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Innovation in the use of wood energy in the Ukrainian Carpathians: Opportunities and threats for rural communities

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ABSTRACT

Ukraine is traditionally deeply dependent on fossil and nuclear energy. However, in response to global climate and energy policies, a major shift towards renewable energy (RE) is presently underway. Apart from ample wind and solar capacities, the country has abundant bioenergy resources, mainly from agriculture and forestry. Particularly in the densely-forested Ukrainian Carpathians, wood is the most prominent bioenergy source used to meet the heat demands of households and public buildings. However, despite increasing forest area and timber volume in this region during the last 50 years, affordable bioenergy from forests remains scarce in many areas. At the same time, local communities suffer from energy scarcity, energy insecurity and high energy costs.

In an effort to understand how better use might be made of Ukraine's bioenergy resource, addressing sustainability goals as well as the needs of local communities, this study assesses the significance and future potential of wood energy for regional economies and households from an environmental, economic and social perspective. The study employs a mixed-method approach combining literature review, a Best Practice contest and semi-structured interviews with forestry sector stakeholders in rural areas of Transcarpathia and Lviv. Several reasons were identified for the scarcity of affordable bioenergy, including the export-oriented wood processing industry, the lack of forest road networks and machinery, the short-term character of national forest strategies in relation to bioenergy, and other institutional settings that limit access to forest resources. Illegal logging, corruption, and lacks of transparency in timber markets add further difficulties. To address these problems and to meet the challenges defined by international climate agreements, two key innovative instruments were identified; 1) certification schemes for forest products and; 2) community-driven bioenergy initiatives (e.g. local cooperatives.). These approaches, ideally embedded in a local energy strategy developed by the communities themselves, have the potential to transform energy and benefit communities and the local economy.

1. Introduction

Although the energy transition is a key challenge for the entire global community (EU Commission 2014; World Wildlife Fund WWF, 2017), options and specific transition pathways need to be identified, negotiated and decided on at the national level. The internationally adopted climate objectives negotiated under the Paris agreement and the United Nations Sustainable Development Goals (UN, 2015), for instance, imply a significant expansion of renewable energies (REs) worldwide. Bioenergy, the focus of this paper, accounts for about 10% of the world's primary energy consumption, yet its potential could be increased to about 15% of the world's energy demand by 2035 (IEA, 2016).

Transforming Ukraine's energy sector is essential to strengthening the country's economic and national security. Despite having ample domestic energy resources, these cover only half of the country's energy demand. Currently Ukraine generates more than 50% of its electricity from outdated coal and nuclear power plants, several of which already operate beyond their designed lifetime. Hydropower and other renewables contribute a negligible share (Savitsky, 2016). In the recent past, the energy situation became even more critical. The country's dependence on Russia for nuclear fuels and the suspension of domestic coal supply for thermal power plants from Donetsk and Luhansk regions as a result of the armed conflict in Eastern Ukraine, make the task of energy transition especially urgent (Yurkovich, 2018). Furthermore, old and inefficient technologies mean that the country is one of the world's most energy intensive economies (Kholod et al., 2018). Together with fostering RE production, increasing energy efficiency is therefore an important goal.

The Ukrainian Government aims to strongly promote green energy

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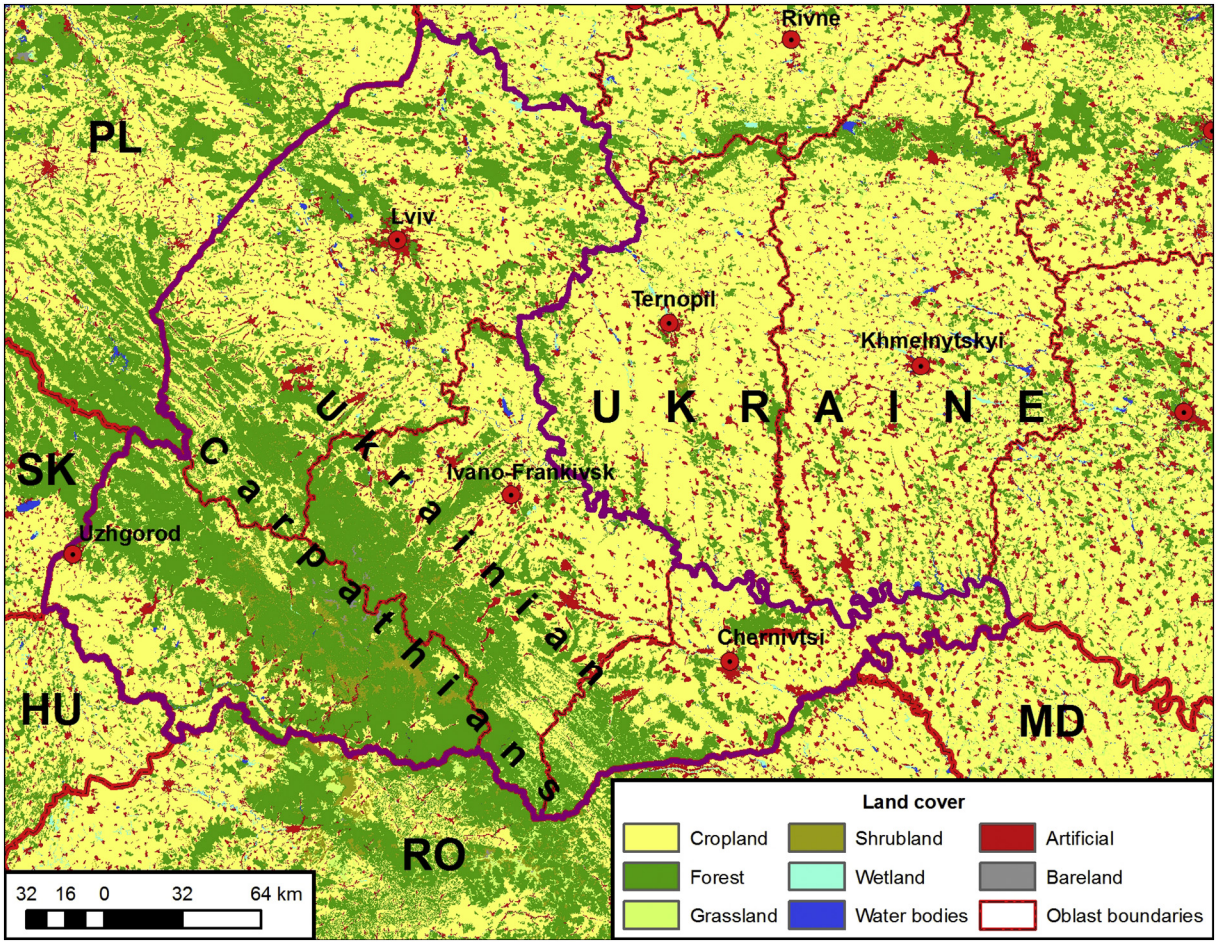

Fig. 1. Land cover in the Ukrainian Carpathians. Lviv and Uzhgorod are the main cities of the two case studies located in the administrative regions (oblasts) of Lviv and Transcarpathia (Map by Anatoliy Smaliychuk, Ivan Franko National University, Lviv).

by adopting the Energy Strategy of Ukraine and the draft National Renewable Energy Action Plan prepared by the State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE). The latter is intended to define a pathway towards the target of 11% electricity from renewables by the year 2020 (Cabinet of Ministers of Ukraine, 2014), and 25% by 2035 (Cabinet of Ministers of Ukraine, 2017). In terms of total energy, the share of REs remains small (about 6% in 2014 (State Statistics Service of Ukraine, 2016a, 2016b), however, it is projected to increase to 20% by 2030 (Cabinet of Ministers of Ukraine, 2017). To attract investment for renewable electricity production, Ukraine has set a green tariff system at 6 to 17 cents/kWh under a guaranteed purchase arrangement until 2030. Such incentives are crucial for the development of REs in the country (Trypolska, 2012). While it is no longer mandatory for production of REs to include a local component (e.g. equipment produced in Ukraine) in order to obtain green tariffs, power plants that do so are rewarded with extra bonuses (Janda and Stankus, 2017).

Recently, the Ukrainian Parliament supported a number of bills aimed at the development of green energy in 2019 and the maintenance of favourable conditions for its development in 2020. In addition, from 2020, a new mechanism for state support of producers of electricity from alternative sources, in the form of price auctions, will be introduced. The starting price will be the "green" tariff, valid at the time the auction is conducted. While some of these laws are still awaiting final parliamentary approval, the fact that they are under consideration is a clear sign of progress towards "greening" the Ukrainian economy.

Alongside other REs, bioenergy could contribute 4.6% to the primary energy consumption by 2030 (Cabinet of Ministers of Ukraine, 2017). The total biomass potential is estimated to 21.2 Mio. t of oil equivalent per year (2016). With 2.6 Mio. t oil equivalent per year, the share of bioenergy from wood is relatively small in national terms; the share of bioenergy from agricultural waste and by-products is much larger. However, in the Ukrainian Carpathians, where forest cover reaches almost 50%, wood as an energy source has a considerable potential.

1.1. Aims and objectives

This paper investigates opportunities and threats arising from the anticipated increase of wood fuel use in forest-dependent regions of the Ukrainian Carpathians. It focusses on the importance of innovative bottom-up RE initiatives in these regions, as a means of increasing energy security and enhancing the socio-economic development and resilience of local communities.

This research was conducted under the remit of the Swiss-Ukrainian project "Identifying Green Energy Options for the Ukrainian Carpathians" (2017–2020) led by the Swiss Federal Research Institute WSL in partnership with the Ukrainian National Forestry University, the NGO Agency of sustainable development of the Carpathian region FORZA, and the Center for Development and Environment (CDE) of the University of Bern. The project emphasized the importance of societally relevant research (cf. Pohl et al., 2017), and co-production of knowledge with stakeholders from forest-dependent communities in the regions Transcarpathia and Lviv was a key element of the work.

Our research addressed four questions:

- What is the potential for sustainable energy from forest wood in the Ukrainian Carpathians?
- What innovative RE initiatives are currently implemented in these regions?
- What kinds of social innovations in the field of REs could promote local development at a larger scale?
- Could forest certification schemes be expanded to include fuel wood in order to promote the sustainable use of wood energy in the Ukrainian Carpathians?

1.2. Study area

Although the Ukrainian Carpathians cover only around 4% of Ukraine's territory, they produce one third of its forest resources (Nijnik et al., 2009; Melnykovych et al., 2018). The Carpathian region consists of four administrative units: Transcarpathia, Lviv, Ivano-Frankivsk, and Chernivtsi (Fig. 1). Forests occupy almost 42% of the territory and play an important role in the livelihoods of forest-dependent communities (Melnykovych et al., 2018; Melnykovych and Soloviy, 2014). Forest income contributes around 5% of total household incomes in forested regions of the Carpathians. According to the ENPI FLEG II Program (2016) collection of non-timber forest products, including resins, Christmas trees, wild fruits and berries, and birch sap, is an important activity of the local population. Forestry is a profitable economic activity in the region. The forestry sector plays an important role, particularly in rural areas where unemployment is high, in terms of provision of jobs and maintenance of rural communities, while also providing essential environmental services (seen also in Ukraine Forestry Sector Note, 2006; ENPI FLEG II Program, 2016). Yet, due to the state monopoly on timber harvesting, many communities do not benefit from the profits of these activities (Nijnik et al., 2019; Sarkki et al., 2019). Communities receive only small shares of the revenues paid by forestry enterprises in the form of stumpage fees. The contribution of such payments to local budgets in 2017 was nearly UAH 1 billion, while the total amount of taxes on forestry enterprises in 2017 was about 4 billion UAH (Bondar, 2018).

In contrast to the steady increase in forest area and volume in Ukraine during the last 50 years, affordable bioenergy from forests is scarce. Unlike in the rest of Ukraine, wood is the most prominent bioenergy source in the Carpathians and is widely used for heating in households and public buildings. Wood is still collected and used for fuel in large quantities due to the high price of gas (Bakkegaard, 2014; ENPI-FLEG II, 2016). Thus, in the absence of alternatives, wood still remains the main source for heating and cooking in most forest-dependent communities in the Carpathians and as such, is essential during winter months, in particular in remote areas (Bakkegaard, 2014; Melnykovych et al., 2018). According to Chernyavskyy et al. (2011), a typical household needs from 6 to 12 m^3 of fuel wood for heating, depending on the household size and its insulation, and the quality of the wood (e.g., tree species).

2. Materials and methods

The research followed a mixed-method approach (Morse, 2016) comprising three distinct phases.

In Phase 1, a comprehensive understanding of the energy wood potential and fuel wood consumption in the Ukrainian Carpathians was acquired through literature analysis.

To identify initiatives and best practices in the region, to establish contacts to local actors and to learn about opportunities and obstacles related to wood energy use at the local level, a Best Practice Contest was launched in early 2018 (Phase 2). It addressed individuals, households, legal entities, public institutions and communities. The entry form asked for the description of the energy challenges in the locality where the practice has been implemented, what has been done and how it contributed to solving the problem of energy dependency on external sources. It also asked for target groups that had benefited from the practice or activity, and the overall implementation costs. The contest considered both examples of practices already implemented as well as those that had not yet been carried out. Proposals had to be related to the use of woody biomass (timber, firewood, chips, sawdust, pellets, briquettes) for heat or electricity production, or to efficiency measures.

Proposals were assessed by an international evaluation committee on the basis of: 1) thematic relevance (the contribution of the activities to higher energy independence, e.g. by better resource allocation or more efficient use of woody biomass); 2) effectiveness (including cost-effectiveness), efficiency and transferability to other places; and 3) the impact and sustainability (long-term impact on the target groups, use of local resources, support of local people). Submissions had to contain a clear proposal on how the innovation grant, i.e. the prize money for the winners, was to be invested.

In summer 2018, five winners were awarded innovation grants of between 700 and 1300 USD. The grants were intended to further improve energy use and efficiency measures the winners had proposed (e.g. devices or equipment). The 14 proposals submitted to the Best Practice Contest provided valuable material for the subsequent analysis of innovative pathways in using wood for energy in the study region while taking advantage of locally available expertise, experience and ideas.

In Phase 3, 61 semi-structured interviews were carried out with forest business-associated stakeholders on the subject of innovative bioenergy products certification initiatives. The survey was targeted at forestry and wood processing enterprises producing pellets, briquettes, or charcoal. It aimed to understand the attitude of managers responsible for certification, together with other aspects of certification for wood biofuels. The hypothesis of the study was that bioenergy certification would facilitate the emergence of a market for certified bioenergy products based on an emerging network of enterprises and consumers, which can be understood as a form of social innovation.

3. Results

3.1. Ukraine's forest bioenergy potential

Solid biofuels such as firewood, wood chips, biomass pellets and briquettes occupy the biggest part of biofuel market. The total production of pellets in Ukraine in 2015 was about 1.32 Mt. produced by 494 plants, including up to 390 kt of wood pellets (Geletukha et al., 2018). In January 2019, Ukraine exported 126.4 thousand tons (including 80.4 thousand tons to Europe) of wood fuel in the form of logs, brushwood, branches, knots, wood chips; sawdust, wood chips, shavings, and waste wood and scrap, briquettes, granules, etc. worth 114.9 million USD (State Statistic Committee of Ukraine, 2019).

Across the Ukrainian Carpathians, the available fuel wood resources are often not sufficient to meet the energy demands of rural households. As many villages do not have natural gas supply, households fully rely on fuel wood for heating. Even if they have a grid connection, poor households may simply not be able to afford to switch to gas. As a result, fuel wood remains essential in remote rural mountain areas, as is the case in Transcarpathia, where firewood is the major fuel for heating and cooking in rural and remote forested areas (Melnykovych et al., 2018). Private users have legal and free access only to thin branches of less than 3 cm diameter. Bigger logs can be purchased from local forestry enterprises or wood processing enterprises. In practice, fuel wood is cut illegally (Melnykovych and Soloviy, 2014) therefore remaining unreported. Increased wood prices make households look for cheaper alternatives such as wood chips or lumber waste supplied by numerous wood processing enterprises in the region. This situation has led to increased competition between industry and households for wood biomass.

Unlike in other countries, wood is still a major source of bioenergy

Table 1
Estimated technical sustainable energy potential of woody biomass (in t oil equ.) in the Ukrainian Carpathians for 2013 (based on S2Biom Report, 2016).

	Harvesting residuals		Wood-processing residuals		Firewood		Woody biomass. Total	
	t oil equ.	%	t oil equ.	%	t oil equ.	%	t oil equ.	%
Transcarpathia	17.9	7%	6	3%	68.7	8%	92.6	7%
Ivano-Frankivsk	16.7	6%	28.9	14%	37.2	4%	82.8	6%
Lviv	19.1	7%	16.5	8%	67.5	8%	103	7%
Chernivtsi	14.3	5%	4.7	2%	58.1	6%	77	6%
Ukrainian Carpathians, total	68	25%	56.1	27%	231.5	26%	355.4	26%
Ukraine, total	271	100%	209	100%	898	100%	1378	100%

in the Ukrainian Carpathians (FORZA, 2017). With 355 t oil equivalent, the estimated potential in the Ukrainian Carpathians is about one fourth of the total country. In fact, all four mountain regions produce considerable amounts of wood processing residuals (Table 1).

State forest enterprises supply timber, but no harvesting residues or wood chips due to the lack of wood chippers. Forest legislation neither regulates the use of harvesting residues for energy production nor provides appropriate access to private enterprises to make use of wood residues. In any case, collecting and transporting harvesting residues is not profitable for state forest enterprises. As a result, wood chips are mostly supplied to consumers by private entrepreneurs.

Geletukha et al. (2018) estimated that the current volume of solid biofuel production (wood pulp) amounts to only 17% of the technically achievable potential of 30 Mio. t/year, providing an immense potential for improvement. Apart from the advantages in terms of the energy it would provide, a more efficient utilization of wood residues throughout the processing chain could generate additional revenues for forestry companies, while reducing their environmental impact and generating new opportunities for forest-dependent communities. To optimize forest-based processing facilities, a whole set of conditions had to be met, related to biomass procurement, logistics, technologies, and sustainability (Camberoa and Sowlatib, 2016). In order to address current and future trade-offs and to tap the full potential of synergies related to other forest ecosystem services, it is important that forest management and related policies take into account possible impacts of energy wood production and trade (Peters et al., 2015).

Wood and wood residues (80%, Table 2) currently represent the biggest share of annual bioenergy consumption in Ukraine, although the area of forest cover in Ukraine is relatively small (17%). The estimated annual volumes of wood wastes for further processing into biomass include 1.4 Mio. m^3 of felling residues, 1.1 Mio. m^3 of wood processing waste, and 3.8 Mio. m^3 of firewood (Geletukha, 2006; Geletukha and Zeleznaya, 2012).

The forest biomass potential is obviously concentrated in highly forested regions: about 35% of all forest biomass for energy purposes is concentrated in Polissia (plain forest zone, north west Ukraine), 30% in the Carpathians and in the forest-steppe zone, and 5% in the steppe zone of Ukraine (Lakyda et al., 2011). From an economic point of view, most of the favourable energy biomass resources are concentrated in the Carpathian region (Lopatin et al., 2011).

A recent project study (Vorobei and Hudz, 2017) identified the following barriers hampering the development of a forest bioenergy market in Ukraine (sorted in order of importance):

a. Lacking motivation of state forest enterprises;
b. Low density of forest roads;
c. The lack of specialized equipment, which means that harvesting of secondary raw materials for energy purposes must take place on the road; and
d. Low biomass market prices leading to low profitability.

Geletukha et al. (2018) added other obstacles, such as:

e. Complicated processes to provide private companies access to logging residues (e.g. for energy use);
f. Absence of record keeping for the logging residues; and
g. Absence of plans for the permanent use of forest for solid wood fuel harvesting under national strategic plans.

Provided that these barriers can be overcome, forest biofuel could significantly contribute to the energy transition, especially in the highly forested Carpathian regions (Lakyda et al., 2011). The better use of wood fuel could benefit both the local economy and the socio-ecological system as a whole.

Furthermore, according to the latest report by the European Court of Auditors, the links between the production and use of renewable (wood) energy and rural local development across Europe should be reinforced (ECA, 2018). REs projects could benefit local communities, linking REs and local development policies and tools. Although large energy companies still dominate the generation and supply of energy across Europe, recent years have seen a notable increase in locally-driven energy initiatives, so-called community energy (Hewitt et al., 2019), in which communities of various kinds are becoming increasingly involved in the generation, supply and management of sustainable energy (Oteman et al., 2014).

Table 2
Biomass and biofuel utilization for energy production in Ukraine. Source: Lakyda et al., 2011

Type of biomass/biofuel	Annual consumption (kt oil equ.)	Current usage of economic potential, %
Straw from grain and rapeseed	43	1
Biomass from wood	**1296**	**80**
Sunflower husk	343	42
Bioethanol	53.6	70
Biodiesel	0	0

3.2. Best practice contest for wood fuel usage in the Ukrainian Carpathians

The 14 proposals submitted to the Best Practice Contest represented six businesses, five communities, and three households in the Lviv and Transcarpathia regions. Five proposals dealt with energy plantations, seven with heat production and two with the improvement of co-operation opportunities related to REs. Most proposals addressed the improvement of continuous biomass supply (e.g. mobilization of woody biomass, substitution of woody biomass with agricultural biomass) or technical aspects (e.g. conversation of gas to solid biomass boilers, insulation, or energy efficiency measures). Innovation in this context is understood as technical modernization and change in response to local priorities. Table 3 shows the five best-practice cases from the contest that rated highest in terms of applicability and potential for replication.

The Best Practice Contest was meant to identify, support and disseminate ideas, practices and innovations in the field of energy wood. It facilitated the dialogue among participants, e.g. during the public award ceremony and site visits, thereby encouraging them to reassess

Table 3
Best-practice cases awarded in the frame of the Best Practice Contest in 2018.

Name of practice	Description	Project Initiator	Innovative aspects
Biomass boiler installation	Installation of a 100 kW biomass heating system replacing the old gas heating system	School No 9, Boryslav	The school organized its own sourcing of fuel. Procurement contracts are negotiated with the Drohobych state forest enterprise, the city forestry or local sawmills.
Growing willow for energy in private garden	Willow biomass production for domestic (private) heat supply. 10,000 *Salix viminalis* saplings planted on private 0.5 ha plot	Private household in town of Zhydachiv	Use of the fast-growing energy plants for private household heat supply to reduce energy costs.
District heating with woody biomass	The town shifts from gas to woody biomass. Four gas boilers were reequipped with solid fuel combustion appliances. Heat networks were newly insulated.	Zhovkva town council & Zhovkvateploenergo communal company	The city conducted a"biomass logistic study" in 2017 to optimize local woody biomass supply and consumption. This approach has a high potential to influence regional policy.
Energy saving technologies and efficiency measures in kindergarten	With public and international funding, the heating system of the kindergarten was replaced and combined with a modular boiler-house.	Velykyy Bereznyy town council	The kindergarten can now use both firewood and pellets, making fuel supply more flexible and cost effective. The town plans own pellet production for self-supply.
Full utilization of sawmill and wood processing residues by wood processing company	The company is located in a region that is not connected to the gas grid. A joint effort of local authorities and the wood-based industry aims at a reliable and affordable energy supply.	VGSM Ltd. based in Velykyy Bychkiv, Rakhiv district	Small sawmills in the area annually generate 30′000 m^3 of sawdust that is only partially burned or recycled, the rest is dumped. VGSM wants to establish a collection and cleaning system to use sawdust either for heating or briquettes production.

their ideas and to make use of cooperation opportunities or innovative business models.

The best practices identified all show potential for extension to other rural or urban communities in the Ukrainian Carpathians facing similar challenges (e.g. inhabitants, foresters, entrepreneurs, mayors, and teachers). Making the ideas available online can encourage others to take steps to improve their energy situation with similar small-scale initiatives or through cooperation.

3.3. Bioenergy certification for forestry-related businesses

FSC-certified forests in Ukraine cover 4,28 Mio. ha or 41% of the forest area of the country. The FSC certification bodies has issued 108 Forest Management/Chain of Custody (FM/CoC) certificates to the forest management enterprises and 256 chain of custody (CoC) certificates to the wood processing organizations and traders (FSC, 2019). The Bioenergy Association of Ukraine (UABio) appealed to the National FSC office about the negative environmental impact of burning harvesting residues directly at logging plots instead of using them for bioenergy production. Also UABio proposed to introduce a criterion (indicator) into the FSC certification forest management standard in Ukraine that should take into account the share of logging residues use as secondary raw materials (UABio, 2018). In the meantime, interest in other certification schemes focused on different aspects or sustainability of biomass production for energy purpose is increasing.

The semi-structured interviews showed that fuel wood certification schemes could potentially be implemented in the Ukrainian context. However, it is unclear how customers would perceive such certification schemes, as they entail higher fuel wood prices. In line with our original hypothesis, 75% of the respondents (n = 61) felt that the implementation of fuel wood certification schemes would lead to the development of new markets. 88% of the respondents were convinced that certification schemes would yield benefits from the bioenergy products. 41% stated that certification would help to enter international markets and could consolidate their positions there, while 14 (23%) believed that certification would enhance their company's image and build the trust of customers (15 respondents; 24%) (Fig. 2a). Interestingly, only 22 (36%) were aware of bio-energy certification schemes such as DINplus, SBP, REDcert, which are currently entering the wood products certification market in Ukraine.

27% of the interviewees identified the lack of motivation from enterprises as the main barriers to bioenergy products certification in Ukraine, 18% judged the high cost of the certification process as an obstacle (Fig. 2b).

The survey results have shown that more than half the respondents (33) view embedding the certification costs in the product production costs as the best option. 40 respondents (66%) agreed that increasing the price of certified products would be acceptable, but differed markedly in the percentage price increase they felt to be appropriate (not greater than 10%, 11 (18%); up to 20% - 15 (25%); up to 40% - 12 (20%); up to 50% - 2 (3%). Some interviewees believed that the price increase should be minimal or absent to keep competitive affordable prices.

Interviews show that stakeholders view certification of wood fuel in Ukraine as appropriate and feasible, as it generates opportunities in terms of market development for wood fuel, CO_2 reduction, and enhanced energy independence. The certification would increase consumer confidence, guarantee product quality and stimulate environmental protection. Moving in this direction is, however, hampered by the fact that producers, enterprises and consumers lack knowledge about certification schemes. So far, most enterprises sell products in markets where certification is not a main criterion for choosing a certain product. Some wood fuel businesses in Ukraine, however, already serve export markets with certified products. From the available certification instruments, the FSC scheme attracted most attention. Certified businesses are found likely to access new markets and customers (Fig. 3a).

On the demand side, most respondents believe that certification schemes serve as a quality label for customers (Fig. 3b). Half the interviewees believe that such certification would benefit communities though environmental protection. Other advantages are the product quality guarantee, the legality of the origin of wood and better image of the enterprise (Fig. 3c).

Bioenergy certification schemes do not cover all sustainability concerns, but may help to improve decision-making by providing more sophisticated analyses.

4. Discussion

Various factors have led to a delay in Ukraine's energy transition process. The high degree of uncertainty in the legal and regulatory environment is one crucial factor; others include lack of regulatory and procedural transparency regarding land acquisition, planning approval, grid connection, and off-take agreements. Moreover, commercial

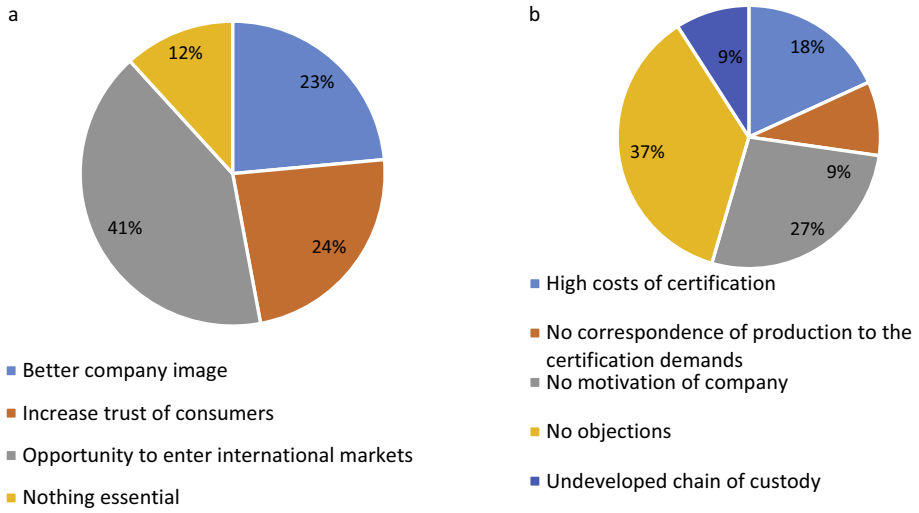

Fig. 2. a. Expected benefits arising from bioenergy product certification in the Ukrainian Carpathians (n = 61). b. Expected barriers for bioenergy products certification in the Ukrainian Carpathians (n = 61).

funding for renewable energy (REs) projects is limited and domestic financial institutions are not trained to assess these projects and their related risks. On the other hand, domestic project developers are not experienced in the field of REs. All these factors hamper the development of strong project proposals and lead to a distorted view of the viability of REs investments (Buchan and Keay, 2016). Potential negative environmental impacts arising, should forest bioenergy be developed without sustainable management regimes, include reduced soil fertility and soil erosion. Also, over-intensive clearing of forest felling areas for biomass collection can lead to carbon release and biodiversity losses.

However, these difficulties are not unique to Ukraine but represent a challenge for many economies. The fact that Ukraine officially joined the International Renewable Energy Agency (IRENA) in February 2018 will stimulate learning from international experiences in energy transition. It is clear that the energy transition in Ukraine will require profound structural changes in its administration, as well as transformations at local and regional levels. A particular threat may be the overexploitation of resources by local communities and forest-related businesses once resources become accessible and profitable. A study commissioned by Earthsight showed how indiscriminate and illegal sanitary felling in protected forests had been occurring all over Ukraine. Illegal sanitary harvesting was discovered in fifteen National Parks, including the Carpathian Biosphere Reserve (Earthsight, 2018). The promotion of certification schemes for energy wood would no doubt be an appropriate measure, yet should not be mistaken as a panacea, as it

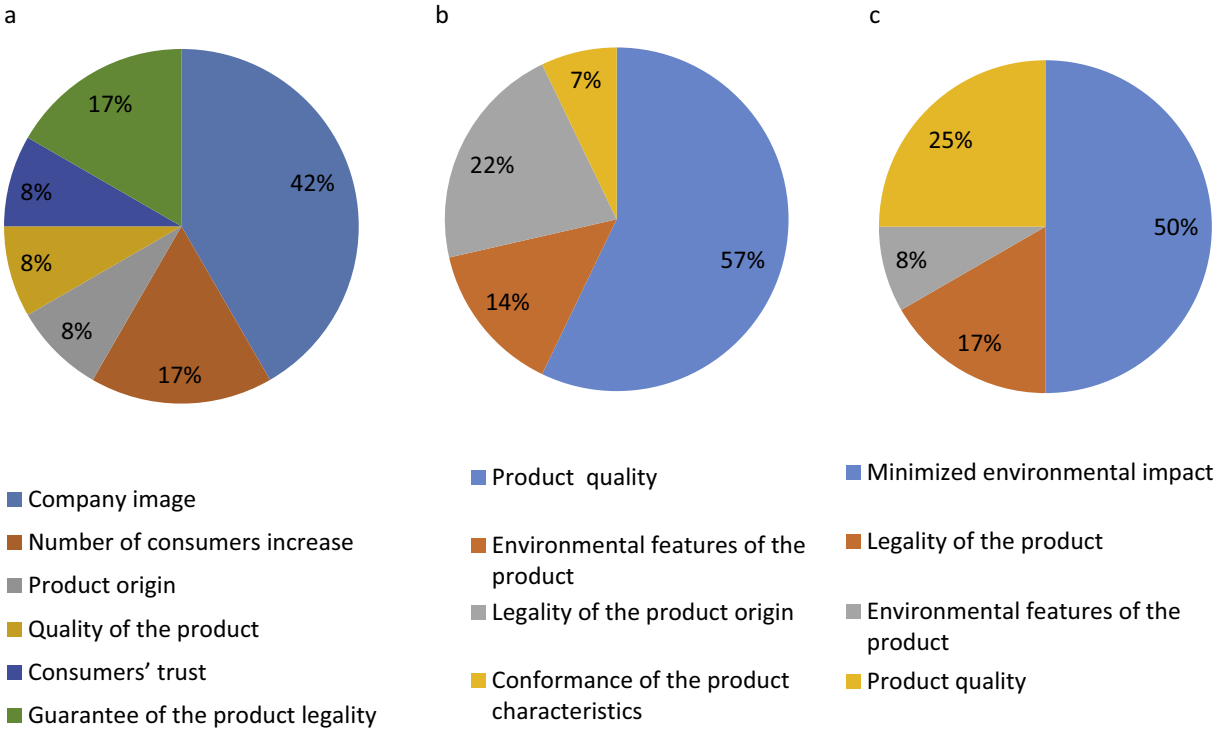

Fig. 3. a. Companies' expected benefits from bioenergy product certification (wood fuel). b. Consumers' expected benefits from bioenergy product certification (wood fuel). c. Society's expected benefits from bioenergy product certification (wood fuel).

again bears the risk of misuse. Last but not least, sensitive engagement with local communities is required to prevent conflicts over the use and sovereignty of forest resources.

4.1. Stakeholders' attitudes towards green energy projects

Community initiatives for REs are emerging across Europe (Hewitt et al., 2019). They vary in size, success rates and in their strategies. Decentralization appears to be one of the most important characteristics of the general institutional development and generally increases the institutional space for local players (Oteman et al., 2014). This can also be observed in Ukraine with a growing number of initiatives led by communities, civil societies and NGOs, or those promoted at different levels of the government (Buchan and Keay, 2016).

Despite the positive spirit of change, literature review reveals that systemic problems hamper the rapid development and diffusion of REs technologies. For instance, a study by Negro et al. (2012), shows that a lack of stable institutions that promote REs, and a poor alignment of these institutions with other sectors and regional/local institutions are key systemic problems; this is also true in the specific case of Ukraine. Therefore, additional attention is needed from policy makers and other system actors that have an interest in accelerating the diffusion of renewable energy. It remains unclear whether the expansion of bioenergy, in particular fuel wood, will be accepted by the wider public and environmentalists, although the promotion of REs is generally supported by many Ukrainians. However, community participation in REs schemes, especially where communities directly share in the benefits, has been shown to improve their acceptance (Rogers et al., 2008; Warren and McFadyen, 2010). So, it may be that community-led schemes like the ones highlighted in this paper (Table 3), may not face the same kind of opposition.

Finally, if the supply of harvesting residues to private companies were profitable for state forest enterprises, or if private enterprises were given access to forests to collect them themselves, the amount of wood used for energy would increase without necessarily compromising landscape or forest ecology. To initiate such a process and to foster the development of a bioenergy market, political attention should be given to implementation of energy strategies (Balitskiy et al., 2014; Baublys et al., 2014; Painuly, 2001; Kharlamova et al., 2016).

4.2. Green energy for sustainable development in forest-dependent areas

To maximise the economic benefits of REs in forest-dependent areas, rural development policies need to align with local conditions and opportunities while enhancing the competitiveness of rural areas. Key factors for successfully linking REs to rural development and relevant for the Ukrainian Carpathians are:

- Energy strategies embedded in the local economic development strategy so that they reflect local potential and needs.
- Integration of REs within larger supply chains in rural economies, such as agriculture, forestry, traditional manufacturing and green tourism.
- Subsidies limited in both scope and duration.
- Use of REs resources appropriate for the specific areas.
- Focus on relatively mature technologies such as heat from biomass.
- Establishment of integrated energy systems based on small grids able to support manufacturing activities. This includes the recognition that REs compete with other sectors for inputs.
- Assessment of potential projects using investment criteria (vs. short-term subsidies).
- Ensuring social acceptance by sharing benefits with local communities and engaging them in the process (OECD, 2012).

Forests are not just providers of primary resources, but supply a number of other essential ecosystem services, and increasing the timber and fuel wood harvest would require adaptations in forest management. Fostering bioenergy should not need exemption from current requirements for forests to be sustainably managed for multiple goods and services. Woody biomass energy potential must be assessed on Sustainable Forest Management principles, which can be subdivided into: theoretically possible, technically accessible, environmentally safe, economically profitable, and socially conditioned factors (Vasylyshyn, 2017).

In general, increasing bioenergy production and use in Ukraine brings both important opportunities, as well as significant threats that must be carefully balanced in an integrated and systematic manner while considering trade-offs with ecosystem services (e.g., carbon sequestration or biodiversity). Key advantages and disadvantages are considered below.

The following opportunities can be envisaged from increased use of forest bioenergy: 1) it is a locally widely available natural and renewable resource; 2) It offers a sustainable way of recycling forestry residues; 3) it directly replaces fossil fuels as an energy source and thus can reduce carbon emissions; 4) it provides an additional source of income for local people and industries; 5) it increases Ukraine's energy independence and energy security; 6) It is a storable energy source with multiple uses for heat, gas and electricity; 7) forest biomass can provide ecosystem services (e.g. carbon sequestration and biodiversity).

The following threats can be identified from increased use of forest bioenergy: 1) extensive forest biomass use could lead to forest over-exploitation,if not properly regulated, especially if energy prices rise -; 2) it requires adaptation of the forest management system and processes along the wood production chain; 3) it is low carbon, not carbon neutral, due to emissions from transport and processing; 4) if bioenergy from wood becomes a profitable business, big companies, rather than local communities, could benefit in the first instance; 5) it has environmental impacts, in particular if timber is used for fuel. 6) poorly regulated forestry can negatively impact ecosystem services (e.g. carbon sequestration and biodiversity).

Knowledge co-production activities could help to engage stakeholders in the REs sector (Hewitt et al., 2017). Several studies indicate that REs projects can be developed to the advantage of local interests and sustainable rural development, for example, by creating direct jobs (operating and maintaining equipment, for example). Most long-term jobs found all along the supply chain are indirect (construction, manufacturing, or in forestry and agriculture in the case of biomass). Some studies reported innovations (e.g. the development of new products, practices and policies) in rural areas with REs installations (Geletukha, 2006; Björnsen Gurung and Seidl, 2017; FORZA, 2017; Soloviy et al., 2018; Björnsen Gurung et al., 2018; Nijnik et al., 2019). REs projects can generate revenues for farmers or forest owners, but also for land owners or local authorities. It is often stated that communities producing their own energy may become less dependent on the price fluctuations of conventional fuels, which in turn improves living conditions, increases competitiveness, and resolves the problem of energy dependence.

Wood certification schemes could offer another promising entry point for the sustainable use of forest biomass. At global level, several certification schemes developed for a range of products and sectors and for various purposes (e.g. fair-trade, organic agriculture). Forest certification schemes such as the Forest Stewardship Council (FSC) were developed primarily to ensure sustainable forest management (van Dam et al., 2010). In response to the sustainability concerns in biofuel production, several new certification schemes were developed worldwide. The EU has also proposed that Member States should use the same criteria for the use of solid and gaseous biomass for energy production. However, sustainability requirements do not apply for biomass used for the production of bio-based products and bio-chemicals. A number of initiatives have been launched to develop voluntary sustainability standards for the production and conversion of biomass to bioenergy. These certification schemes include limited environmental, economic

and social aspects, while some specific issues are missed, such as indirect effects, food availability and security. The environmental viability of biofuels has been questioned based on concerns over indirect land-use changes that need to be addressed in a certification scheme for bio-based materials in general (Scarlat et al., 2015).

However, the majority of stakeholders engaged in our study supported energy production from forest products both in the Ukrainian Carpathians, and in Ukraine as a whole. As Vorobei and Hudz (2017) have observed, in a study of the status of the bioenergy market in nine western regions of Ukraine, communities play an important role in market development. A range of factors, including decentralization, the increase of financial resources in communities, and the need for energy saving, are likely to stimulate demand for bioenergy solutions at the local level. Further, it is expected that the interest of communities in public-private partnership with energy service companies will increase and that communal enterprises will become more significant players in the market leading to a growing biofuel demand. In particular, private companies with transparent public-private partnership mechanisms will benefit from the emerging market. On the other hand, a lack of expert support in the organization of public-private partnership processes in bioenergy might prove to be a deterrent.

4.3. Innovative initiatives for green energy transition: lessons learnt

Both the Best Practice Contest and the project “Green Energy Options” focus on both rural and urban communities. Our research aimed at system understanding and social relevance, it was action-oriented from the outset of the project, and specifically designed to help trigger local activities to enhance energy provision, energy security and energy efficiency. Including the vision and experience of people for whom forests really matter, i.e. communities in the rural Carpathians, provided a valuable basis for the establishment and re-adjustment of research priorities.

Fuel wood could certainly contribute to the reduction of Ukraine's dependence on fossil fuels and imported energy. Ukraine already has thousands of private REs installations. Entire villages in the Kiyv, Vinnytsia, Kharkiv, Lviv region have become entirely energy self-sufficient, some of them even selling surplus heat or electricity (Melnyk, 2017). However, these initiatives are scattered and not systematically promoted. According to a comparative analysis on energy cooperatives in Eastern Europe (Eichermüller et al., 2017), civil society in the Ukraine has been a strong actor in the democratic transition and thus, could also play a determinant role in the development of energy cooperatives and other community energy initiatives. Currently, rapid change is still hampered by the economic crisis.

Considering the role of certification as a policy instrument, we suggest that biomass energy production would be much more advanced if forest and woodworking enterprises were motivated through bioenergy products certification. This statement is based in outcomes analysis of the successful implementation of FSC forest certification standards in the Ukrainian forest sector during recent years. Ninety percent of the forests under control of the State Agency for Forest Resources in the Ukrainian Carpathians are certified. However, FSC also was criticized by the recent Earthsight Report (2018), on the basis of its inability to ensure legality in Ukraine. Certification is only likely to be successful, if illegal logging and miss-classification of wood can be controlled. To do this, it would be necessary to collect data on suppliers throughout the supply chain, and analyse both the risk of illegality and measures to mitigate against it, e.g. through developing a due diligence system of wood business companies. These initiatives are likely to be beneficial to REs business development, would promote energy independence of Ukraine, and strengthen the bio-economy as a whole.

However, the results of our interviews revealed weaknesses and threats related to the development of such certification schemes. The complexity and cost of the certification procedures are clear obstacles. Also, the fact that the majority of Ukraine's heating systems uses gas instead of wood, makes certification unattractive. An additional important threat relates to the insecurity of green tariffs. In some European countries (e.g. GB, ES, GR) formerly generous feed-in-tariff schemes have been abolished resulting in a decline in newly installed capacity (e.g. Alonso et al., 2016; Karneyeva and Wüstenhagen, 2017). In Ukraine as elsewhere, reliable and predictable public policies and incentives are needed to stimulate the transition to renewable energies. In the case of the Carpathians, specific measures are needed for solid fuel boilers. Getting the policy landscape right could trigger an inflow of funds to promote green energy initiatives, reduce CO_2 emissions, and contribute to local economies.

5. Conclusions

Domestic renewable energy, in particular bioenergy from forests, has a vital role to play in strengthening Ukraine's sovereignty and energy security at the local scale. Steering the green energy transformation process in the Carpathian mountain region requires sound system understanding and a well-designed procedure allowing communities and individuals to shape their energy futures. In the context of the country's post-Soviet history, this process calls for careful planning, long time-frames and a high degree of flexibility, as citizen involvement and other public participation is weak.

Accordingly, to launch successful REs projects at the local scale requires a sound understanding of the larger European and national political frameworks. Indeed, bioenergy has a key role in the European Union (EU) policy and its implementation at national, regional and local levels calls for the inclusion of stakeholders' opinions to increase social acceptance and to reduce conflicts (Nikodinoska et al., 2015). The harmonization of the environmental policy of Ukraine with EU policies in the framework of Ukraine's association membership in the EU, as well as the geopolitical situation defines the interests in advancing green energy development. The institutional efforts towards an integration with Europe's community energy movement are essential to strengthen communities' “green energy” initiatives.

These larger frameworks and policies set the stage for the analysis of local/regional energy systems as a basis for the consecutive design of an economic development strategy, including energy production and consumption. Agreement on a local energy strategy encompassing larger supply chains and linkages to other sectors would be the next logical step, ideally developed through a participatory approach to ensure maximum acceptance. Such analysis includes sound knowledge and information on the required resource base, available potentials and the anticipated impacts of altered management practices and regulatory systems, both in the present and in future.

However, clear opportunities for further research can be identified with respect to the potential opportunities arising from the long-term transformation of energy and the economy at the local level, and the role of education and research institutions in supporting the “green energy transition”.

This research addresses a topic of key relevance to Ukraine's energy transition, the potential for locally led innovation to transform the forest bioenergy sector. Our findings, based on a stakeholder-centred approach, help raise awareness of this topic at local, regional and national scales, thereby increasing knowledge of opportunities and threats for a broad range of policy-makers and other stakeholders. By providing a larger picture of the potential role of fuel wood in the Ukrainian Carpathians from a natural science as well as social science perspective, this research contributes to sound decision-making related to the Ukrainian energy transition. Approaches like the one we have followed in this paper offer good potential to enable communities, local entrepreneurs and policy-makers to include bioenergy, in particular the use of fuel wood, into their local and regional development strategies and portfolios.

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