



# The Implementation of Smart Energy into Transformation of the Rural Area: The Use of Public Policies for Smart Villages Development

Petr Hlavacek<sup>1\*</sup>, Vladimír Skalník<sup>2</sup>

<sup>1</sup>Department of Regional Development and Public Administration, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University, Pasteurova 1, 400 96 Ústí nad Labem, Czech Republic, <sup>2</sup>Innovation Centre of Ústecký Region, Ústí nad Labem, Czech Republic. \*Email: [petr.hlavacek@ujep.cz](mailto:petr.hlavacek@ujep.cz)

Received: 15 February 2021

Accepted: 27 April 2021

DOI: <https://doi.org/10.32479/ijEEP.11203>

## ABSTRACT

The article aims to evaluate the government policies in the Czech Republic that have an impact on energy development and energy production development in the rural areas, and to propose the areas where smart energy solutions are appropriate for rural communities. The setup of the public companies is compared with respect to current trends in the development of Smart Villages, where the smart energy solutions are being developed. The research and development conclude that the development policies will require a setup to make the decentralization of the energy sources strengthened. As well, to allow more intensive communication and negotiation with local communities. Achieving the synergy effect, while starting up the process of use of local energy resources of the location and community energy in transformation of the rural area, should be the goal.

**Keywords:** Energy Policy, Smart Cities, Smart Villages

**JEL Classifications:** Q42, Q48, R11

## 1. INTRODUCTION

In connection with how quickly new technologies appear in the field of energy production, a standalone topic of the use of these innovative technologies, or concept, in the rural areas comes to the forefront (Holtmeyer et al., 2013; Jenkins et al., 2018). These challenges need our intensive focus to strengthen the energy independence of the rural areas. According to Clausen and Rudolph (2020), the existence of the best technology will not guarantee its use, which, rather likely with respect to the lagging of the rural areas, behind the development of urban regions, in the field of the energy. On top of that, the lower density of the population of rural areas makes unit costs for provision of available energies to inhabitants of the rural areas higher. The disadvantage of the areas is that they lack political power and the agglomeration benefits of the urban regions (O'Sullivan et al., 2020; Klanięcki et al., 2020).

Abbas et al. (2020) point out the risk of growing energy poverty being associated in particular with peripheral rural areas.

Not only the availability of the energy sources, but also the setup of the energy policy and other policies, which deal with the rural area development with respect to availability and use of the energies to a certain level, influences the development of the rural regions in the field of energy.

To that end, the article evaluates the current setup of the public policies, what targets have been defined for development of smart energy, and for the use of the energy sources in the rural areas in association to the support for implementation of the smart solutions there. Upon evaluation of the government policies, the article will define the field for implementation of smart energy to the development of the rural areas, and directions for establishing

a new energy transformation policy for the rural areas for the development of the smart rural areas.

## 2. LITERATURE REVIEW

According to OECD, the rural and interjacent areas (OECD, 2016) occupy 88.2% of the territory of the European Union (Eurostat, 2016), and they include most of its natural resources. Many European villages, including those in the Czech Republic, have already been using the potential for making the projects focused on energy saving happen with the emphasis on the use of the renewable energy sources. An example of such a functional design is the energy communities in some European states where there is an environmental law, which is much more favourable for the individual and decentralized production of energy (ENRD, 2018). The local system outside the grids then complements those centralized ones (Groth, 2020). It is inevitable for the rural areas to avoid the import of knowledge and capital necessary for the introduction and use of innovative and smart solutions in energy in the future. However, Benedek et al., (2018) draw attention that the use of the renewable energy will require good predictions of the capacities of the local energy sources.

In conformity with the policy of the European Union in the field of climate and energy, the Czech Republic prepares for the transposition of the laws from the “Clean Energy for All Europeans” package into the Czech laws. By 2050, the European Union intends to be a climate-neutral area. The European Commission implements initiatives at the EU level that deal with the challenges of towns and municipalities in the field of energy. One of these initiatives is the European innovation partnership, the Initiative for Smart Cities and Communities. It is a partnership across the areas of energy, transport and information and communication with the objective to catalyse progress in the said areas. Energy production, distribution and use, mobility and transport, and information and communication technologies (ICT) are intimately lined and offer new interdisciplinary opportunities to improve services while reducing energy consumption (European Commission, 2012).

The change to shift to low-carbon and a sustainable economy will require a huge effort, investments, and interdisciplinary approach. The development and use of modern energy systems, technologies, and infrastructure needed are the fundamental requirements for achieving the change (Naumann and Rudolph, 2020). There has already been a start with the implementation effort of the European laws in the Czech Republic in the field of energy represented in particular by the Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, directive (EU) 2018/2002 of the European Parliament and of the Council on energy efficiency, and directive (EU) 2018/844 of the European Parliament and of the Council on the energy performance of buildings, i.e., with respect to energy transformation processes and renewable energy sources (RES) development. The Rural Area Development Draft of the Ministry of Regional Development of the Czech Republic deals with the field of the rural area development. The draft aims to support the rural area development by a more intensive use of

the local energy sources (Ministry of Regional Development of the Czech Republic, 2019). It would be therefore necessary to implement the activities related to smart energy so that the rural areas have created a quality infrastructure (energy, transport, and technical), powerful, stable, and diversified economy, as well as a healthy and climate stable environment. According to Mekhdiev et al., (2018), the governments should focus on increasing the energy consumer’s satisfaction level regarding quality and energy supply costs with good support from the decentralization of its production. Despite increasing energy savings, the consumption and demand for energies will continue to grow. Involvement of the government programs, regional, and local governments will be required to secure the new energy sources where there is just room for support of implementing the smart solutions. However, the use of the public support should be linked to collective bargaining about future forms of energy production and distribution. According to Berka and Creamer (2018), these factors will play a key role in the transformation processes, towards increased energy production at the local level, i.e., in the rural communities as well.

## 3. METHODS

The article is structured into a couple of related chapters that conform to the phases of the methodology of the research. First, collection of information was made on current needs for development of the communities, and the description of expert publications. The next phase mapped out legal and planning dimensions, and analysis of policies of the Czech ministries focused on the field of energy with impact on the rural areas. Then, the Smart City concept analysis followed, including identification of the main directions of the smart energy development for the rural areas. The analytical part of the present article is topped up by the specification of smart solution for rural areas with an emphasis on endogenous energy sources, including findings and recommendations for the smart energy development in the rural areas.

The descriptive analysis in scripted documents, public policies, methodologies, and expert bibliography study will be used in the research. The good practice method (Stockley, 2012) is being applied for the searching and mapping of the smart solutions in the field of energy in the rural areas. The good practice method has been developed in the field of management from where it expanded to other areas. The method aims at the mapping of solutions employed as model examples and uses them for the solution of other problems or development goals.

## 4. RESULTS AND DISCUSSION

A couple of planning and strategic documents indicate the development in the field of energy in the Czech Republic – National Action Plan of Energy Efficiency of the Czech Republic, National Action Plan for Smart Networks, National Action Plan for Renewable Energy Sources 2010-2020 for the Czech Republic, State Energy Concept of the Czech Republic, and the Strategy for Regional Development of the Czech Republic 2021+. The analysis

of the disciplinary policies of the ministries showed that they define the development goals in the field of energy impacted also by the rural areas in many of their own disciplinary policies. The Ministry of Industry and Trade of the Czech Republic, being responsible for agenda in the field of the energy and energy policy of the Czech Republic, is the main entity responsible in the Czech Republic for energy development, also in the rural areas. Not only, this ministry also deals with the themes of energy and transformation of energy sources, including the consequences of the transformation. The analysis of the policies of other ministries revealed that other goals of the individual programs may be found in the impact on the field of the energy production and energy also in the rural areas. For the summary of evaluation of individual goals of the government programs and policies, refer to Table 1.

In addition to the above-mentioned goals of government policies, the need to develop smart energy networks is also mentioned,

**Table 1: Evaluation of policy goals of the Czech ministries with an impact on energy transformation of the rural areas**

Ministry in the Czech Republic	Goals of the policy
Ministry of Industry and Trade	<ul style="list-style-type: none"> <li>- To implement energy-saving measures</li> <li>- To increase efficiency in use of energy, and reduce energy demands</li> <li>- To process design and territorial documentation to support energy saving</li> <li>- To make loans intended for reduction of energy demand more favourable in order to achieve energy saving</li> <li>- To support biomass use as RES</li> </ul>
Ministry of Agriculture	
Ministry of Regional Development	<ul style="list-style-type: none"> <li>- To permit energy transformation of the rural areas background of the regional centres</li> <li>- To ensure effective prevention of social exclusion and energy poverty, and to support the community life in the communities</li> <li>- To improve air quality in the communities where the emission limits are exceeded (replacement of local air-polluting energy sources)</li> <li>- To develop new energy repositories</li> <li>- To develop net energy sources extracting energy from RES</li> <li>- To modify the transmission and distribution grid in order to make the connection of a new RES possible</li> <li>- To use smart solutions in urban and rural areas</li> </ul>
Ministry of Interior	<ul style="list-style-type: none"> <li>- To repair or maintain properties of the communities, in particular, in the field of transport and energy</li> </ul>
Ministry of Environment	<ul style="list-style-type: none"> <li>- To reduce energy demand of the existing blocks of flats</li> <li>- To fund the construction of the blocks of flats of very low energy demand</li> <li>- To effectively use the energy sources</li> <li>- To use heat from waste water</li> </ul>
Ministry of Education, Youth and Sports	<ul style="list-style-type: none"> <li>- Use examples of energy saving solutions and environmental measures to educate</li> </ul>

Source: Own processing

which is associated with the expectation of achieving greater efficiency of energy networks, but creating greater independence in deciding how to meet the energy needs of the rural areas. Hence, measures such as energy distribution, production, and accumulation based on the principle of smart network and smart instrumentation, including the support for the development of distributed and centralized energy accumulation systems should be adopted. At the same time, the new infrastructure should also expand the options for customer consumption management at the level of low voltage as a part of the smart network systems. The development of smart energy aimed at achieving carbon neutrality by 2050 brings about a lot of new challenges and opportunities. From the energy sources perspective, the priority is logically put on the maximum use of the RES. However, the use of secondary energy sources, as well as the use of waste, must not stay aside as they are the representatives of typical examples of linear economy transformation into the circular one. The sources may be called modern or innovative energy sources.

#### 4.1. From Smart Cities to Smart Villages

Recently, the Smart Cities concept has been penetrating, over the last years, in the development of the energy policies at the regional level, which is based on the principles of sustainable development and the organization of cities with the use of smart technologies in the field of energy as well. An important concept document from the Ministry of Regional Development of the Czech Republic is the Smart Cities Methodology (Ministry of Regional Development, 2018) that considers smart energy, sources, and services as the main areas of the Smart Cities' technological infrastructure. Smart energy includes the following areas:

- Smart energy consumption control, including energy management of municipal buildings and support of their energy-saving solutions
- Use of RES or combined electricity and heat production, and their safe integration into the municipal energy grid
- Use of the "smart grid" elements in the municipal or regional distribution grid, including smart micro-grids
- Smart control of municipal services towards effective use of energy and natural resources – in particular, energy-saving and environmentally-concerned public lighting, effective waste management, and effective water management (Ministry of Regional Development of the Czech Republic, 2018).

The development of the rural areas' development policy is inevitable without the development of smart energy in the rural areas. Smart rural areas are the rural areas and communities that build on their advantages and values to date, as well as on new opportunities in their effort to achieving increased value where both traditional and new grids are upgraded through digital communication technologies, innovation, and improved use of knowledge in favour of inhabitants (ENRD, 2018). A synonym for the power development could to some extent be the Energy 4.0 concept (the Ústí Region, 2020). From the perspective of this energy, it is a portion of the energy eco-system integrating the ICT elements, in particular smart production, distribution, and energy consumption management in real time, which supports the distributed production from renewable sources of energy.

Based on the targets and policies specified above, which directly or indirectly coordinate the energy development at the level of regions and municipalities as well, the basic smart solutions may be defined as the upcoming vision of the rural areas as being the territory attractive for true living. The effective use of the smart systems for the operation of the community and communication with inhabitants is important for the rural area in the field of energy. It is necessary to evaluate the level of self-sufficiency of the rural areas in the energy production for the system development of smart rural areas and their energy sources, and to transform the energy sources into low-carbon economy. With the change processes being set, differences of individual rural areas and endogenous principles must be considered in creating the local energy policies in the rural communities.

The energy self-sufficiency of a municipality may be the potential goal of the smart solutions in the field of smart energy (Figure 1). An energy self-sufficient municipality is not an isolated entity, it remains integrated with the other communities and territories in a communal way. It is able to procure all the needs, or its energy consumption right in the community. The essence is a principle that consumption and production occurs at one place with an effort to cover the consumption as most as possible from its own sources, which widely opens doors to modern technologies. In no way is the essence of the energy self-sufficiency separated from the central power supply systems, but rather to use as most as possible the local available potential, which also improves the resilience of the community and provides extended safety. The smart solution in the power field and energy production in the rural areas should be applied in the fields described in Table 2. The self-sufficiency level is given by a specific layout of the community or territories to a high extent. Therefore, the definition of the territorial potential and possibilities of its technical and economical use are the keys for the rural area's development. An energy self-sufficient municipality consists of a community being able to sustain its needs, i.e., local consumption through energy production on spot. It does not mean that it is isolated from the central power supply but local energy sources will be used as much as possible.

The smart energy consists in diminishing fossil fuels and the development of low-carbon economy also in the rural areas, for example by the use of RES (solar and wind energy, biomass and bio-gas for electricity production, reduction of energy demand, and more) at higher levels and in overall energy management.

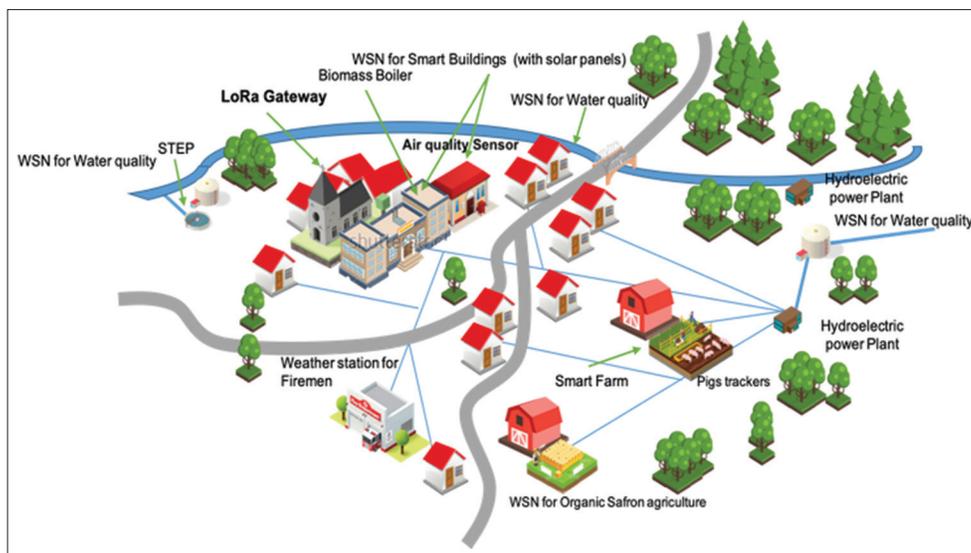
The ability of the community's policy to communicate with a wider area, to advance in a horizontal approach in the creation of a symbiotic relationships with other communities, and in a vertical approach in the development of energy; this will play an irreplaceable role by the integration of the rural communities and locations with the regional centres at a higher level. To achieve an acceptable level of resilience and self-sufficiency of the rural areas, it is necessary to deliver relevant technical infrastructure (local distribution systems with the elements of smart grids).

**Table 2: Areas for implementation of the smart solutions in the rural areas**

Energy grids
Reconstruction of distribution grids for connection of new sources of electricity, or RES
Development of transmission and distribution system and energy repositories
Building of infrastructure for island systems for energy supply
Energy production
Reduction of energy demands
Use of alternate sources of energy, e.g., in bio-gas stations
Use of RES
Support of new local (innovative) sources of energy
Support of effective use of energy sources and switching to low-carbon rural economy
De-concentrated energy systems
Socioeconomic area
Reinforcement of the circular economy in the field of the energy production
Development of low-carbon economy
Reduced risk of energy poverty
Support of local energy producers

Source: own processing

**Figure 1: Basic representation of smart village**



Source: Antoine-Santoni et al., (2019)

Should there be an insufficiency of individual energy sources, the smart energy solution should perform the control and coordination activity between both systems so that community inhabitants notice no inferior quality of supply or outages. In addition, a lot of smart solutions are related to Internet and electricity, and thus it is necessary to eliminate potential outages as a prevention so that purely technological smart solutions will be able to operate in a continuous way.

Consolidation of diversification of the source base and tight cooperation with the surrounding communities and regional centres under clearly defined rules and correct management will allow the reduction of the operation expenses, and provide higher stability of the environment and resiliency of the rural areas against extreme situations. According to Vallivaara (2017), the Artic Smart Community Cluster project may be an example where the community in cooperation with various organizations, including companies, funding institutions, researchers, and mediators harnessed the potential for capital outflow and increasing the local quality of services in two key areas – energy and food sale. The cluster participants have developed an integrated strategy to support local business operators, which includes education through schools, making public tenders accessible, and establishing local food and energy hubs. It has been confirmed that the implemented projects create new jobs, reduce waste and emissions, control costs, and keep local income in the local economy (ENRD, 2018).

## 5. DISCUSSION AND CONCLUSION

In essence, smart energy in the rural areas is not limited to the size of the area, and it belongs among the fundamental pillars of the smart development concept of the rural areas. The object is that it may be generally considered as a part of everyday life of all inhabitants, and it does not matter whether it is applied in a metropolis or in a rural community. It includes a set of systems and activities that a modern society may not simply operate. What distinguishes smart energy from a “traditional” perception of the energy is the achieved level of energy efficiency of all systems being used, the level of RES, its availability (limitation of the energy poverty), and the resilience level towards changes to conditions.

The energy self-sufficiency of a community and the development of community energy is an apposite result, however, the central energy systems should remain as a backup, or add-on, because energy self-sufficiency is the first aspect and provision of individual services in the community, so that inhabitants will live well and better in the future, as this is the other aspect. In reality, perhaps only a few communities would be capable of securing the services using its own sources at a level available from the central system, and therefore, each system needs to be interconnected. For pushing smart energy through, a properly configured energy policy is absolutely fundamental – to ensure the conditions for a long-term sustainable development and decentralization of the energy sources (Yazdanie et al., 2016). The policy should be characterized by achieving the synergy in the integration of the energy and information and communication technologies (ICT).

For rural communities, it is better that the energy challenge (and therefore, the energy self-sufficiency) is discussed at the level of locations and not by way of individual communities, and hence, to support so-called community energy. The energy associations being formed by the communities, and therefore by inhabitants, show growing importance, and the energy policy should aim toward more intense communication and negotiation with the local communities. It would be ideal in each case, that all directions described for the new solutions in the field of the energy development of the rural areas are supported by the government policy by the system of subsidies and invitations to help in the transformation of the energy sources and higher independence of the rural communities.

The next steps in the research could focus on mapping out the efficiency of the government programs and looking for successful projects of the community energy development in the rural areas. The above mentioned is associated with the need of looking for examples of an effective energy transformation of the rural regions. The knowledge gained about the transformation processes could be the examples and they may be universally portable to other rural areas.

## 6. ACKNOWLEDGMENT

The paper presents the results of the research within the TACR project No. TL03000066, “Smart countryside: sustainable rural development using Smart solutions.”

## REFERENCES

- Abbas, K., Li, S., Xu, D., Baz, K., Rakhmetova, A. (2020), Do socioeconomic factors determine household multidimensional energy poverty? Empirical evidence from South Asia. *Energy Policy*, 146, 111754.
- Antoine-Santoni, T., Poggi, B., Federici, D. Manicacci, F.M., Gualtieri, J.S., Aiello, A. (2019), Proposition of a Smart Environment Architecture for Ressources Monitoring and Rural Activities Management. The 13<sup>th</sup> International Conference on Sensor Technologies and Application, Conference Paper IARIA. p62-68.
- Benedek, J., Sebestyén, T., Bartók, B. (2018), Evaluation of renewable energy sources in peripheral areas and renewable energy-based rural development. *Renewable and Sustainable Energy Reviews*, 90, 516-535.
- Berka, A.L., Creamer, E. (2018), Taking stock of the local impacts of community owned renewable energy: A review and research agenda. *Renewable and Sustainable Energy Reviews*, 82, 3400-3419.
- Clausen, L.T., Rudolph, D. (2020), Renewable energy for sustainable rural development: Synergies and mismatches. *Energy Policy*, 138, 111289.
- ENRD. (2018), EU Rural Review 26 Smart Villages: Revitalising Rural Services. Available from: [https://www.enrd.ec.europa.eu/publications/eu-rural-review-26-smart-villages-revitalising-rural-services\\_en](https://www.enrd.ec.europa.eu/publications/eu-rural-review-26-smart-villages-revitalising-rural-services_en). [Last accessed on 2021 Jan 21].
- European Commission. (2012), Sdělení Komise Inteligentní Města a Obce evropské Inovační Partnerství. Available from: [https://www.ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives\\_cs](https://www.ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives_cs). [Last accessed on 2021 Jan 19].
- Eurostat. (2016), Share of Land Area Using Different Typologies. Available

- from: [https://www.ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Share\\_of\\_land\\_area\\_using\\_different\\_typologies\\_\(%25\\_of\\_land\\_area\)\\_update.png](https://www.ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Share_of_land_area_using_different_typologies_(%25_of_land_area)_update.png). [Last accessed on 2021 Jan 21].
- Groth, A. (2020), Overcoming one-way impact evaluation of rural electrification projects. *International Journal of Energy Economics and Policy*, 10(2), 464-476.
- Holtmeyer, M.L., Wang, S., Axelbaum, R.L. (2013), Considerations for decision-making on distributed power generation in rural areas. *Energy Policy*, 63, 708-715.
- Jenkins, K., Sovacool, B.K., McCauley, D. (2018), Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change. *Energy Policy*, 117, 66-74.
- Klaniecki, K., Duse, I.A., Lutz, L.M., Leventon, J., Abson, D.J. (2020), Applying the energy cultures framework to understand energy systems in the context of rural sustainability transformation. *Energy Policy*, 137, 111092.
- Ministerstvo Pro Místní Rozvoj ČR. (2018), Metodika Smart Cities. Available from: [https://www.mmr.cz/getmedia/f76636e0-88ad-40f9-8e27-cbb774ea7caf/Metodika\\_Smart\\_Cities.pdf.aspx?ext=.pdf](https://www.mmr.cz/getmedia/f76636e0-88ad-40f9-8e27-cbb774ea7caf/Metodika_Smart_Cities.pdf.aspx?ext=.pdf). [Last accessed on 2021 Jan 15].
- Mekhdiev, E.T., Prokhorova, V.V., Makar, S.V., Salikhov, G.G., & Bondarenko, A.V. (2018). Smart Cities in Future Energy System Architecture. *International Journal of Energy Economics and Policy*, 8(5), 259-266.
- Ministerstvo Pro Místní Rozvoj ČR. (2019), Koncepce Rozvoje Venkova. Available from; [https://www.mmr.cz/getmedia/279d5264-6e9e-4f80-ba4a-c15a26144cd0/Koncepce-rozvoje-venkova\\_202001.pdf.aspx?ext=.pdf](https://www.mmr.cz/getmedia/279d5264-6e9e-4f80-ba4a-c15a26144cd0/Koncepce-rozvoje-venkova_202001.pdf.aspx?ext=.pdf). [Last accessed on 2021 Jan 15].
- Ministry of Regional Development of the Czech Republic (2018). Metodika Smart Cities. Available from; [https://mmr.cz/getmedia/f76636e0-88ad-40f9-8e27-cbb774ea7caf/Metodika\\_Smart\\_Cities.pdf.aspx?ext=.pdf](https://mmr.cz/getmedia/f76636e0-88ad-40f9-8e27-cbb774ea7caf/Metodika_Smart_Cities.pdf.aspx?ext=.pdf).
- Naumann, M., Rudolph, D. (2020), Introduction to the special section: Rural energy transitions - Contestations and perspectives. *Energy Policy*, 142, 111531.
- O'Sullivan, K., Golubchikov, O., Mehmood, A. (2020), Uneven energy transitions: Understanding continued energy peripheralization in rural communities. *Energy Policy*, 138, 111288.
- OECD. (2016), OECD Regional Outlook 2016: Productive Regions for Inclusive Societies. Available from: <https://www.regions20.org/wp-content/uploads/2016/08/OECD-Regional-Outlook-2016.pdf>. [Last accessed on 2021 Jan 10].
- Stockley, D. (2012), The Rise and Fall of the Best Practice Method. Available from: <http://www.derekstockley.com.au/newsletters-05/042-best-practice-consulting.html>.
- Ustecky Region. (2020), Energetika 4.0. Available from: [https://www.kr-ustecky.cz/assets/File.ashx?id\\_org=450018&id\\_dokumenty=1748688](https://www.kr-ustecky.cz/assets/File.ashx?id_org=450018&id_dokumenty=1748688). [Last accessed on 2021 Jan 21].
- Vallivaara, J. (2017), Implementation of Smart Specialisation Arctic Smart Rural Community. Available from: [https://www.enrd.ec.europa.eu/sites/enrd/files/s4\\_rural-businesses\\_aritc-cluster\\_havukainen.pdf](https://www.enrd.ec.europa.eu/sites/enrd/files/s4_rural-businesses_aritc-cluster_havukainen.pdf). [Last accessed on 2021 Jan 15].
- Yazdanie, M., Densing, M., Wokaun, A. (2016), The role of decentralized generation and storage technologies in future energy systems planning for a rural agglomeration in Switzerland. *Energy Policy*, 96, 432-445.