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Regional impacts of sustainable energy in western Finland

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ABSTRACT

The scope of this research is to make quantitative estimates of the potential economic and employment impacts of renewable energy self-sufficiency. The study aims to make generalizations on a regional, or even national level, and to give directions for future research. This paper analyses direct monetary values and employment impacts in two regions, in a theoretical situation where all energy is produced by renewables from the respective region.

Renewable energy, especially utilization of existing but presently unused resources, can play an important role in vitalizing regional economies, especially in rural areas. The money spent on fossil energy could be kept circulating in the regional economy. The amount spent on energy in the research areas was almost €4860 per capita per year, totalling more than €300 m annually. The existing data shows that there is the potential for self-sufficiency, or even surplus production. The results suggest that the regional economic impacts increase considerably if the region is self-sufficient in raw materials, including intermediates. On a larger scale, e.g., nationally, the loss of jobs in the fossil energy industry and the eventual variations within economies potentially based on renewable energy, will affect the overall impacts.

There is at present insufficient scientific literature, knowledge or quantitative data for analysing these impacts thoroughly. This paper contributes to filling this gap.

1. Introduction

The concept of sustainable energy (SE) directly follows from the concept of sustainable development, which has more than three hundred definitions within the context of environmental management, (e.g., IUCN, 1980; WCED, 1987; Markandya et al., 2002; Johnston et al., 2007; Chichilnisky, 2011; Peura et al., 2014). A plethora of definitions of SE can also be found in the recent literature. Based on a wide review, the SE concept was redefined to include the following (Peura, 2013a; b):

1 **RUE** (rational use of energy, saving, efficiency)
2 **RES** (renewable energy sources)
3 Integration of RUE and RES
4 Sustainability management

There are a number of technologies for **RUE** and **RES** that can be implemented separately or in combination. The **integration** of these is the key for complete solutions. With different combinations of techniques and regional RES, it is possible to create solutions with different degrees of energy self-sufficiency. The use of RES depends on the carrying capacity, and cannot be increased limitlessly. Sustainability management is necessary to avoid adverse impacts and careless use of RES. There is always a danger that SE projects may become a type of ecological colonialism, where a pattern of robbery will take over (Peura, 2013a; b), and principles of maximal economic gain and carelessness regarding the environment will be applied while producing RES in the name of sustainability (Blarke, 2008; Moriarty and Honnery, 2009).

SE has become one of the key concepts in reforming the energy sector in the EU and worldwide. The production of energy has caused major impacts on the environment, leading to the following statements. "*Renewable energy is one of the most efficient ways to achieve sustainable development*" (Goldemberg, 2007). "*One of the main tasks in this century (…) will be to manage a transition process towards a sustainable energy system*" (Haas et al., 2008).

The potential regional economic and employment impacts are among the most powerful drivers for SE. For instance, it is

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repeatedly claimed that RES generates more jobs than conventional energy (Sastresa et al., 2010). The claim that "… *real effects have stayed on a non-measurable level*" (Hoffmann, 2009), has also become a widely discussed issue, with estimates having a "… *high level of dispersion in the ratios and the order of magnitude*" (Sastresa et al., 2010).

We know that the business case for RES, including investments (Peura and Hyttinen, 2011; Masini and Menichetti, 2012) and benefits beyond business profitability, can be significant. The **regional value added** (monetary aspects, reduction of costs, increase of purchasing power, creation of jobs, tax income, social, ecological and ethical aspects and improved vitality) would be remarkable if all the money which currently flows out remained within the region (Hillebrand et al., 2006; Lehr et al., 2008; Moreno and López, 2008; Thornley et al., 2008; Blanco and Rodrigues, 2009; Hoffmann, 2009; del Río and Burguillo, 2009; Openshaw, 2010; Sastresa et al., 2010; Dalton and Lewis, 2011; Masini and Menichetti, 2012).

However, the scientific literature on the socio-economic impacts of SE mainly concentrates on costs and employment, for instance methods for analysing employment within some branches or for separate technologies (and in some cases their value chains), and includes jobs created during the construction phase as well as the operation and maintenance of the studied production plants (for reviews, see Ortega et al., 2015; Connolly et al., 2016; Többen, 2017) or in low-carbon technologies, including RES (Markandya et al., 2017).

These are mainly ex ante assessments of potential impacts, based to different extents on existing data and scenarios for future systems. Often, the results are confusingly contradictory, depending on the settings, approach, scale and regional content of each study. For instance, the job creation impact in the operation and management phase has been proven, while the impact in the construction phase has not been as large as predicted in Italy (Cai et al., 2017). Another study showed that renewable energy generation has a positive impact on economic growth at the regional level in Italy (Magnani and Vaona, 2013).

The methodology has not been established, and there are very few analyses that cover potential regional economic impacts of RES self-sufficiency. It is rather simple to "count euros" for certain power plants or a combination of plants, but there is clearly a gap in estimating economic impacts for a whole region and its economy, and for different branches in a 100% RES regional system.

The physical prerequisites for SE exist. "*There is a consensus that the energy system will need to change, but … a lot of uncertainty* …" of "… *how*" (Connolly et al., 2016). A shift towards SE and away from fossil fuels will presumably be on the global agenda in the near future. However, there are institutional and other barriers slowing the process (Peura, 2013a; b). The barriers are non-technical challenges, rather than technical issues (McCormick and Kåberger, 2007). Therefore, all analyses are based on different potential future scenarios of, e.g., 100% renewable energy systems. It is crucial that the main principles of SE are followed, and especially that the solution is sustainable.

The scope of this research was to estimate the potential economic and employment impacts of the renewable energy self-sufficiency that could be put into practice in the target areas. The paper aims to make generalizations on a regional level, with the potential for also applying the approach nationally and internationally. It also aims to give directions for future research.

Improved knowledge and understanding concerning the potential regional economic and employment impacts of sustainable energy is important because:

- These impacts are among the main drivers for implementing sustainable energy (SE),
- The scientific literature on them is sparse, and a research methodology has not been established,
- Sustainable energy has become one of the main topics in the ongoing transition of the whole energy sector.

The paper has been organised as follows: Section 2 highlights the research design and study area, Section 3 presents the methodology and Section 4 collates the results. A discussion is presented in Section 5, and conclusions are given in Section 6.

2. Research design and study areas

2.1. Research design

The scope of the research was to make quantitative estimates of the potential economic and employment impacts of energy self-sufficiency (100% RES production, all sources from within the region, some comparisons with 125% and 150% self-sufficiency) at three regional levels, as follows.

- Villages: the small areas in the Energy Village project.
- Municipalities: where the Energy Villages are located.
- Regions: the areas surrounding two Energy Villages (Jepua and Perho).

All initial data about energy balances were gathered from the Energy Villages and their municipalities and regions, including official figures for electricity consumption, calculated heat demand and transport fuel, accompanied by the calculated bioenergy potentials and projected wind energy potentials.

The main potential solutions in these areas have been the production of biogas, the use of CHP (combined heat and power generation) via combustion of mainly wood material, and wind power. In Jepua village, there is already a biogas plant in operation, and there is considerable experience in the combustion of wood (logs, chips and pellets) in Finland. There are also a number of wind farms at the planning stage and undergoing permit procedures, in the research areas. These three technical solutions were selected, firstly, to avoid an overcomplicated cloud of parameters in the calculation, and secondly, because they are the potential solutions most likely to be implemented in the very near future.

The regional economic and employment impacts were estimated in two ways.

1. In the villages, municipalities and regions, the impacts were calculated for an imaginary technical (biogas, CHP, wind) composition of 100% RES production, based on the initial data from separate supply chains for biogas, CHP and wind power production. Wind energy was taken into account whenever there was insufficient bioenergy potential for producing 100% RES self-sufficiency.

2. The regions were modelled using the RegFin regional economic model with the initial data from Jepua and Perho Energy Villages based on 100%, 125% and 150% RES production, where 125% and 150% signify the ability to sell energy outward from the village. The same value chain data as above were used here.

2.2. Study areas

The research areas were selected from the Energy Village project. The main criteria for selection were the availability and quality of the initial data and the suitability of the villages and regions for the RegFin research model. The study areas are shown in Fig. 1 and the main regional characteristics have been collated in Tables 1 and 2.