Comparative Analysis of Barriers for Renewable Energy Technologies Diffusion in Finland and Poland

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Abstract. Renewable Energy Technologies (RETs) are critical for the energy transition towards environmentally friendly solutions. There are many international regulations enhancing climate change mitigation. However, on a national level, disruptive technologies often struggle with many various barriers. There is ample evidence supporting the claim that innovative energy technologies require the whole ecosystem to support their diffusion. In fact, it is often a case that the change starts at the regional level. Therefore, some country-specific limitations are worth investigating.

In this study, we examine various barriers of renewable energy technologies diffusion in the case of two European countries: Finland and Poland in the first phase. It served to perform a comparative analysis in a second stage, revealing the similarities and differences between them. An analysis provides insightful knowledge about the current constraints of widespread and effective renewable energy technologies diffusion. As a conclusion, the directions and possibilities for improvement are suggested.

Keywords: Renewable Energy · Barriers · Technology Diffusion · Sustainable Regional Development · Comparative Analysis

1 Introduction

Climate change is becoming an increasingly important issue for the international community. Numerous efforts to minimize its adverse impact have been made through the implementation of certain policies, namely by the United Nations and agendas of the European Union. The goals of recent regulations for 2020 were aimed at reducing greenhouse gases (GHG) emissions by 20% compared to 1990, as well as increasing the usage of renewable energy sources (RES) and energy efficiency to 20% [7]. New targets for 2030 were set and they are even more ambitious: 40% CO2 emissions cut compared to 1990 realities, 32% RES share and 32,5% energy efficiency [6]. Moreover, the European Commission has presented the strategy for climate-neutral Europe by 2050, aiming at 80-95% GHG emissions reduction compared to 1990 levels and RES usage of 50% [8]. European Union policies are in line with the UN Paris

Agreement [37] objective to maintain the global temperature increase to well under 2°C and pursue efforts to cling to 1.5°C. As can be seen, international policies play a key role when it comes to leading the way towards facing the challenges connected with global warming. According to [5], renewable energy markets are likely to develop more by dint of supportive policy frameworks and less through the determinations of mere competitive and commercial interests. Furthermore, governments tend to implement the RETs into the energy sector when they can clearly observe the potential benefits, with special regard to the long-term interest, that they can provide. They can be presented in different forms, e.g. sustainable development [14], energy security [39] or proficient use of native resources [1]. However, in order to enhance an improvement in that aspect, a multi-level contribution from different interest groups coming from various sectors is necessary. It is argued that the successful diffusion of renewable energy technologies requires the whole ecosystem to support it [33]. It is also claimed that technology push, market pull, and the regulatory framework are the key drivers of green innovation and thus, of sustainable cleaner production [15]. Moreover, environmental awareness of consumers is a vital variable, since ecologically sound products may be brought in through market pull elements [31]. Therefore, environmental policies persuade businesses to develop sustainable innovations.

Still, the challenges to business are meaningful: throughout industries, enterprises are increasingly struggling with social and environmental difficulties while stakeholders expect firms to operate according to the concept of a triple-bottom-line of economic, environmental and societal value generation [11], rather than sole short-term income orientation [14]. On the other hand, being environmentally sound and energy-efficient will not guarantee renewable energy initiatives will gain and sustain a long-period market share and there is a cost decrease requirement in order to become competitive with the conventional solutions. Nonetheless, it is argued that the cost of energy generation from renewables will become competitive if the cost of harnessing the environment and internalizing the externalities are considered [24].

There are numerous studies exploring renewable energy diffusion. As it is a complex and multi-perspective process, researchers focus on different specific renewable energy sources e.g. biogas [4], [29], [38] wind energy [22], or solar PV [28]. Moreover, authors tend to contextualize it to certain factors or viewpoints of different interest groups as well as to conduct case studies on different geographical areas. For instance, [32] or [35] examined the barriers of renewables adoption from the customer's perspective, while [5] expresses the investor's viewpoint. Studies led by [30] and [17] explored the social acceptance and so-called willingness-to-pay aspects. Authors like [36] and [27] focused on the technology diffusion process in the sustainable energy context. Nevertheless, the mainstream of research on renewable energy diffusion focuses on energy policy analysis [20], [19].

However, in this study, we decided to take a holistic approach towards RES as well as the diffusion and its barriers, following the tactic of e.g. [16], [3], or [33]. This method helps in analyzing the barriers of different kind in two European countries taken into the scope of this research: Finland and Poland, which allows us to make a cross-case comparative analysis. After making such a comparison of key barriers in each country, brief solutions for the betterment of the existing state of affairs are proposed in conclusions.

2 Major barriers of RES diffusion in Finland and Poland

The literature on barriers to the successful adoption of various RES is quite bountiful. For instance, [32] studied the non-environmental barriers in the viewpoint of Finnish electricity customers and they have identified three categories: cognitive, characterized by the lack of knowledge and trust; orientational, connected with time and effort linked to prior habits and preferences; and economic, referring to the relatively higher cost. Moreover, [24] pointed out externality costs as market-related barriers, and these are the cost of damaging the environment and GHG emissions, which are often unconsidered in business strategies. In addition, [2] studied the potential for different renewable energy sources in Finland, which concluded in collective barriers and they are the following categories: environment, cost, or policy. Furthermore, [18] presented energy efficiency barriers in Finland, and determined insufficient technical skills, non-functional regulation or imperfect information flow as key obstacles perceived by the energy companies. However, in order to express country-specific barriers, it is important to include National Renewable Energy Action Plans from both countries, which were created to efficiently, realistically and appropriately respond to the legally binding obligations resulting from the international regulations mentioned before (namely the Directive 2009/28/EC). In the case of Poland, the target for the RES share in total energy consumption in 2020 has been reduced to 15% and the goal of 10% biofuels share in the transport industry has been additionally set [21], [25]. In the case of Finland, the expected share of RES has been raised to 38%, and in terms of GHG emissions, the national target referred to the 2005 level and aimed at a 16% decrease. What makes Finland a role model for the rest of Europe, these targets have been reached already in 2014 [9].

As can be concluded from Fig. 1, solid biofuels are the main RES type in the total energy generation (for electricity, heating and transport purposes) in the whole EU. In energy statistics, they refer to the *"product aggregate equal to the sum of charcoal, fuelwood, wood residues and by-products, black liquor, bagasse, animal waste, other vegetal materials and residuals and renewable fraction of industrial waste", whereas liquid biofuels is "the sum of biogasoline, biodiesels, bio-jet kerosene and other liquid biofuels"* [10]. Both Finland and Poland are characterized by an abundance of forest and agricultural areas, hence wood fuels and biomass have the biggest share in these countries. However, in the case of electricity production, which has a leading position in terms of energy usage, different RES break into the mainstream. In Finland, the share of RES in electricity generation in 2018 amounted to 46%, with hydro (42%), black liquor (21%), other wood fuels (19%) and wind (16%) [23]. In Poland, the wind took the leading role with a 59% share, followed by solid biofuels (25%), hydro (9%) and biogas (over 5%) [34].

A major barrier for RES diffusion in Poland, a coal-based energy mix, is of a complex nature since it has many unfavorable implications. National energy policies are insufficient and ineffective in terms of RES adoption because the focus is still being put on the coal and lignite sector development. This is due to long-lasting experience, and thus, reluctance to change the current state of affairs, which would require the transformation of the whole infrastructure, including e.g. smart grids installment.

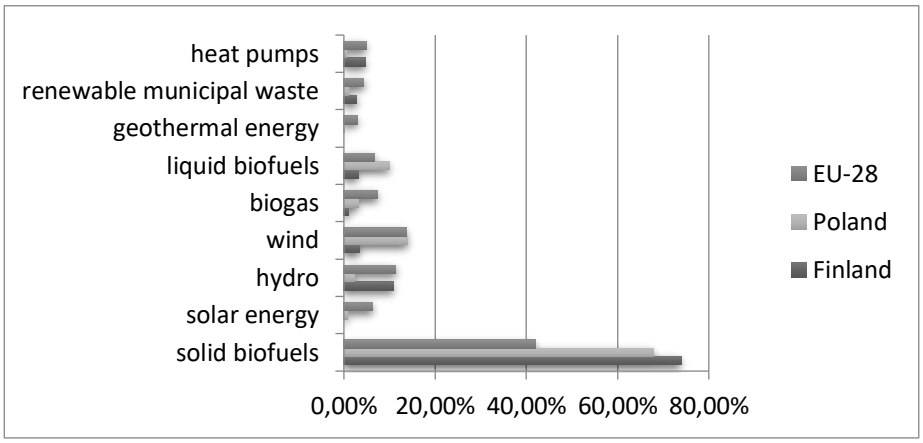

Fig. 1. Renewables by source type in 2017. Source: Own calculations based on [34]

The Polish *'coal culture'* is strongly cultivated, which has had even more socioeconomic consequences: limited financial resources and changes in the EU support (e.g. reduction of feed-in tariffs or green certificates). It results in the lack of social and political acceptance, expressed in the unwillingness to pay more for the green energy as well as fear of the consequences of such change to the mining industry.
In Finland, the major barriers to RES adoption are market-related. Finland, being a developed country, has a solid infrastructure and regulatory support needed for the RES diffusion [33]. Energy transition became the country's inter-sectoral priority. Therefore, a key barrier to the RET diffusion that Finnish companies face, is a relatively small demand for the green energy, compared to the conventional-sourced solutions.

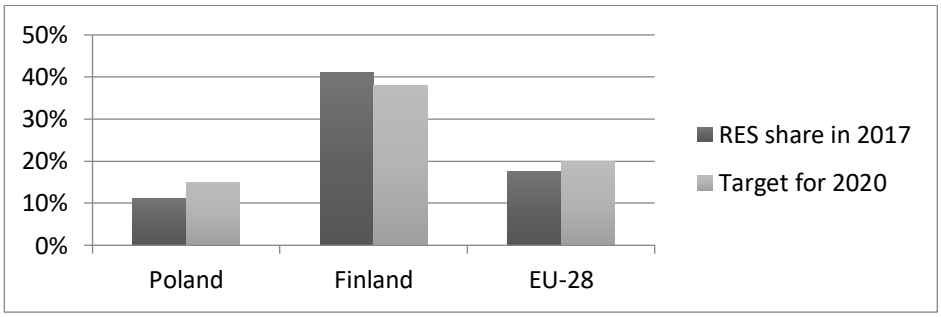

Fig. 2. Renewables share in total gross consumption. Source: own calculations based on [34]

This critical economic barrier is due to the small-sized domestic market, which in consequence, pushes business initiatives to internationalize their operations. It is even more troublesome for the start-ups and SMEs, often struggled by the lack of strategic, managerial human and financial resources, which often do not consider the commercialization aspect, but focus solely on the technology development process [33]. Moreover, according to the study by [40] with the existing energy infrastructure, Finland has a limited capacity of a maximum of 50% RES share.

Table 1. Summary of the analysis

Comparison aspect	Finland	Poland
EC & UN / national goals for 2020 – are they met?	RES share 38% - **YES** GHG emissions 16% lower than in 2005 – **YES** 10% biofuels in transport – **YES,** 18.8% in 2017 Energy efficiency of 35.9 Mtoe – **NEARLY**, 32.9 Mtoe in 2018	RES share 15% - **NO**, 11% in 2017 GHG emissions 20% lower than in 1990 - **NO** 10% biofuels in transport – **NO**, 4.2% in 2017
Major RET diffusion barrier(s): **1) Economic/market** **2) Policy/regulatory** **3) Social/behavioral**	Dynamic and small-sized domestic market, uncompetitive green energy prices, long pay-back time, imperfect information flow	Coal-based energy mix, ineffective policies, reduction of subsidies (e.g. feed-in tariffs), limited infrastructural and financial resources
RES with the highest share/development potential	Solid biofuels (wood fuels, black liquor), hydro, wind	Solid biofuels (biomass), wind, liquid biofuels, biogas

3 Conclusions and suggestions towards improvement

The analysis performed reveals insightful information about differences and similarities between Poland and Finland. These two European countries have agreed to implement national policies aiming at addressing obligations coming from international regulations. However, only Finland had successfully fulfilled its renewable energy goals. This is due to differences in resources, infrastructure, and behavioral patterns. Finland is one of the most innovative countries in the world [12], having a strong cultural foundation towards climate change mitigation. The fact that it has nuclear power plants is also crucial since the usage of conventional, high-emission energy sources is reasonably limited. Conversely, in Poland, a coal-centered energy sector with nearly 90% of coal in total energy usage (coal and lignite combined), classifies this country as struggling with the energy transition strategy implementation.

In order to overcome the most significant barriers in these countries, intensive multi-level cooperation of the energy industry, government, academia, and society is highly expected. Namely, a further institutional contribution is necessary since a supportive regulatory framework is seen as a catalyst for renewable energy technologies diffusion. In Poland, the defenders of the current state of affairs could perhaps learn from the German example of a swift and effective transition from a coal-based economy towards RET (*vide* Energiewende) [13]. Moreover, societal barriers are common for both countries, and they concern e.g. noise-disturbing, animal-endangering and landscape-destroying wind power plants or foul-smelling biogas plants. This phenomenon

called ‘Not-In-My-Backyard’ (NIMBY) [26] could be addressed by some promotion and awareness-raising actions. Lastly, efforts directed toward the further development of biomass- and waste-based CHP (combined heat and power) technologies would significantly improve the current state of affairs in both countries.

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