Periodica Polytechnica Social and Management Sciences

24(1), pp. 52-59, 2016
DOI: 10.3311/PPso.8336

Evaluation and Practice of Interactive Value Production in Living Labs

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RESEARCH ARTICLE

Received 06 May 2015; accepted 22 June 2015

Abstract

Interactive value production with different sorts of end-users takes place already in several industries in the form of Living Labs (LLs). This article summarizes the results of two researches. Firstly, targeting the analysis of working LLs in the EU, in order to describe the working method of LL organizations. Based on the results, the existing methodology for the evaluation of LLs is improved. Secondly, there is a comparative research made on the attitude and present practice of interactive value production, targeting the renewable energy industry in Styria (Austria) and Hungary. Based on the results of the qualitative researches, the obstacles and recommendations of creating LLs in Hungary are summarized.

Keywords

Living Lab, open innovation, user-involvement, renewable energy, interactive value production

1 Introduction

Innovation practices show that end-users have increased self-consciousness and their knowledge can be used effectively and efficiently with significant added value for a company. As the European Commission emphasizes: „LLs are open innovation environments in real-life settings in which user-driven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures." (EC Infso 2009, 5). LL method is such a co-creation approach. It is a special sort of open innovation. The innovation concept called LL is about a user-centric innovation environment where, in their practice, the company or collaborating companies actively involve end-users into their innovation activity even at the early stage of the development process.

The aim of the research introduced in this paper is to highlight the added value of interactive value production through LLs in the renewable energy industry. Additionally, determine, if the utilization of LLs might increase the renewable energy usage in Hungary. The second aim is to determine the possible obstacles in Hungary to spread innovation through LLs.

The research consists of two phases: In the first phase there is a research made on the members of the European Network of Living Labs (ENoLL) to have a clear picture about the working mechanisms and results of already existing LLs. The research is based on the Harmonization Cube Methodology (Murder et al, 2008), which aims the evaluation and comparison of LLs. After the evaluation of questionnaires, this methodology is supplemented in order to provide a more concise way of evaluation and comparison of LLs.

The second phase of the research is a qualitative comparative analysis for the evaluation of the attitude and present practice of interactive value production. The comparative analysis targets the institutes dealing with renewable energy in Styria (Austria) and Hungary as well.

Based on the evaluation of questionnaires and deep interviews, the possibilities to foster the creation and sustainability of the successful operation of LLs in Hungary is summarized.

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2 The Existing Evaluation Method of LLs

In the following paragraph the methods for evaluation and comparison of LLs are introduced. For the evaluation and comparison of LLs, there is the LL Harmonization Cube created, in align with the structure of the "Rubik" cube. (Murder et al, 2008) Each side of the cube represents one criteria to be evaluated in align with the maturity of LL organizations. The columns of the cube describes the organizational, contextual and technological issues of a LL. The rows of the cube represents the maturity level of LLs, as: setup, sustainability and scalability. The structure of the cube is illustrated by Fig. 1.

In align with the structure the elements evaluated are described by Fig 2, 3 and 4.

When comparing the working mechanism and maturity of LL-s, each side of the cube is evaluated on a 0-100 scale. The problem with the evaluation, that – according to the present practice – there is no clear criteria or quantitative analysis behind this method. The evaluation of LLs are done by determining a median for an evaluation scale, for example the evaluation of the user involvement side are described by Fig. 5.

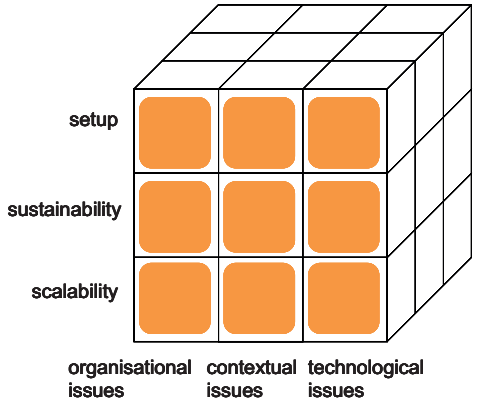

Fig. 1 The Structure of the Harmonization Cube (Murder et al, 2008)

As you can see on the example above the values besides the median can not be determined precisely. Supplementing this method, there was an analysis based on a simple quantitative method created in the frame of the Alcotra project (2013). This is a detailed, well-structured method, appropriate for the evaluation and comparison of LLs, if using it together with

Fig. 2 The Elements of the Harmonization Cube I. (Murder et al, 2008)

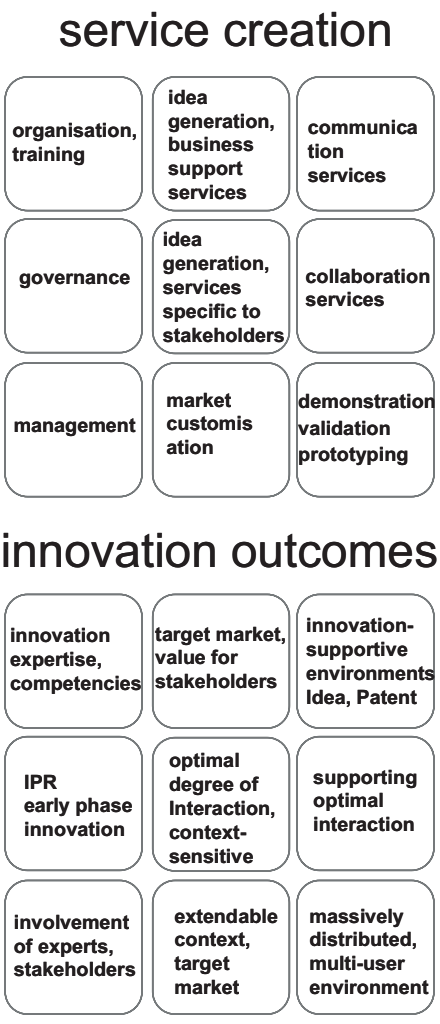

Fig. 3 The Elements of the Harmonization Cube II. (Murder et al, 2008)

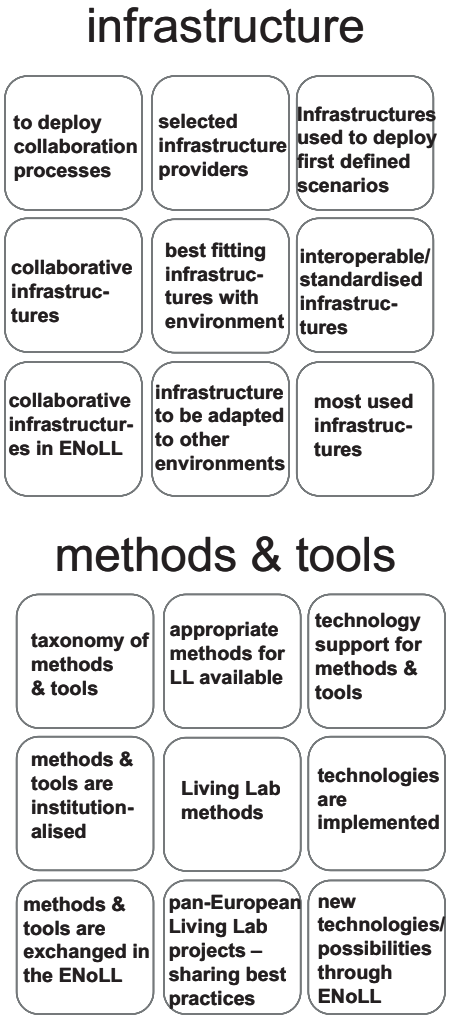

Fig. 4 The Elements of the Harmonization Cube III. (Murder et al, 2008)

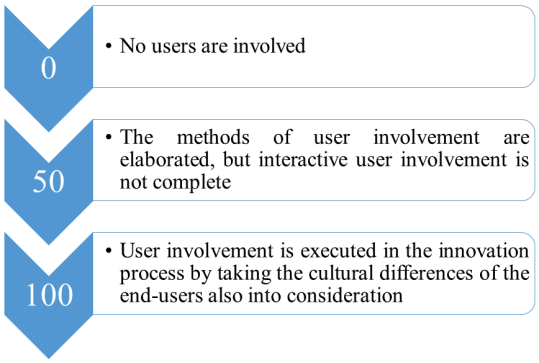

Fig. 5 The Evaluation Criteria at the User-Involement Side of the Harmonization Cube (CoLLabs, 2009)

the Harmonization Cube Methodology. (For the method please check: Alcotra, 2013). The Alcotra method sums the indicators of the following elements of the LLs: Community building and proper functioning, User-driven, open innovation methodology implementation, Pilot outputs and outcomes, Administrative and R&D productivity and the added value of the cross-border aspect.

3 The Research on ENoLL Members

In the previous paragraph the evaluation method of LLs were introduced. The research, conducted in April, 2014 aimed to map the members of ENoLL. The questionnaire contained questions about the user involvement method to highlight and evaluate its added value, and the number of end-users participating in the LL. The other focus of the questionnaire was about the establishment, sustainability and financing of LLs. From the 350 members of ENoLL 52 LL filled in the questionnaire. The research was conducted without industry specification. The main profile of LLs participating in the research: ICT, healthcare, education, telecommunication and renewable energy. Based on the questionnaires, the LLs involved in the research execute their operation with 10 or more members, which can be considered as positive, as the more member participate in the research, the more competences are involved in the collaboration. Most of the LLs involve universities, with a dominating role. The number of end-users involved in LLs is summarized on Table 1.

As for the number of end-users involved in LLs, the picture is quite positive. Every fifth of the LLs involve more than 1500 user into its development process. More than half of the LLs involve more than 150 end-users into the development. The involvement of users targets the user-friendliness, effectiveness, and alignment of the product into the end-user's milieu. According to the research results, more than half of the users participate at the early stage of the development process, in the creation and testing of the first prototype. More than 25% of the respondents participate in the development process during the testing of later prototypes. Less than 10% of the respondents participate in the testing just before entering the market with the product. It is positive, that

Table 1 Number of users involved in LLs

Number of users involved	% of respondents
1-50	17,65%
51-150	19,61%
401-600	31,37%
801-1000	5,88%
>1500	25,49%
	100,00%

more than half of the respondents produce value since the early stage of the development process. The involvement of users into the development process is realized by the rest of the respondents only in later stages. Therefore the practice of LLs shows, that in some cases the working of LLs do not align with the theory, while some LLs works with success. Evaluating the theory and the practice, there is a contradiction. In practice, there is an ambitious, spreading form of collaboration, if we accept the testing of later prototypes with the involvement of end-users, as LLs. But if we do not accept the extension of the LL definition, the spread of LLs is weak. In the majority of LLs involved in the research, user-driven innovation is not fully integrated in the creation of products and services yet. Disregarding the theory, the involvement of end-users into the development process enhance social innovation and the marketability of products.

The research focused also on the motivation and financial background of LLs. The majority of the respondents used EU or governmental support in order to establish and sustain their organization.

The differences among LLs with different industry specification showed, that the comparison and evaluation of LLs is not possible when the LL Harmonization Cube or the Alcotra methodology are the only evaluation methods. There is therefore a need to extend the already existing evaluation methods, which takes the industry specifications into consideration. The main reason for the need of the industry specific evaluation: there is a difference in the number of end-users, organizations and profiles involved in LLs in each industry. For example in software development it is normal to involve more than 1000 users in telecommunication or ICT. While the development of healthcare products is executed with less than 500 end-users. Therefore, when comparing and evaluating LLs, we can not have a realistic result by comparing the number of end-users or organizations involved. There is an additional method needed to take industry specific analysis into account.

4 Supplementary Method on the Evaluation and Comparison of LLs

In the previous paragraphs general statistics were introduced about the real working of ENoLL members. We had the result, that the evaluation and comparison of LLs need a

supplementary method. The aim with this is to have a picture about the LL "way of working". The "Alcotra" methodology (and also the Harmonization Cube) are well-developed and structured models for evaluation. By using them we can summarize the quantitative features of the LLs. The Harmonization cube methodology is also a detailed model, but the categorization should be based on a more reliable method, which is introduced in this paper.

The first step of the evaluation method is a scoring system based on the main elements of the Harmonization Cube. The LL get 1, as a score, if the first steps (Setup) are in process, taking into account the Organizational, Contextual or Technological issues. The LL, which is over the Setup phase can get a 2 score (Sustainability) and also the score 1. While the well-developed, and working LL will get the score 3, (and also the score 1 and 2). Of course each stage can be evaluated in align with the Organizational, Contextual and Technological issues. Therefore one side of the Harmonization Cube can be evaluated as Table 2 shows.

Table 2 Example for the scoring of a developed LL – one side of the cube

	Organizational	Contextual	Technological	**SUM**
Setup	1	1	1	**3**
Sustainability	2	2	2	**6**
Scalability	3	3	3	**9**
SUM	**6**	**6**	**6**	**18**

Therefore, the maximum score for one side of the cube is 18. The elements of one side of the LL can be evaluated as per the columns, taking into consideration the organizational, contextual and technological aspects. After scoring each side of the cube the total scores can be determined as per the columns and the rows illustrated by Table 3.

Table 3 Calculation of the total scores of the Harmonization Cube

	Per sides	Total score in the cube	Phases
Setup	3 (3x1)	18 (6x3)	LL in early stage
Sustainability	6 (3x2)	36 (6x6)	LL in developing stage
Scalability	9 (3x3)	54 (6x9)	LL in matured phase
Total	**18**	**108**	

When evaluating LLs, we can consider 108 as the maximum score, which is a score of a totally developed LL. According to the development stages we can fix the 18, 36 and 54 scores, as table 3 shows.

Besides evaluating the development stages of LLs, we can also evaluate the elements of these scores as per the columns of the Harmonization Cube. Therefore we can evaluate which area, elements (Organizational, Contextual or Technological) of the cube needs further development.

As an example, let's analyse one of the most relevant side of the Harmonization cube on Table 4.

Table 4 Example for the scoring of the user involvement side of the Harmonization Cube

	Organizational	Contextual	Technological	**SUM**
Setup	0	1	1	**2**
Sustainability	0	2	2	**4**
Scalability	0	0	3	**3**
SUM	**0**	**3**	**6**	**9**

In order to analyse the scorings above, please check Fig. 2, the elements of the user involvement side. Then, to summarize the user-involvement side of the LL: The highest score of the LL is on the technological element (score: 6). It means, that the LL already created its infrastructural background, which is appropriate for automatic data collection. Meanwhile identified the user groups involved in the data collection. The main features of these groups with the appropriate monitoring and data collection methods are determined. The only element missing to have the highest score on contextual issues is to take the cultural differences into account when organizing the user groups. The organizational element of the cube (score: 0) shows, that there is no user involvement realized in practice, and it is not in process yet. It means, that the LL have just built up the main conditions (infrastructure and the identified user groups) to start the motivation of end-users. This scoring system is typical for a LL in its early stage, when the motivation and involvement of users did not start yet.

If we consider the total cube, we can evaluate the organizational, contextual or technological elements together. Then, the maximum score per sides are 6 each (summing the 1, 2 and 3 scores of LL maturity). It means as total, 36 scores per each aspects, as organizational contextual and technological. This score 36 can be also further analysed, as each side of the cube (user involvement, service creation, infrastructure, governance, innovation outcomes, methods & tools) represents the elements of the cube.

Analyse one cube as an example, described on Table 5.

Table 5 The scores of the Harmonization Cube per sides

	Organizational	Contextual	Technological	**SUM**
User involvement	0	3	6	**9**
Service creation	1	1	1	**3**
Infrastructure	1	3	3	**7**
Governance	3	3	3	**9**
Innovation outcomes	1	0	1	**2**
Methods & Tools	1	1	3	**5**
SUM	**7**	**11**	**17**	**35**

It is evident, that the maximum score in a cell above is 6. (Details are in Table 2). Then evaluating a LL with the scorings of Table 5: The user involvement side of the LL is the same as in Table 4. This LL is in early stage, users are not involved yet. Therefore the scores of the service creation and the innovation outcomes and methods & tools elements are the lowest. Then the infrastructure, governance and user involvement sides got the highest scores. It is interesting, as there is no user involvement in the LL, but the users groups are identified, all the methods to analyse user feedbacks are created and the infrastructure is implemented. In the cell of infrastructure/technology, the LL has the score of 3, instead of 6. It means, that the infrastructure is created, but as user involvement is not realized yet, it is not properly tested and used. Therefore it can not be considered as adaptive by other LLs (For detailed explanation please see Fig 3, the infrastructure side. As a result, we can have a total score of 35/108, which is the category of "LL in early stage" (Table 3).

When doing this detailed analysis as per the sides of the Harmonization Cube, it is evident, that the maturity of LLs is also analysed. This scoring system provides us several further possibilities for quantitative analysis. Therefore by complementing the already used methods with this analysis we can have a final score to evaluate the maturity status of LLs and we can compare the development status of LLs working in different industries. We can analyse the elements of LLs, as well as using it together with the Alcotra method, we will have a total, objective picture about the LL, which makes it comparable.

5 Research Method on the Attitude and Practice of Interactive Value Production

In order to understand, what are the elements to build up a LL, it was necessary to conduct the research targeting the working members of ENoLL. Complementing the method, we can see the main elements of LLs and their links with each other.

The industry specific analysis on interactive value production targets the renewable energy industry. The research aims to determine the role of interactive value production in innovation. It aims to analyse the present role of users in development, as well as the attitude of companies on involving users into the innovation process.

Wüstenhagen et al. (2007) emphasizes, that the innovation of renewable energy technologies requires specific attention because of the social acceptance of these technologies. The even more active role of users is confirmed also by the researchers of IFZ (Ornetzeder, Rohracher, 2006), emphasising the role of „self-building", groups in the Austrian solar technology innovation. They highlight, that the involvement of users supports the creation of products and their introduction to the market. (Ornetzeder, Rohracher, 2006)

Heiskanen and Lovio (2010) made a research on the interaction of users and producers, targeting the development of energy focused projects. They confirmed, that user involvement has added value in the social acceptance of developments. They also emphasized the importance of diversified knowledge in innovation. (Heiskanen, Lovio, 2010)

The significant Austrian research institute, the Centre for Social Innovation conducted a research on open innovation. They had the result, that the products supporting low energy usage can be introduced to the market more successfully if the users are involved in the development process since the early stage. They found it key to consider sociological aspects in innovation. (Centre for Social Innovation, 2008, 3) The research results published so far in the topic confirm, that the role of users are in align with the global tendency.

The research aimed to identify, if the interactive value production is present in Styria, in a well-developed region in terms of renewable energy usage. Most of the LLs are established in the frame of EU or governmental programs. Therefore it is evident to make a research, if the elaboration of LLs may be driven by real economic processes. The research targets the analysis of biomass and solar companies in terms of their attitude and innovation processes. The Styrian region is especially active in the utilization of biomass and solar energy (Schreuer, 2010). The research targeted the members of the cluster Eco World Styria active in the utilization of biomass or solar energy. The research was executed in spring 2012. The number of companies targeted were 59 (cluster members). Finally 30 deep interviews were done in person, lasting an average of 45-60 minutes. The interview guideline was based on the main elements of the Harmonization Cube, but after several probe interviews the guideline was modified. The main elements of the guideline in terms of associations: the activity of the association on fostering open innovation, networking activity, the involvement of end-users into the projects, the role of users and their changes in the innovation processes, the opinion of the interviewee on open innovation and its role in the utilization of renewable energy technologies.

Regarding the companies the following main topics were included in the guideline: the source of knowledge, the development of services, the open innovation activity of companies, the activity of companies to make the technologies accepted by the society, the role of interactive value production in the renewable energy industry. In order to analyse specifically the user involvement aspect of the companies, the activity of users, (suggestions for modification, interaction forms, identification of lead users, the activity of lead users) are analysed. The opinion and attitude of the interviewee on interactive value production was also the focus.

The Austrian research was continued in Hungary in order to highlight on the differences. In general, lack of trust and low innovation activity are the challenges in Hungary. The changes in the role of users and the attitude of economic actors on interactive value production were the target of the research.

The Austrian guideline was not ready to implement to the Hungarian circumstances. The Austrian guideline supposed the presence of more active users, while it was not the case in Hungary. After some probe interviews it was clear, that the companies are sceptic about interactive value production.

6 Results

The interviews were analysed basically with qualitative tools, but the creation and analysis of quantitative data provided support to strengthen and draw conclusions. The use of quantitative methods is only supplementary, it is not the primary source of the results. The quantitative analysis was based on the Cramer – index to analyse the independence of the answers of interviewees and draw conclusions. There was altogether 30 deep interviews prepared, but in the categorization 25 interviews were used, as not all interviews could be done in a structured way.

Each answer were categorized on a scale consisting of 3 elements. Based on the research results, the active role of users were confirmed. It is important to emphasize, that it does not mean, that interactive value production is present in the Styrian region. It means, that the more active role of the users is evolved without EU funding, only based on real economic processes.

Using the Cramer index:

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(f_{ij-f_{ij}^*})^2}{f_{ij}^*}$$

$$C = \frac{x^2}{N \times \min\{(r-1),(c-1)\}}$$

Where if C=0, the two elements are independent from each other, while when C=1 the elements are totally dependent from each other. When evaluating these results, we have to consider, that it does not show any causality.

Companies involving the end-user into the development process appreciate open innovation (Cramer: 0.8). Therefore they find it useful to involve users into the company innovation process.

There was also a close association between the source of external knowledge and the opinion of the interviewee about interactive value production. Therefore the more companies using external knowledge in their innovation processes, the more typical it is to identify lead users and involve into the innovation processes. Meanwhile their opinion about interactive value production is positive.

The development of product-related services and the open innovation activity of companies also have close association (0,7). Therefore, companies active in open innovation develop their product-related services more actively. Therefore the relevance of service innovation besides product innovation assumes high level of open innovation activity.

There is also a close relation between the open innovation activity of companies and the relevancy of interactive value production in the innovation process and the attitude of the interviewee about the importance of open innovation.

Therefore if a company use interactive value production it has a positive attitude about it.

Summing up, based on the interviews analysed, the LL based interactive value production has relevance in the renewable energy industry, regarding the products, technologies targeting the utilization of biomass and solar energy. As for the Austrian analysis, the subject of development is quite widespread, its aim is the optimal and user-friendly creation of the products, as well as its alignment to the already existing energy supply systems. The aim is to create an optimal combination, efficiency and user-friendliness in align with the user preferences.

The interview series was continued in Hungary, but the Austrian interview guideline could not be used. Its reason is, that the activity of users was limited to buying the products of the company. The interviewee were the representatives of companies and associations active in the biomass and solar business. There were altogether 15 organizations involved in the research with conducting deep interviews.

Most of the interviewee considers governmental support, information campaigns and new business models relevant. After the interviews, most of the interviewee finds it realistic, that LL organizations will be created in the biomass and solar industry in Hungary. They think, that their sustainability should be reached by creating real economic processes. But if we rely on the governmental incentives, the more favourable taxation system, legal conditions and the launch of LL trials are considered relevant.

Compared to the Austrian examples none of the associations knew about open innovation and interactive value production. But during the interviews, after introducing the term by the interviewers they saw the added value of interactive value production and open innovation in Hungary.

Comparing the research results there is significant difference in the attitudes of interactive value production and

Table 6 Comparison of the Austrian and Hungarian research results

	Austria (Styria)	Hungary
Tendency on interactive value production	The users are more and more active, they tell their ideas for the manufacturers	The more active role of the users is not relevant
The relationship of the producers and users	The producers intend to involve users into the development process	The companies do not intend to involve users into the development process.
The source of knowledge in the developments	The companies intend to involve external sources of knowledge, especially the knowledge of the users	Companies do not intend to involve external knowledge into the development process
Attitude - interactive value production	Positive attitude, companies see this tendency in the renewable energy industry	Positive attitude, after they knew more about the topic. They think, that the demand for products should be increased first.
Interactions to involve the users into the development process	The use of marketing tools are relevant, but the companies foster other interaction forms to increase interactive value production	The main communication is most of the time just before entering the market with the product
Identification of lead users, their role	Some companies identify lead users and try to involve them in the development process	The companies do not identify lead-users
The relevancy of interactive value production in the innovation process of the company	The companies consider the interactive value production relevant, even if they do not use it	The companies found it relevant, but they do not use it yet

the innovation activity of companies. Most of the institutes involved in the Hungarian research did not hear about open innovation and interactive value production before.

The main reasons for the low attitude on open innovation and interactive value production is the lack of trust and the specifications of the Hungarian renewable energy industry (expensive products, low level of government support). Additionally, in Austria, the "solar self-build" groups were evolving in the 80's. It meant, that the inhabitants in and around Gleisdorf (Styria) started to build solar collectors by themselves, sharing the tools and the knowledge as well. Based on this initiative a company (AEE Intec) was established in order to provide tools for the self-building groups. (Schreuer et al, 2010).

Therefore it is evident, that in Austria the level of trust and motivation of the companies and also users is much more relevant on value creation and open innovation, than in Hungary.

7 Conclusion

The paper introduced the evaluation methodology of LLs, and introduced a complementary method to use it without industry specifications. The paper also introduced the added value of interactive value production in the renewable energy industry. The research was firstly executed in Styria, a well-developed region of Austria, then it was continued in Hungary.

There is a significant difference in the attitude of the companies. The related Hungarian companies are less interested, and not active in interactive value production. Its reason is the different innovation culture, the lack of trust and openness of companies. It is the matter of course, that the government might have role to support the creation and sustainability of LLs, but their role should be limited. Companies have to foster the creation and sustainability of LLs only if they have real economic added value. Therefore the added value of interactive value production can be used and the working model of the LLs can be aligned to the internal processes, aims, products, services of the institutes participating in the LL.

There are possibilities for further research on the effects of education and information campaigns on the attitude and LL practices in Hungary. As well as, regarding the theoretical research, the supplementary method can be used to evaluate the ENoLL members. It requires a deep understanding about the working of LLs. Instead of questionnaires, the preparation of deep interviews might provide reliable information for this analysis. This research is not conducted within the framework of this PhD research.

Acknowledgement

The project presented in this article was funded by the Austrian Agency for International Cooperation in Education and Research, Centre for International Cooperation and Mobility, Austria (http://www.oead.at/). Project ID: ICM-2011-03428. The research was executed in the frame of the fellowship program of the "IFZ - Inter-University Research Centre for Technology, Work and Culture", Graz in the 01.01.2012-30.04.2012 period. I thank the contribution of my supervisors, Dr. Günter Getzinger, Deputy Director of IAS-STS, and Dr. Imre Hronszky for providing advices and useful inputs to my research. I also acknowledge the contribution of all interviewees participating in the research.

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Appendix - List of interview topics

1 Recent and past innovation activity

- The innovation process, projects of the company, knowledge creation, diffusion and exploitation
- Internal/external sources of innovation? How do you involve them? (Innovation intermediaries?)
- Have the sources of innovation/its tendency changed in the last years? If so, what was the reason for changing?
- Do different innovation sources, as actors have definite different roles in different stages of the innovation process?
- Do you focus on your core technology and outsource, licence other technologies? Were there any related changes in the last years?
- What is the additional value of the cluster you belong to (if you belong)?

2 The role of the user

- Were any modifications introduced as a result of user experience so far? User interaction forms, in which way are the users/customers involved in the innovation process? Do you have different user groups, identified lead users, who intend to innovate? How can you get over information asymmetry?
- Is the so called INTERACTIVE user-involvement realized in your company? Were users involved in the development of innovation in any stage? Did users have any idea for product/process development (rearrangement?)
- What are the possibilities of user involvement in your company? Do you think user involvement in early stage of the development process cause higher social acceptance related to the new technologies? Do you involve users for giving feedback after measuring their energy usage, like smart metering, and then use these data for further development?
- Do you educate users? Do you organize any meeting with the users during the development process?
- Do you provide additional services for the users?

3 Business models

- Do you offer an individual business model to each building site, to users/investors based on the investment they can afford?
- Business model behind to enhance social acceptance? Social acceptance of new technologies, how is social acceptance gained?
- What services do you offer, were there any change in that offering so far? Can your product be provided as a service for users? (eg. Pay after usage or the energy produced, pay the users as they consume). Any changes in your internal working model or IT infrastructure accordingly? (N=1; R=G tendency, NIH Syndrome)
- Open innovation portal participation? Pros and contras?

4 The role of government

- What incentives, projects do you have (e.g. research project supported, or fully financed by the government) and what tools the companies use to keep the results sustained alive
- Available incentive forms to enhance RE usage.
- Who are the main innovation actors, what is the innovation system like in the Austrian renewable energy sector?
- Do you know anything about the changes in the practice of incentive forms and government project practices in the last decade in the renewable energy industry? What do you think about its tendency?

5 Intellectual property rights (IPR) protection

- Practice; IP management in your sector, company
- Licensing practice, in-out in your sector
- Do you have any new development, which they /who?/ do not use, or sell outside, (ratio, patent coverage) outsourcing, license