3.1 Objectives and outcomes

The Strategy's aims and anticipated achievements are closely associated with the expected energy development in the Southeast Region. There can be no doubt that the R&I in energy and environment will make a real contribution to the long-term goal of the region's sustainable decarbonisation. This may be accomplished via the implementation of research that informs policy instruments, offers answers to regional difficulties encountered in the energy and environmental sectors, and contributes to economic competitiveness and development.

Effective and efficient R&I systems are needed to produce strong scientific, technological and innovation outputs, both in terms of quality and relevance, to address societies' economic and social challenges.

Vision 2030

The vision for 2030 of the Southeast Region (SER) of Bulgaria is derived by the main findings in the SWOT analysis:

Improving the quality of the public research systems and putting in place the right framework conditions to facilitate investment and innovation in the region.

A general overview of the R&I shows that in the EU regions scientific excellence is still to some extent concentrated in a group of leading regions, for example ones in the United Kingdom, the Netherlands, and Denmark. This achievement is due to the high quality of public research systems - higher education and academia and the well-built national and regional framework to facilitate the R&I activities in the region.

Creating the optimal circumstances for investment and innovation in the area by improving the quality of public research systems is of crucial importance to be achieved by 2030 and thus become a main aspect of the Vision 2030, part of this strategy.

A strategy for a more stable research system based on discussion, trust, and cooperation is proposed to improve the underdeveloped R&I. Three main principles need to be addressed in order to improve the public R&I system in energy and environment:

Principle 1. Increased percentage of the GDP invested for public R&I in the region;

Principle 2. Increased public-private collaboration;

Principle 3. Creation of public laboratories with a progressive rise in public R&I intensity; crowding-in effect shall be introduced from the public support to private R&I expenditures, leading to a progressive increase of private R&I intensity in the region.

A gradual increase of R&I budget allocated by the government is needed to stimulate businesses in SER to spend more on R&I. The effect would be more investments in the region for energy and environmental R&I, resulting in more research projects, more qualified researchers, and more high-tech businesses. This will lay the foundation for the next priority, included in Vision 2050.

Vision 2050

Decentralisation of R&I - strengthening of the regional academic and business potential and their linkage through a set of instruments and access to more funding opportunities

For the development of R&I in energy and environment, a R&I Strategy focused on decentralisation of the R&I is needed. This would strengthen the regional academic and business potential and can be achieved via two main pillars:

1) Introduction of a set of instruments to boost R&I in energy and environment;
2) Improved access to funding opportunities for the regional academy and business.

The introduction of these pillars should be seen in a longer horizon and thus it is suggested to be included in Vision 2050 priorities. Decentralisation of the R&I - strengthening of the regional academic and business potential and their linkage through a set of instruments and access to more funding opportunities, can done by taking into consideration the thematic priorities of the Innovation Strategy for Smart Specialisation (IS3).

The intelligent specialisation requires a clear idea of the strengths and weaknesses of a country or region that must be combined with a strong leadership position and a common vision of innovation stakeholders. A good approach to support R&I is to bind all participants in the process and strengthen their entrepreneurial attitude with a view to adding value throughout the value chain. That is expected to build efficient and effective networks among stakeholders and to stimulate those factors that contribute to the achievement of intelligent growth.

The key to decentralisation of R&I is identifying areas in which the country or region have the potential to distinguish from and be more competitive than others. This can be done by Entrepreneurial Discovery Process (EDP), successfully illustrated in TRACER project. EDP consists of developing creative solutions to problems by combining strengths and new partners, taking risks, experimenting, looking for new ideas along the chain of value creation, or participating in new value chains. The ultimate goal is innovation: presenting innovative solutions on the market and generating growth and jobs. Research organisations, universities, creative sectors, public authorities, and civil society play an important role in this process.

The **European Digital Innovation Hub Zagore** should be given particular attention in Vision 2050, because it has the potential to serve as a focal point for R&I - to bring together public and private R&I projects and activities, to attract investments, innovative start-ups, business innovations, academic research, and accelerate the decarbonisation of SER. This includes development of solar, wind, energy storage, hydrogen, and waste-to-energy R&I projects for energy and economic diversification and attraction of investments. EDIH Zagore has established highly ambitious aims and targets that are precisely aligned with SER's strategic development. Below are listed the major themes on which academia, public and private R&I, investors, local businesses, local governments will collaborate on:

- Organic and large area electronics;
- Internet of things;
- Artificial intelligence;
- Cyber security;
- Virtual, augmented and extended reality;
- Simulation, modelling and digital twins;
- Software as a service and service architectures;
- Industrial biotechnology.

It is foreseen and agreed on by all local stakeholders that EDIH Zagore will be the leading body setting the R&I agenda in energy and environment in SER.

3.2 Key guiding principles

The transition toward climate neutrality by 2050 in the EU gives energy a leading role, being responsible for more than 75% of the EU's greenhouse gas emissions. To achieve net zero emissions, the EU is in the process of developing a comprehensive research and development network that will guarantee the vitality of the sector and boost the creativity of European scientists. The long-term vision in the sector needs to be comprehensive and structured and should follow certain key principles.

It is essential, however, that the energy transformation is implemented smoothly by all affected regions and does not negatively affect the economies of the member states. Thus, the next key principles need to be followed by the local and regional decision-makers. These principles have been derived from the review of the region's existing R&I ecosystem and the sector's potential for further development, taking into account the SER's economic and social characteristics:

- Tailor-made policy design and implementation framework in favour of R&I sector, created for every member state;
- Complementarity of support mechanisms and diversification of sources, so as to have all sectors equally financed;
- Creating a link between research and business - making scientific achievements accessible for the business;
- Adopting a nexus approach - integrating environmental management and governance across sectors and scales;
- Improving accessibility of R&I achievements and bringing it closer to society;
- Public awarding the R&I employees and showing the good example;
- Applying a holistic approach to deal with the complexity of decarbonisation processes - to ensure that nobody will be left behind;
- Establishing of multi-level partnerships to maximise the chance to award investments;
- Ensuring coordination and cooperation between public, private and research entities;
- Engaging local, regional, and national stakeholders in the decision-making process;
- Promoting the lower and responsible energy consumption of customers.

These principles complement the strategic goals set in the respective existing legislation in Bulgaria that mainly focuses on enhanced support for more effective cooperation between research organisations and business. The principles would support new forms of partnership, such as between business and Centres of Excellence, among the Centres of Excellence, between Digital Innovation Centres and Research Infrastructures, the development of which is supported and funded through the implementation of the National Roadmap for Scientific Infrastructure 2020-2027). The focus on R&I in the fields of energy and environment will strengthen the support for participation of all stakeholders, mainly business and research circles, in international projects. That participation would internationalise research and development and bring foreign experience and researchers in the teams implementing R&I projects, e.g. projects funded by EU's Horizon Europe Framework Program.

4 Support framework for R&I in Energy and Environment

4.1 Multi-level governance structure for R&I policies in Southeast Region

For the current Strategy, it is important to take into account that SER does not have an elaborated regional innovation strategy, despite the attempts made in the past. A document that touches upon the topic of innovation in terms of environment is the "Integrated Territorial Strategy for Development of the Southeast Region on NUTS2 level for the Period 2021-2027".

It is a strategic planning document defining the general political, spatial, economic and thematic framework for the development of the region in the years of the new programming period 2021-2027, in accordance with the National Concept for Regional Development for the period 2013-2025, and takes into account the projections of sectoral strategies at the regional level in the field of economic development, education, science, transport, water, energy, broadband communications, health, social services, tourism and environment (MRDPW, 2020).

In priority 1, it is stated that support will be granted for boosting the smart and dynamic economy of the SER with the main aim to achieve sustainable economic growth by developing a competitive economy. This circumstance plays a key role in creating conditions for improving the quality and standard of living of the population in the region. It is underlined that the construction, maintenance and access to modern scientific infrastructures, the introduction of new technologies and the application of innovations is the surest way to increase the competitiveness of the region. In the same direction is also the proposal for the establishment of a "High-Tech Academic Centre Burgas" based on the potential of universities in the region. It encourages the creation of new industrial zones with a focus on investors in logistics bases and environmentally friendly, high-tech industries that create sustainable employment and ensure high wages, and are an important factor in the development of the region. Serious emphasis is being placed on the development of the maritime economy (MRDPW, 2020).

The multi-level governance of the current R&I Strategy in the field of energy can be implemented by the working group, formed jointly by the EU projects TRACER and DeCarb, for the purpose of the development of a vision, strategy and action plan for the energy transition of SER. The working group consists of representatives from the following stakeholders:

- Local and regional authorities, especially the ones most affected by the transition;
- Research bodies from SER and other regions;
- Regional businesses and their associations;
- Energy centres, energy consultants, NGOs, labour unions, and others.

The local authorities, especially the largest ones – Stara Zagora and Burgas municipalities, are committed to triggering the R&I potential of the SER. For example, in September 2021 the municipality of Stara Zagora co-organized in partnership with the Chamber of Commerce and Industry (CCI) and the Trakia University training for business model development and academy of innovation, which trained representatives of the innovative businesses and students in the region to develop a business model for innovative start-ups. Another example was the business meeting held in June 2021 in the city of Burgas, dedicated to the investment climate and prospects in the city as well as the potential development of innovative products and manufacturing methods with high added value. The SER shows potential for setting of digital hubs in Burgas and Stara Zagora, where also the biotechnology sector can be developed.

Photo credit: ***Trakia University Central Research Laboratory***

Creating a regional innovation ecosystem will increase the potential of Stara Zagora (the district and municipality most affected by the transition) in the field of science & innovation and business relations. In comparison, in 2018 the capital city of Sofia attracted about BGN 322 million for the development of science and innovation, while the funds for the Stara Zagora region in this direction were 15 times less (Evgeniev E., 2020). Stara Zagora, as a strong industrial centre, could attract considerable foreign investments in the coming years, with an

increasing share of R&I. In this direction, the local and regional authorities and relevant associations need to make steps towards consolidation of the interests of science and business, e.g. by networking the research and educational entities with businesses.

Among the research bodies in SER, potentially an important player in the multi-level governance structure for R&I policies is the **Central Research Laboratory** (CNL) within the Trakia University established in 2008. CNL is a developing laboratory for the implementation of high-tech methods and analyses in the field of natural sciences and research at high and modern standards. The specialists working in this centre provide qualified assistance and advice to research teams from all major units of the University (Trakia University, 2022).

4.2 Funding opportunities

4.2.1 National Strategy for Development of Scientific Research in the Republic of Bulgaria 2017-2030

The "National strategy for development of scientific research in the Republic of Bulgaria 2017 - 2030" (CoM, 2017) analyzes in-depth the current structure of R&I funding, and successfully identifies significant issues in the existing funding model. The Strategy determines the goals and the corresponding measures and actions for boosting the development of research in the period 2017-2030. It was one of the necessary conditions for achieving the objectives set out in the Partnership Agreement of the Republic of Bulgaria with the EC in the programming period 2014-2020 and was directly linked to the Innovation Strategy for Smart specialisation (IS3) 2014–2020. The strategy has the ambitious goal to turn Bulgaria into an attractive centre for cutting-edge research through the rapid, large-scale and long-term development of scientific system research. It demonstrates support for research and development of new technologies, attracting and retaining young talents in Bulgaria, strengthening the responsibility of Bulgarian science to society and business and vice versa, raising the international authority of the country in the field of science and as a final result achieving economic growth and significant improvement of the quality of life in the country.

According to the Strategy, the funding methods at the national level fall within the scope of two national instruments - the Bulgarian National Science Fund (BNSF) and the National Innovation Fund (NIF). BNSF has a flexible structure and can integrate new directions depending on the expressed interest and trends in project proposals. The NIF, on the other hand, relies on thematic priority research areas to facilitate the selection of potential candidates to support research and its implementation and improvement. BNSF has a limited budget, which was significantly limited after Bulgaria's accession to the EU, with the presumption that this difference will be offset by the funds raised from European science programs. However, research institutes in Bulgaria fail to take advantage of these opportunities, it is difficult to have a leading role in international teams and we traditionally maintain the last place in attracting funds per capita and the success of project proposals (CoM, 2017).

4.2.2 National Innovation Fund (NIF)

The NIF, established in 2004 in accordance with the draft Innovation Strategy for Smart Specialisation of the Republic of Bulgaria 2014 – 2020 (IS3), is one of the tools for implementing the innovation strategy of the country. Through the implementation of the activities under the Fund in the period 2016-2020 the goals set in IS3 are followed. The main goal of the Fund is to promote research and development, increase the competitiveness of enterprises, and stimulate cooperation between science and business in Bulgaria. Additionally, the Fund has as a purpose to (MEI, 2021):

- encourage the implementation of research and development projects initiated and implemented in enterprises in order to develop new or improved products, processes, or services;
- increase the volume of production;

- improve the quality of manufactured goods, services or processes;
- reduce the amount of resources used;
- increase investment in efficient enterprises.

The thematic areas embraced by the NIF are in accordance with IS3 (MEI, 2015):

- mechatronics and clean technologies;
- information and communication technologies and informatics;
- healthy living and biotechnology industry;
- new technologies in the creative and recreational industries.

4.2.3 Bulgarian National Science Fund (BNSF)

The BNSF's purpose is to support financially projects and activities for the promotion and development of research in accordance with the European Framework for State Aid for Research, Development and Innovation, the National strategy for developing of scientific research, the National Reform Program, the EU framework programs, and others. The BNSF provides financial support for the implementation of world-class research and development of scientific capacity in Bulgaria, related to (BNSF, 2022):

- the creation of new scientific knowledge;
- Bulgarian history, language, culture and national identity;
- promoting the development of the natural, technical, humanitarian and social sciences;
- solving problems in the field of economy, education, agriculture, ecology, social processes, human resources, security, defence and health.

The activities of the BNSF are carried out by funding national scientific programs and research projects in universities and research organizations in Bulgaria, following internationally recognized standards and taking into account the existing national scientific potential and public needs and priorities. The Fund, with the assistance of the Ministry of Education and Science, works in coordination with other research funding institutions. BNSF is involved in the preparation and implementation of the programmes set out in the budget in the program format of the Ministry of Education and Science. The financial stimulation of research is carried out in a way that ensures efficiency and transparency in the spending of public funds (BNSF, 2022).

4.2.4 Competitiveness and Innovation in Enterprises Program 2021–2027

The new Competitiveness and Innovation in Enterprises Program 2021-2027 (CIEP), the successor of the Operational Program Innovation and Competitiveness 2014-2020, puts a special emphasis on innovation as a main driving force for improved competitiveness, sustainability, and progress. CIEP aims at achieving smart and sustainable economic growth, as well as industrial and digital transformation in the country. As an instrument for the implementation of the European Cohesion Policy for the period 2021-2027 and the European Regional Development Fund, CIEP is intended to contribute to the achievement of the following policy objectives set at EU level (CoM, 2022b):

- *A smarter Europe by promoting innovative and smarter economic transformation*. The aim is to strengthen the capacity for R&I and the introduction of modern technologies, mastering the benefits of digitalisation for citizens, companies and governments, enhancing the growth and competitiveness of SMEs, developing skills for smart specialization, industrial transition and entrepreneurship. The CIEP provides for increasing the share of developed and implemented product and process innovations in enterprises and support for the application and protection of industrial property.
- *A greener, low-carbon Europe by promoting clean and equitable energy transition, green and blue investment, circular economy, climate change adaptation and risk prevention and management.* The CIEP supports energy efficiency measures and transition to circular (secondary) use of materials. The European subsidies support modernization in waste

management. The European Fund emphasizes the awareness of entrepreneurs about the benefits of developing circular business models, as well as support for starting the production of green products and services.

- *Innovation and growth*. The financial assistance from CIEP is determined to strengthen the R&I capacity, the introduction of modern technologies to increase the innovation activity of small and medium enterprises, taking into account the regional differences and the available potential in different regions. Financial resources are provided for the implementation of digital solutions.
- *Digitization*. The COVID-19 crisis calls for intensive promotion of digitalization in order to restructure workflows. The goal is to provide support in correspondence to the needs and potential for the use of ICT technologies by enterprises, as well as to anticipate and create a system for measuring the level of digital transformation of enterprises.
- *Digital Education Action Plan* (2021-2027) - outlines the European Commission's vision for high-quality, inclusive and affordable digital education in Europe. It focuses on stimulating the benefits of digitalization for citizens, companies, and governments. The purpose of the projects under this program is the achievement of successful digital transformation of Bulgarian SMEs, introduction of digital solutions and programs, cybersecurity and data confidentiality.
- *Strengthening the R&I capacity and the introduction of modern technologies*. Support is provided for the development and implementation of in-house innovations, attracting foreign researchers and creation of innovative start-ups.

The main activities envisaged by the CIEP 2021-2027 include implementation of innovations in the processes, marketing and organizational structure, whether it is in-house innovation or innovation in collaboration with other companies and the implementation of digital solutions in support of R&I, building research teams, providing access to relevant for the innovation process with information and knowledge, stimulating the implementation of internal R&I for enterprises, increasing the share of developed and implemented product and process innovations (CoM, 2022b).

4.2.5 Programme for Research, Innovations and Digitalisation for Intelligent Transformations 2021 – 2027 (RIDPIT)

With a budget of EUR 860 mln, RIDPIT is one of the tools for the implementation of the new policy of interaction between R&I areas. RIDPIT addresses the deficits and challenges in the research and development activities in the country and directs its efforts to (SARI, 2022):

- Building and developing a national R&I ecosystem, inclusive of integration and productive interactions among the separate participants in the system;
- Establishing and developing stable partnerships between the research, academic and innovation teams and the business, in order to intensify the intake of knowledge, technologies and innovations in strategically important spheres of industry and economy;
- Intensifying the transfer of technologies and the marketing of research results through efficient licencing, creation of spin-off companies and building up the capacity for transfer of technologies, including by means of improved financial tools;
- Speeding up the pace of internationalisation and the effective participation in the space of European R&I, including through synergy with EU Framework Programme for R&I; initiating and strengthening of global partnership networks and collaboration for the purpose of increasing the added value of a given idea, research results and products;
- Continuing the processes of digitalization of R&I;
- Developing an efficient electronic government and creating a new digital environment for furthering the progress of the Bulgarian economy and society;
- Developing and heightening the cyber security level in the digital space in the public sector in collaboration with it, including on international level. (SARI, 2022)

The measures envisaged at the regional level for accelerating of R&I ecosystem include the creation and development of regional innovation centres and/or specialized R&I infrastructure as part of the setting up of industrial parks and innovation clusters. Support will be provided only after mapping the needs and according to the National Roadmap for Research Infrastructures. These measures complement the support provided in NRRP for industrial parks identified as strategically important. This approach is considered highly beneficial for regions such as SER which are facing the challenge of the energy transition and the transformation of the local economy to low-carbon, clean and sustainable practices.

The activities will be implemented through the Integrated Territorial Investments (ITI), for the period 2021-2027. The supported measures must meet the objectives and priorities set out in the relevant NUTS2 integrated territorial development strategies (a bottom-up approach) and mapping of needs, carried out at the national level for the development of the R&I ecosystem (top-down approach). ITI will support a set of interrelated and complementary project ideas, implemented through partnerships involving a wide range of stakeholders and actors in the socio-economic life of the specific area. The sources of funding for the individual projects are different and include programs co-financed by the ERDF, ESF+, financial instruments, state and municipal budgets, own funds and others, etc (SARI, 2022).

The implementation of the individual projects will be carried out in a coordinated manner, combining the measures under the RIDPIT for smart transformation with the interventions at the regional level under the other programs of the cohesion policy. Thus, support for regional innovation centres and specialized R&I infrastructure in industrial parks will be complemented by support for the development of the innovation capacity of enterprises in and around industrial parks and their creation, growth and internationalisation under the Competitiveness and Innovation Program. Infrastructure measures to promote economic activity in the municipalities, including technical infrastructure for business development and industrial parks, will be supported by the Regional Development Program. If necessary, the above measures will be complemented by measures promoting partnerships between educational institutions, social and economic partners under the Education Program and social measures under the Human Resources Development Program (SARI, 2022).

4.2.6 Bulgarian National Recovery and Resilience Plan (NRRP)

The Bulgarian National Recovery and Resilience Plan (NRRP) is the only strategic document, which includes a list of aims and reforms in the key sectors of Bulgarian economic, scientific and social life, followed by the investment projects for its achievement. They are supposed to help the economy recover from the Covid-19 crisis and accelerate the green and digital transformation of the economy. At the same time, the implementation of the reforms is a condition for obtaining financing for the planned investments, applying the principle "money against reforms". The plan contains 59 investment projects and 46 reforms in four main pillars - "Innovative Bulgaria", "Green Bulgaria", "Connected Bulgaria" and "Fair Bulgaria". The total financing of the investments included in the Plan is BGN 21 billion, of which BGN 13 billion are provided under the Mechanism for Recovery and Sustainability (CoM, 2022a).

The notion of innovation has a central role in the NRRP. What is more, the NRRP is the first official strategic document that sets a date for the final shutting down of the coal capacities - 2038. In the field of R&I, the priority is to strengthen and stimulate scientific activity in higher education, improve research infrastructure and research capacity. The Innovative Bulgaria chapter focuses on education and skills, R&I, and intelligent industry. Its main goal is to provide a favourable environment for the implementation of new products and processes and the development of innovative enterprises as a prerequisite for creating a high-tech industrial base to bring the economy on a higher growth trajectory. A top priority is considered the stimulation of the scientific activity in the higher schools, as well as the overall improvement of research infrastructure and capacity to develop critical mass and knowledge to deal with the transition and prepare the country for accelerated development.

The NRRP admits that the R&I potential to support productivity remains underused. Bulgaria needs to eliminate the significant difference in comparison to the EU average in terms of R&I spending and the ability to retain and attract talent. The country still ranks in the group of "modest innovators". The major reason for the weak relative result and performance of Bulgaria is the quality of research in the country.

According to the NRRP in the period 2021 - 2026, BGN 411 million (approximately EUR 210 million) will be allocated for R&I. This significant amount is expected to boost the reforms and investments in (CoM, 2022a):

- Implementing common policy for the development of research & innovation and technology for the accelerated economic and social development of the country;
- Programming for accelerating economic recovery and transformation through science and innovation;
- Increasing the innovation capacity of the Bulgarian Academy of Sciences in the field of green and digital technologies.

The distribution of NRRP funds is shown in the below figure.

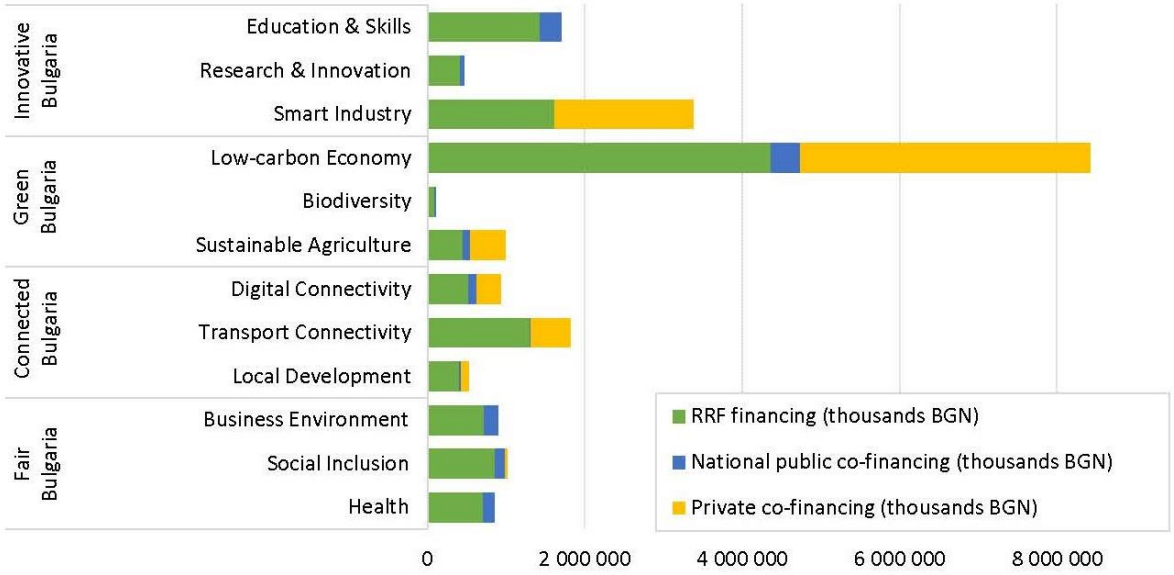

Figure 4: Distribution of funds within NRRP (IME, 2021)

4.2.7 The EU Research and Innovation Programme Horizon Europe (2021–2027)

Horizon Europe, the EU's R&I programme, is the successor of Horizon 2020, which runs from 2021 to 2027 with a total budget of EUR 95.5 billion. It is committed to supporting researchers and innovators to develop and deploy their ideas and create new products and services. The aim of the program is to strengthen the EU's scientific and technological base, including by developing solutions to implement policy priorities, such as the environmental and digital transition. The program also contributes to achieving the goals of sustainable development and stimulates competitiveness and growth. This is the EU's flagship initiative to support R&I - from concept to marketing. Horizon Europe brings together the most brilliant talents and provides them with world-class research infrastructures. It also supports revolutionary innovation and helps create new services and markets. The total funding that Bulgaria has received under the EU Horizon 2020 is only 0.26% of the total budget of the programme; the results show modest performance of the country.

4.2.8 Stara Zagora Territorial Just Transition Plan (SZTJTP)

The decarbonization ambitions of EU require bottom-up regional efforts. In pursuit of the ambitious decarbonization targets of EU, the territorial just transition plans (TJTP), which are to be adopted for all over 40 EU regions directly affected by the energy transformation, plays an important role in the transition planning for the next 10-15 years. The SZTJTP covers the territory of the Stara Zagora district, being the most affected one by the envisaged energy shift.

Although not yet being elaborated by the Bulgarian Ministry of Energy, the Stara Zagora Territorial Just Transition Plan (SZTJTP) is envisaged as a central strategic document for the development of the region and a roadmap for the implementation of the Just Transition Fund (JTF) measures. The territorial plan is the necessary condition for the region to receive funding from the JTF, through which Bulgaria has agreed to 1.3 billion euros by 2027.

Among the greatest challenges for the region in terms of R&I, the SZTJTP identifies the improvement of cooperation between academia and business and the creation of a more functional ecosystem between them. The plan takes into account the need to develop technology centres and business incubators and to support the development of R&I in enterprises. It elaborates on the necessity to support digitalization, digital innovation and digital connectivity in the Stara Zagora district (PWC, 2021). Thus, one of the three pillars of the SZTJTP is devoted to the diversification of the local economy, including support for research & development and innovation.

The following R&I project proposals were received from stakeholders (PWC, 2021):

- Development of Kazanlak Technical School as a centre for R&I;
- Creation of business incubators;
- R&I for hydrogen transport systems, including hydrogen fuel cells - batteries; batteries - power motors;
- R&I training and retraining, innovation and technology centres (hubs, laboratories);
- Additional services supporting the business and economic development of the districts;
- Combining research, innovation and technology centres with technology/high-tech entrepreneurship centres (hubs, incubators, accelerators);
- Scientific and research competitions and challenges;
- Establishment of a centre that includes large enterprises, SMEs, innovative start-ups, universities, research institutes and research centres focused on the development, practical implementation and commercialization of technologies;
- Establishment of a scientifically accredited laboratory for analysis and certification of materials and products;
- Innovation and prototype centre for micro-mobility and electromobility;
- Green Transition Centre to facilitate the transition to sustainable and green economy through research, innovation and technological development;
- Centre for Research and Implementation of Technologies that Use Green Hydrogen.

However, a sustainable funding model for R&I, mainly based on activity by individual units, is missing. Programme funding needs to be strengthened through specifically targeted EU funds and investment instruments. This funding should also be done by actively attracting private investment, which will, among other things, help strengthen the link between business and science. This link must be at the forefront of the development of innovations and their implementation, including in terms of increasing the share of commercialization of research.

Specific measures that can be implemented to support additional R&I activities, including those set out in the "National Strategy for Development of Scientific Research in the Republic of Bulgaria 2017-2030", may be:

- Promotion of shared use and access to scientific equipment and infrastructure;
- Creation of scientific and innovation complexes;
- Expansion of the scope of scientific competitions to attract program funding;
- Facilitation of the research process initiated, including by the public sector;
- Introduction of tax incentives and motivation for the development of R&I activities, including through public-private partnerships;
- Promotion of partnerships between scientists and private companies on the principle of "outsourced research".

In order to achieve these goals, it is necessary to mobilize both public and private investments, which should be combined in a way that would involve as many organizations as possible. The existence of synergies between them is key to developing a wide range of potential financial instruments to invest directly or indirectly in R&I. Flexibility is needed in both their implementation (number of measures applicable, amount of funding attracted, profile of participants) and territorial scope - including going beyond IS3 priority areas by regions for planning, which is rather dissuasive (PWC, 2021).

4.3 Priority areas for Research and Innovation

The present Strategy defines a set of priority areas that meet regional R&I potential in the field of energy. The proposed priority areas are based on the region's potential and capacities, analysed in the previous chapter. These are considered promising not only in terms of energy generation, but also in the light of R&I capacities in the observed region.

4.3.1 Research and Innovation in the RES sector

As described in detail in section 2.2, the SER demonstrates small untapped wind potential, so it is unlikely that serious wind energy projects will be realized in the region. The perspectives to biomass energy projects are similar. On the other hand, SER has significant solar energy potential for the development of large-scale and small-scale solar PV, especially large-scale ones on the territories of the current coal complex Maritsa East. Finally, waste incineration installation is planned in the former coal-fired TPPs in the Maritsa East complex.

Despite the high energy engineering capacity in the region, it is highly unlikely that the region becomes one of the EU’s R&I leaders in any of the above technologies, due to limited R&I traditions, funding, and infrastructure required to advance the technological R&I. Instead, in the field of RES the promising R&I fields for the region include:

- Energy modelling, including both long-term energy scenario modelling and short-to-medium term electricity market modelling. Modelling is largely underdeveloped in Bulgaria, although it is highly needed to simulate different energy mix (mainly RES) options, especially in the light of the serious energy sector restructuring;
- Multi-disciplinary socio-economic research related to the market penetration of RES technologies, including studies about people’s perception, citizen’s involvement (e.g. in relation to distributed generation, energy cooperatives, etc.), cost-benefit analyses, support schemes, policy framework, and others.

4.3.2 Research and Innovation in hydrogen

Bulgaria and the SER have significant potential for the introduction of hydrogen by 2030. Its realization requires decisive measures to support development and operation of hydrogen production in the region. The NECP admits the growing importance of hydrogen for the future energy structure of the country. Thus, a legislative basis, strategy for implementation and a roadmap for hydrogen production are extremely necessary components that shape the future energy vision of the country.

A hydrogen strategy is a key factor in the transition towards a low-carbon economy since hydrogen can ensure large-scale renewable energy storage with sectoral integration, thus proposing a new direction for the hydrogen economy. On a national scale, the NRRP emphasises hydrogen production via electrolysis, as well as hydrogen transportation using the gas grid (CoM, 2022). With respect to mobility, hydrogen is included in the National Roadmap for alternative fuels and infrastructure, where a detailed program till 2030 is developed with some predictions for 2050. Stara Zagora region is part of the National Roadmap as one of the regions with advanced plans for the introduction of hydrogen electromobility at a regional level.

Among the most crucial aspects of the successful transition towards green hydrogen is to make the transition socially acceptable and fair. Everybody will be affected by the transition and we must ensure a fair distribution of profit and transformation costs. Therefore, the energy transition must be considered holistically as a socio-economic challenge. It is important to introduce a dedicated policy for public acceptance of hydrogen demonstrating a clear and transparent regional strategy involving research entities, public bodies and industry for:

- Demonstration activities and information campaigns introducing the benefits and safe use of hydrogen in our personal daily life more visible (e.g. in public transport and households, employment opportunities, etc.);
- Pursuing of interdisciplinary approach for the development of hydrogen technologies including economic and social sciences to achieve public acceptance;
- Promotion of knowledge translation between behavioural science and public policy;
- Ensuring close cooperation between industry and science in RTD&I, especially for development at TRL>4.

4.3.3 Research and Innovation in smart grids and digitalization of the energy system

A tipping point in the creation of a properly functioning energy system is the reform of the existing electricity grid which seems to be starting with timid steps in Bulgaria. The lack of reliability and stability of RES is an argument often used to refute the much-needed transformation of the energy system and the connection of decentralized generation, demand response, and storage. It is therefore important for R&I to address the security of supply and particularly smart grids. Both market players (consumers, grid companies, and producers) and technologies need to adapt to the future intermittent generation and become more flexible. Smart grids combined with smart meters, smart utilities, Internet of Things (IoT), artificial intelligence (AI) and blockchain are just some of the latest innovations driving the transformation of the energy industry. SER, being the “energy heart” of Bulgaria, is in excellent position to take part in the related R&I.

4.3.4 Research and Innovation in energy storage systems

The SER is considered to be a leader in the energy storage industry, according to the NRRP. The Plan aims to accelerate regional decarbonization by building large storage systems that will help to balance the national energy environment. To make the use of batteries and energy storage devices easier, the scope of legislation and regulations must be expanded and clarified. Furthermore, important R&I activities must be completed prior to the creation of a viable economic sector in the field of energy storage technologies. The region shows significant potential for this sector’s development, thanks to a large number of skilled workers and the existing well-developed energy infrastructure.

4.4 Evaluation and Monitoring

Although there is no standardized approach for development of monitoring and evaluation system, indicators allow the proper tracking of progress and are an important prerequisite of

every strategic document that envisages progress in a certain field. A system for monitoring of performance indicators enables the evaluation of the effectiveness of the R&I activities.

Typically, the Bulgarian strategic R&I documents in the energy field meet the requirement for setting measurable targets and indicators for assessing their progress. However, the follow-up procedure is not clear enough to guarantee the proper implementation of the envisaged measures and to assess their level of success. The application of a well-functioning monitoring and evaluation mechanism in partnership with all stakeholders is a cornerstone for implementing an effective and reasoned evaluation. It is necessary to ensure the link between smart specialization and the goal of strengthening the orientation of public funds to results in general. Last but not least, the results of the monitoring should be reflected in the further decision-making process and in the formulation of the subsequent legislative framework.

The elaboration of the performance indicators, the monitoring of the performance, and the agreement on corrective actions related to this Strategy and the forthcoming R&I Roadmap for SER, will be carried out by the Working group (WG), formed jointly by TRACER and DeCarb projects, constituted by representatives of all major stakeholders – research, businesses and their associations, local and regional authorities, labour unions, NGOs, and others. The WG will be supported by the two project teams. Additionally, it will be discussed how to include the local society, which would be the most by the R&I in each energy field, into R&I co-design sessions and monitoring activities.

5 Concluding note

The SER is a strategic region not only for Bulgaria but also from an EU point of view, being the host of the biggest energy complex in South-eastern Europe. In the next decade, the coal region will need to undergo substantial transformation of its energy system towards decarbonization.

R&I has a vital role to play in the region's planned energy transition. Despite its current state of underdevelopment, Bulgaria's R&I sector has large untapped potential for becoming a driving force behind the country's forthcoming energy transition and earning a competitive advantage in the decarbonization process.

The national R&I legislative framework, which is crucial for delivering working solutions and system reforms, is being aligned with the European goal for the sector's growth, which is a positive indicator for the sector's future development. Furthermore, the current legislative framework in the energy sector for research and development is developing and is geared to promote R&I in the country.

The presence of a number of R&I entities in SER and the availability of funding opportunities are not sufficient to drive R&I excellence. Long-term effort needs to be put on the improvement of R&I human capacity, including better education and attracting leading researchers. Additionally, the national planning, funding, and monitoring systems need to ensure that research activities effectively support energy decarbonization.

Despite the lack of regional decentralization in Bulgaria and the limited empowerment of local and regional governments in energy matters, there are optimistic signs that SER would manage to enhance its economy and energy through R&I. The evident political intent, when combined with the considerable funding resources that are expected to be invested in the region, provides a promising potential to make the Just Transition into a beneficial, well-functioning, and desired phenomenon in the SER and nationally.

The current Strategy identified several priority areas for energy-related R&I in SER. In the field of renewables, it is suggested that efforts are directed towards energy scenario modelling and socio-economic research focused on consumers, cost-benefit analyses, and policies. Another

key priority is hydrogen, where R&I need to address both the technological development and socio-economic aspects ensuring positive attitude and supporting legal environment. The next priority is dedicated to smart grids and energy system digitalization – these will support the market liberalization and the flexibility of market players. The last priority are energy storage systems, where research efforts are necessary to assess the role they could play in the energy system and to support the planned batteries manufacturing in SER.

It is critical to increase and better focus public and private R&I expenditures. The R&I and the promotion of its results may be particularly essential for the preparation of societal attitudes and behaviour change towards energy decarbonization. R&I would assist the society to better understand the benefits and support the European Green Deal.

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