4 Broadening the inquiry

New Internet-based energy communities

4.1 Introduction: communities as catalysts for innovation and technology proliferation¹

The importance of internet-enabled and user-maintained forums became salient in the course of our ethnographic data gathering. These online environments allow dispersed energy users to seek information and tap into each other's ideas in a manner that far exceeds anything that adopters, users, and self-builders have had at their disposal in the past. While internet communities have existed for some decades, they have begun to provide widespread support for different technologies only after the introduction of easy-to-use open-source platform software in early 2000s, after which it took some time for the communities to mature.

As such peer-to-peer exchanges have long been known to be important for the dissemination of new ideas and novel technologies (Rogers, 2010). Peers are further known to aid in the selection, appropriation, integration, and adaptation of new technologies (see, e.g., Bakardjieva, 2005; Stewart, 2003) as “local experts” (Stewart, 2003; Bakardjieva, 2005) and “configurers” of generic solutions to the specific needs of other adopters (Okamura et al., 1994; Barnes, 2016). In these capacities, peers act as *user-side intermediaries* that are involved in *configuring* technologies, users, and spaces for technology appropriation; *facilitating* the uptake of new technologies; and *brokering* connections and transactions between the other actors involved (Stewart and Hyysalo, 2008; Hakkarainen and Hyysalo, 2016; Barnes, 2016).

Also innovating users tend to get help from their peers, and this help is often vital for realizing their designs (Lüthje et al. 2005; Jeppesen and Molin, 2003). As in more conventional R&D, specialization is high and inventive users are proficient in particular aspects of focal technology, and the scope of design they can master alone remains more limited than when pooling their competencies with peers (Baldwin and von Hippel, 2011; Benkler, 2006). In many domains, innovating users are deeply embedded in communities of practice and have organized design-oriented networks within them (Franke and Shah, 2003; Baldwin et al., 2006; Hiennerth, 2006; Bethwaite, 2008). Also in renewable energy the few reported user-innovation success stories feature self-building

groups and cooperatives (Ornetzeder and Rohrer, 2006; Seyfang, 2010; Nielsen, 2016), and this may not be just because of their higher visibility to researchers.

However, users (particularly the relatively few innovation-prone ones) are often geographically dispersed (von Hippel, 2005). Internet-enabled services can boost visibility and connectivity among people who share the same interests. This has been observed in many online game environments (Jeppesen and Molin, 2003; Prügl and Schreier, 2006), open-source development (Freeman, 2011; Benkler, 2006), and variations of the open design movement (Abell et al., 2011; Kohtala, 2017), and also in designing physical products, even if only some aspects of these products could be shared across the web (Sawhney et al., 2005; Jeppesen and Frederiksen, 2006). Studies of online peer innovation support have, however, examined relatively uniform hobbyist communities of practice and have mostly done so quantitatively (Jeppesen and Molin, 2003; Jeppesen and Fredrikssen, 2006). There is some research on DIY modifications and the related blogs and forums, and how they act as information repositories (Shove et al., 2007; Kuznetsov and Paulos, 2010) and showcase how personal experiences and knowledge gained from creating physical objects are projected into the public sphere (Kuznetsov and Paulos, 2010; Meelen et al., 2019). Nevertheless, there is little research on the interrelation between user-innovation and online user forums that are not set up for innovation per se. User-run internet communities are, at most, pointed to as a resource for managers to *harvest* or *mine* innovative ideas for manufacturers' benefit (Jeppesen and Molin, 2003; Pitta and Fowler, 2005; Franke et al., 2006). This is an important oversight in research given that user-run discussion forums are the largest type of product- and technology-related internet communities and the most widespread in terms of the topical areas they cover. In such forums, people organize themselves around products and technologies to discuss use, purchasing, experiences, community knowledge about products and producers, and DIY projects, etc.

To go deeper into the role that user-run internet forums play in adoption and user inventiveness, we turn to the concepts of science and technology studies (S&TS) as a means to describe participation in complex sociotechnical formations. Our first point of departure is that design and use are not static categories and should be examined as emerging and evolving in their relationship to technology (Hyysalo, 2010; Johnson et al., 2010). People are not born users, lay users, or lead users, but rather, the emergence and evolution of their *usership* should be examined as a processual engagement between the person, the practices she or he enacts, and the technology she or he appropriates (Helgesson and Kjellberg, 2009). In such an engagement process, peers and peer networks have been observed to play a significant role as *user-side intermediaries* (Stewart and Hyysalo, 2008) that address the often mundane, but important, assistance that goes into the purchasing process and making technologies work.

The processual view endorsed by S&TS further underscores that attention should be paid to more than just giving and receiving help and contributions, which dominates user-innovation studies on the topic. Many user communities

(e.g., local communities, issue-based digital communities, the user-developer communities of software and hardware) are known to be multifunctional spaces for their participants (Freeman, 2007; Grabher and Ibert, 2014; Johnson et al., 2010; Mozaffar, 2016; Smith et al., 2016a, 2016b; Verhaeg et al., 2016). Attention needs thus to be broadened to different orientations and learning that takes place in the course of the development of usership (i.e., the competences the participants build and to what effect) (Heiskanen et al., 2010). Concepts that seek to capture learning as participation such as legitimate peripheral participation are particularly helpful as they help capture the often complex and multifaceted learning (and growth) process of a person moving from being a relative novice towards having increasing mastery of a given practice (Lave and Wenger, 1991; Wenger, 1998).

The further pertinent questions raised by S&TS concern how the practices in a given type of internet community are organized. Here, internet forums feature considerable diversity. Some such forums accompany a relatively homogeneous practice, such as the forum for single-speed bicycles, which could well be characterized as a medium for a community of practice (Wenger, 1998). Others are tied to a joint development project, such as is the case in most open-source development initiatives, rendering such community primarily an innovation community (Jeppesen and Frederiksen, 2006; Freeman, 2011; Heiskanen et al., 2010). Yet other forums are diverse to the extreme, such America Online (AOL) or Suomi24 (Finland24), which feature thousands of discussion areas and interests, and little moderation, making most of the discussions threads too low in competence and reliability to aid technology adoption, or for making modifications or reliably qualifying products (Grabher and Ibert, 2014).

In between these extremes are product- and technology-focused—and typically user-moderated—internet discussion forums that exist for many product, software, and technology types. They feature broader sets of orientations than a community of practice would but are focalized, moderated, and curated (through pinning important posts, moving posts to appropriate sections, linking related posts, and so on) nonetheless. Such forums can be characterized as digital *boundary infrastructures* that allow for a partial co-existence of multiple social worlds by catering for the wide and accessible entry of many participants while providing various sections of deep knowledge and engagement for those with the interest and competency to engage in them (Bowker and Star, 1999; Johnson et al., 2010).

All these internet community/collectivity forms entail somewhat different modes of participation and learning. The user-run internet forums on renewables that we research enable learning through legitimate peripheral participation but appear to be more diverse in their participants' orientations, competences, and interests than, say, sporting-related communities or project-oriented innovation communities. This is also visible in the outcomes of the projects of their participants, which range from simple adoption and adaptations on to monitoring, modifying, inventing, and acting on the market.

The diversity and geographic spread of usership also make the internet communities novel regarding sustainable energy. Research on the early

phases of energy transition underscores the importance of citizen groups, such as community energy groups, for example, working as activists and innovators, initiating the development of novel S-RETs (Ornetzeder and Rohracher, 2006, 2013; Nielsen, 2016). Research on community energy and grassroots innovation (e.g., Smith et al., 2014, 2016b; Walker and Devine-Wright, 2008; Hargreaves et al., 2013) and energy-related citizen movements (e.g., Ornetzeder and Rohracher, 2006, 2013; Nielsen, 2016) has further underscored how communities and movements create solutions that can be adopted into the mainstream, inflict change among dominant regime actors, and foster critical discourse and the practicing of technological and social alternatives (Smith et al., 2016). Following this, the energy-related research on communities has to date largely concentrated on community groups and movements that are united by an ideological commitment to alternative forms of energy and are often also geographically local (see, e.g., Devine-Wright and Walker, 2008; Smith et al., 2016b). Community energy groups have also co-operated with each other through shared learning and networking, often facilitated by national and regional intermediaries and recently also via emerging international platforms (Smith et al., 2016b; Alarcón Ferrari and Chartier, 2017; Hyysalo et al., 2018). In some countries such as Denmark and Germany energy cooperatives have become recognized energy market actors, and this is likely to become amplified with the new EU energy community directive (Ehnert et al., 2017; Romero-Rubio and de Andrés Díaz, 2015). In all, community energy initiatives have been important in the early phases of energy transition, but it remains open as to what the traditional locality-based communities and new digitally mediated communities offer for the mass-market phase of sociotechnical change. Below we seek to clarify their differences and complementarities.

Our journey into S-RET-related internet communities proceeds as follows. We first examine what internet communities offer for individual citizen users who seek to acquire or deepen their understanding of S-RET. After this we discuss the forums as more aggregated phenomena and discuss how they affect systems change. We end by discussing the implications of their potential for wide diffusion (aka the “acceleration phase of transition”; Rotmans et al., 2001) by comparing their structure to locality-bound community energy forms and distributed cooperatives, as well as discussing the nature of the technology-related discourse these different forums tend to foster. In the final section we draw conclusions.

4.2 The individual’s view: from acquiring usership to growing inventive

4.2.1 Supporting acquisition and usership: Providing the information missing in the market

The bulk of the 500,000 posts in the heat-pump forums deal with issues that have the most relevance to people who are considering whether to buy a heat

pump, which model would be most suitable, and how to handle typical acquisition problems. The posts are well categorized so as to facilitate comparisons and finding information: general discussion, brand-specific discussions, and usage stories, in addition to sections on the acquisition, scaling, and ordering of heat pumps.

Let us first examine in detail a key “entry post” on ASHPs from 2007 (see Figure 4.1), pinned as “read this first” in the acquisitions section.

The post shows a condensation of much of the knowledge that prospective adopters need to understand and which would be difficult for them to establish otherwise. The first five bullet points deal with technical issues and introduce the relevant terminology: what solutions can be regarded as up to date and the threshold values for typical concerns such as noise level. These are followed by three bullets for the Finnish national context on how to scale the heat pump for different winter temperatures. The most important issues feature links to other posts that provide more information at the forum. The lower list of bullets instructs how to navigate vendor-provided information. Here the peer perspective becomes visible through an instruction regarding the two core values (the coefficient of performance and max power) which run in opposition and how vendor-provided information obfuscates this, particularly for cold conditions.

Resulting in 40,000 reads in five years, this posting and many of its kind help potential buyers to approximate what they need to know in order to make a sensible heat-pump acquisition: clarifying the characteristics of the space to be heated; the energy use and cost profile; the current heating system and whether it makes sense to replace it or combine it with S-RET solutions, such as pellet burner or solar PV; the actual local weather conditions particularly during winter; considering heating controls and operation options such as set-timers and remote operation; and personal preferences on what the heat pump may sound and look like post-installation. Guiding prospective users to these parameters is paired with instructions, calculators, and long threads related to each of these key topics. For instance, with respect to local weather conditions, winter temperatures are linked to (1) energy consumption data in different locations, gained from the research institutes and users providing their actual monitoring data and (2) particular heat pump makes and models, and their measured efficiency for optimizing the investment and regarding the possibilities to retain some of the existing heating options (e.g., solid wood or oil heating)² (Hyysalo et al., 2018).

In doing so forums provide a suggestive image of what it means to be an *informed consumer of S-RET* and the nature of the *information to be consumed*. In Stewart’s words, they *preconfigure* the user regarding the relevance of technical characteristics (Stewart, 2003; Hyysalo, 2010). The entry postings typically collect, condense, integrate, and explain information produced by other parties. They further configure the information to the national market specifics, making it directly relevant and reducing scientific and professional content that is not directly relevant for peers. Such bricolage, aggregating, editing, and

AHP selection check list.
 15.05.07 - 12:59

I came across with this relatively easy and compact check list how to approach selection of AHP for heating:

- Check that it is **inverter pump**, because it saves electricity during partial load range.
- Look for a compressor type that is best in class technology: **Scroll** (spiral compressor) and **Twin-Rotary** is more efficient technology than **Rotary** and can save when AHP is running on partial load (see list of the most common motors and fan motors here and Panak's motors here).
- Also try to confirm that AHP has **electronic expansion valve** (so called **EEV**) in cooling circuit, because it usually gives more accurate and economical adjustment for heat production in all outside temperatures.
- For coolant gas good selection is **R410A**.
- Noise level should not exceed the following limits: **indoors 47 db (day) / 44 db (night)**, **outdoors max. 52 db**. Because of used logarithmic scale every approx. +3 db increase in specified noise level doubles the heard noise level (decibel, Wikipedia).
- Compare the lowest temperature in your locations to heat pump's **lowest operating temperature value** (-20 °C can be achieved with some models).
- If winters in your location are mild, try to find as **high as possible COP** in other words good partial load efficiency for your AHP.
- For winter temperatures are lower than -15 °C, try to find **high as possible heat output (kW)** when AHP runs with full 100% power. The best heat producers can be typically recognized from outdoor unit's highest weight (= larger motors & heat exchanger size) and large dimensions. After all outdoor unit's heat exchanger internal surface limits the AHP's possible maximum heat production.
- Select enough well known **brand**, **proper maintenance and warranty**.

This looked very compact list for novice AHPist when the main focus is on selecting a right device.

Note also that...

- COP that you see on advertisements and max heating power do not happen at the same time when using AHP in normal conditions. They are alternate: When COP is maximum because of partial loads also heating power is minimised.
- COP value is interpreted in advertisements as rate of free energy produced from electricity, which is typically measured at 50% partial load at +7 °C outdoor temperature. This usually describes well how AHP works in a normal home.
- On the other hand max. Heating power can be achieved by using 100% power in +7 °C outdoor temperature. This type heating power is required rarely if ever. In this case COP is much lower.
- When outdoor temperature is -15 °C in heating power and COP goes down significantly and manufacturers measurements don't tell about this situation anything.

Source: Heat Pump Primer, EEH

Last edited: 07.01.08 - 12:33 written by Jope112

Figure 4.1 An entry post-guiding ASHP selection (text translated from Finnish).

opening topics (Botero, 2013; Botero and Hyysalo, 2013) for peer commentary and validation are typical *infrastructuring* activities of peers (Pipek and Wulf, 2009), which greatly facilitates other users even though peers do not physically configure each other's energy equipment.

Somewhat more advanced posts establish the relation between particular concrete projects and the principles of sound action in the market. These also give an idea of the magnitude of effort that may be involved in acquisition (and thus the service the forums provide for the readers); let us briefly recount a calculation posted by one of the users (Figure 4.2) to aid others in the task

☺ **Mitsubishi FA25V Row House 96 m2 Hyvinkää**
« : 31.01.07 -:19:18 »

Scaling the Air-Source Heat Pump into a new house with no prior knowledge or experience of consumption is problematic. Below my own attempts at the subject matter.
<http://lampopumput.info/foorumi/index.php/topic,1334.0.html>
<http://lampopumput.info/foorumi/index.php/topic,1010.msg9643.html>

The problem of choosing the 'right' pump came after this, once the 'right' size has been defined.
<http://lampopumput.info/foorumi/index.php/topic,986.0.html>
<http://lampopumput.info/foorumi/index.php/topic,1409.0.html>

Simultaneously while asking for offers on equipment, one has to, of course, plan where to locate the equipment and rack in the apartment.
<http://lampopumput.info/foorumi/index.php/topic,1052.0.html>
<http://lampopumput.info/foorumi/index.php/topic,1711.msg18519.html#msg18519>

It took me 5 months to do the above mentioned, but I could not move into the new apartment before that anyway. ☺

Row house 4 rooms + Kitchen + Sauna heating power need.png

Standardized heating electricity need.jpg

Monthly electricity consumption 2011.jpg

Home COP Test Mitsu FD35VABH.xls
 « Edited: 28.02.11 - klo:15:53 Written by N.N »

Row house 4 rooms + Kitchen + Sauna 96 m2 Mitsubishi Electric FD35VABH Hyvinkää and log data N.N.(at)lampopumput.info

Figure 4.2 An example of a forum user giving advice for others regarding scaling and selecting a heat pump, and finding a location for it (translated from Finnish).

of scaling and choosing a heat pump for a newly built house that lacks any energy-use history upon which to draw.

There are several issues in this posting worthy of our attention. It reports a necessary task (scaling and choosing a model) that new users must engage in. One could assume this to be an easy task, or at least one easily available from vendors or suppliers, but the post points to the difficulties involved: it took five months to do it properly and reliably for a seasoned person when reference data was missing. Without it, any supplier or assembler advice would be hard to assess (their quotes potentially having self-serving biases). It also indicates that a one- to three-hour assessment by a supplier would be a rather rough estimate at best. The uptake of the post, read almost 100,000 times, bears witness to the demand for this type of information and calculation model.

Finally, the signature of the posting is typical and telling of the forum sociality. Instead of a name or some information about the person (e.g., her or his interests or education), there is a description of his house, its location, and the heat-pump equipment in use. His signature tells readers what he has done with heat pumps (consumption monitoring, ASHP scaling, and ASHP pictures); all in all, it articulates the parameters that another user can use to qualify the provided information and comparing the setting with her or his own. The signature is not information about the “discussant” or “person” but about a specific relationship (between a person, equipment, and the context) and specific relational sociality between those engaged or engaging in similar technology and contextual relations. To paraphrase Helgesson and Kjellberg (2009), these forum posts foster the emergence and deepening of *usership*, the relation between people and the technologies they are engaged in, and interestingly, in the whole forum one finds only isolated items that broaden the writer’s position beyond that of his or her technological relationships.

In these relationships, the forum helps make what Stewart and Hyysalo (2008) call *user-side intermediation* available to peers. For instance, the specific pump-type discussion features peers who are a little more knowledgeable about the technology and are happy to reply to questions about the technology that may appear silly—a noted core facet in the uptake of any more complex system (Sørensen and Williams, 2002; Berker et al., 2006). Forums also feature *local experts* (Stewart, 2003, 2007), people who are more knowledgeable than most users and to whom more tricky problems can be addressed. Some of the local experts are just seasoned users, but also professional assemblers, resellers, and dedicated hobbyists volunteer their advice regularly on the forums once an issue in a thread becomes flagged as interesting for high-competence people and requiring more serious thought.

As noted regarding the entry post, a key aspect of these intermediary actions is to point to non-human mediators by providing pointers to previous threads on the same topic, links to manuals, instruction videos on YouTube, web pages elsewhere, and to the coefficient of performance calculators. While most users are quite able to follow instructions, the step toward defining the problem

or question is the part where more knowledgeable peers become indispensable. As one of the user inventors reflects:

After all, the forums provided a lot of tips before I acquired [a heat pump]. [I] browsed and read much about what brands would be worth ordering.

(User inventor for AHPs)

All in all, acquisitions, scaling, help with problems, and help with dealing with suppliers are topics that draw in thousands of people. This provides a critical mass of people with the potential to answer complex and difficult questions and allows for timely and competent feedback. We shall next argue that it lays the ground for deepening orientations and actions related to the S-RETs.

4.2.2 *Learning technology and deepening engagement*

Several of our interviewees stressed that the forum led them into having a deeper engagement with both the knowledge base and with what can be done with the technology. Let us illustrate this with forum members' comments at different stages of their participation, moving from meeting problems in use toward DIY projects and finally turning to lead users:

Thanks for the clear information. In this area [a ground circuit] it feels that when one grasps one thing, you just end up with further questions.

(User, GSHP forum)

Without this forum I would have faced huge problems with this unit. I doubt that I would have proceeded building this further. It [the forum] has been of great help.

(Inventing user for ASWHPs)

I have rather given more to the forum than taken from it. That's the direction ... I have tried to instruct guys who do this [DIY project], especially in dimensioning, so that they get it working and one does not go too far astray.

(Semi-professional who creates designs for a small reseller)

An important step in the deepening of learning lies in moving from just implementing a heat pump to understanding how it works and what issues affect its functioning. This typically ensues from gathering, organizing, and sharing comparative usage data. In the forums hundreds of people post or automatically feed their measurements into the forum for comparison and comments or to answer polls set by others (for example, see Figure 4.3). Most of these users are out to verify how their installation compares to others and to factory claims. Some have more general interests in establishing how different models

Figure 4.3 Users share heat-pump monitoring data graphs via forums and their own internet sites.

behave in temperatures that differ from the European standard of $+7^{\circ}\text{C}$. The results tend to show occasions and/or areas where one's installation could be improved, and the forums feature active discussions about theoretical matters in heat-pump functioning, as well as discussions on trials of changing values and working around sensors. These comparisons also typically involve hacked and redesigned devices, as many hacked systems feature extra sensors and measurement points and are run by enthusiasts—indeed, many lead users report having gotten a cheap “toy air-heat pump.”

Further on, many improvement projects are documented meticulously, picture by picture, and there were also attempts to create lists of useful DIY parts, as well as step-by-step (including pictorial) instructions on how to order, install, and use specific tools that are useful for monitoring and DIY work, such as Mango and a PolluCom energy meter, that spread hacking skills within the user group. Using some of the same parts and DIY tools also spreads competence and promotes collaboration on further modifying and inventing, in effect increasing the user base and the (mini)market for DIY parts and assemblies. This spread of competences is critical for heat pumps that have a mix of digital, electric, cold gas, and plumbing parts, which makes few people experts in all aspects of the technology.

Users are part of an ecology of producers, resellers, importers, regulators, bodies giving professional training, etc., as well as being part of peer-to-peer

networks such as those found in user forums. Many, if not most, people engage in peer-to-peer networks because of a lack of needed information elsewhere and gradually change their perception, occasionally moving from an apprenticeship position toward increasing mastery. In the words of an interviewee:

Well, when you first buy a device from the store you sort of expect that now you have it [all sorted out]. It is not exactly a natural response to open it up and start messing with its internals, losing the warranty, and spending a fair deal of time on it. But then you encounter problems and oddities, go to forums and see that others are not so shy about examining these devices and reporting fixes and improved energy yields. It becomes more natural to see the product as not so perfect, to learn about the topics more. After a while you find that you have implemented a few simple hacks and there was nothing to it. That would have been simply unfathomable upon first encountering these devices.

(User with a GSHP, an ASHP,
and micro-wind power)

The aspects of the systems that users who deepen their competencies come to master (moving beyond their initial competences) include terms and notations (e.g., assembly diagrams that are different for all technical subsystems), background theories (e.g., coolant gas thermodynamics), skills (e.g., attaching sensors), means (e.g., programming languages), regulations (e.g., the licenses that are needed to work with each part of the technology), and cost-benefit issues (e.g., compromising reliability in some situations for increased yields in others). This knowledge determines what one can do with the technology, as well as what governs which sections of the forum one can participate competently.³ These learning trajectories fit well with the idea of learning as legitimate peripheral participation (Lave and Wenger, 1991). Its prevalence in S-RET, particularly in regard to heat pumps, owes much to the technology combining several distinct specialist domains (in case of heat pumps: coolant systems, electronics, software, and in many cases also plumbing). All of the interviewed user inventors had started with modifications for which they had background competence: coders built software, electronics engineers hacked sensors, and so on. None had the competence to bridge to a more overarching (re)design from the outset—this emerged gradually over the course of their engagement, often over the course of months or even years:

By and large, I read [those posts] for about a year, and then, when I started to understand a bit, I did a bit more intensive reading; you see, thermodynamics presents a bit of a tricky domain.

(User with a modified GSHP)

It is noteworthy that internet discussion forums were conducive to legitimate peripheral participation to a far greater extent than the open-source

development projects analyzed by Freeman (2007), who took part in our internet ethnography. The open-source project “OpenOffice.org,” which she followed ethnographically for seven years, featured the frequent turning down of volunteers who did not have the required programming skills from the outset (i.e., the project remained open only insofar as one was already competent or close to being competent at the activities in which the community is involved). The internet forum’s DIY sections feature some of the same characteristics: some naïve questions do not receive responses or merely get a referral to a thread elsewhere in the forum. Yet the forum supports myriad other ways to participate other than self-designing, and they are also more open-ended as to what is being done as part of community membership, including using, sharing, comparing, planning, theorizing, and visioning acts. In contrast, most open-source participants are involved in testing and in making small additions to the software. Hence, while user forums are less organized and less coordinated than open-source projects in their design activities, the former also have important strengths in relation to attracting and deepening usership and the growth of lead-user characteristics. The user-run renewables forums differ markedly from a clear innovation community, as well as from a clear community of practice, as the forum participants have a wider range of orientations, expertise, and practices that connect them to the forum. The diversity may be best conceptualized as a *boundary infrastructure* that is partially shared by several intersecting social worlds (Bowker and Star, 1999).

The learning and inventiveness found in these forums tie them to being run by peers. Those of our interviewees who had been following forums in other countries stressed that English-speaking forums had, in their assessment, curbed user modifications and critical evaluation due to being hosted and moderated by suppliers. Our informants equally stressed the importance of some of the administering solutions being conducive to success. These include light but active moderation, strong segmentation of the manufacturer-specific parts of the forum, a DIY section, and a debate section “hot ring” to which moderators move controversial and contested content and hence only have to dismiss content that is truly libelous or out of the scope of the forum. This was seen as favorable to the outcome of multiple specific orientations coexisting within a forum.

4.2.3 Peer assistance for inventive user projects

The most in-depth learning in the forums pertained to DIY projects and inventive users. Interviews revealed that all inventive users had some presence in the internet communities. These interviews and analysis of the discussion threads indicate that the inventive users received various kinds of help from other users, most commonly from two to five people. The most common responses to questions or flagged projects expressed different forms of community memory and expertise, such as whether an idea was worth pursuing or, more commonly, that something similar had been tried before. Typical

question–answer sequences related to posting an idea of a modification project can be illustrated with the following exchange (see Figure 4.4):

The discussion in Figure 4.4 gives the project initiator a fair opinion on whether his suggested hack can be done and has, in fact, already been tried, as well as some of the likely issues he may be faced with. Our interviewees regarded these kinds of peer responses to be highly valuable:

The greatest benefit is that it has experts that really know what they are talking about. And regarding these specific areas they have [expertise in], you could say, they have an expert's and experimenter's attitude. That is what is interesting and useful. You get information on many things that would be very hard to get from elsewhere.

(User inventor for ASHPs)

Melting with the warmth of the return gas?
 « : 06.05.12 - Time:13:29 »

Is it possible to thaw the outdoors unit with the gas that returns from the indoors unit that still has some warmth in it? Put an extra bend onto the top of the outdoors unit bottom plate? Could one thus use after/waste heat of the gas for thaw instead of direct electricity?

Will such hack create problems with thawing, functioning of the device or efficiency or into the defrosting of the lamelles?

Red house and ...

Cellar + 2 floors:
 4 x Mitsubishi Electric MSZ-FD25VA+MUZ-FD25VABH

Re: Melting with the warmth of the return gas?
 « **Reply #1** : 06.05.12 - Time:13:59 »

Yes. Apart that its not gas at that point. Or if it is, something is wrong. The only problem you can encounter is that during the defrosting sequence and with reversed circulation the tube can freeze. Even though that doesn't seem to create problem.

This one did not ice up the whole winter, apart a small bit in the rear end:

<https://picasaweb.google.com/...>

Here is the number one version of AWHP thawing tube:

<https://picasaweb.google.com/...>

Version two has that tube raised into the bottom plate, while I turned the water going inside and into the drain. Last winter is through without any need to interfere whatsoever.

Figure 4.4 The start of an exchange between members regarding a potential hack.

Many user designs attracted further ideas, suggestions for solving problems, and direct iterations of design drawings posted on the forum. However, the users active in DIY threads formed a relatively small group of roughly 300 people that mostly had good technical competence in at least one or two technical areas related to heat pumps. Among the user inventors were also several researchers working within industry and academia, heat-pump professionals (such as those working as assemblers and resellers), and users with an entrepreneurial orientation in regard to furthering their business (e.g., in home automation). Gaining control of one's technical equipment, the joy of tinkering, training for their profession, and the possibility to stretch the limits of one's professional skills were all stressed as reasons to engage with self-building activities. Yet two issues featured in next to all interviews: the importance of forums for learning, and the importance of forums offering "a community of the like-minded," which motivated and justified one's tinkering. These observations parallel those made by Kuznetsov and Paulos (2010) and Grapher and Ibert (2014) on other internet communities.

Both an analysis of forum threads and interviews indicated that multiple modes of interaction, made possible through the forums, allowed users to turn their diversity into an asset rather than a hindrance. The forums allowed public postings and responses, as well as private postings and responses. The more advanced and more professionally oriented users used private messages as the predominant response medium regarding DIY projects and stressed the importance of anonymity as well as the possibility to then shift to a one-to-one discussion out of forum—via e-mail or the phone. Their occupational reputation and commitments would have precluded them from playing around with heat pumps in the open. This range of interaction modes also played a major part in referrals of services, materials, and tools as many DIY projects and help given stretched, or even violated, warranties, insurance, and professional rules of conduct at some point in their development (cf. Torrance and Von Hippel, 2016).

Importantly, the relevant interactions were not limited to the small in-group of DIY participants. The larger community had been found indispensable for inventive users. In the words of one of our informants:

The heat-pump forum is a rather conservative site and [it is] not nearly as welcoming and inventive as people in the free-energy forum or pellet forum... [but], for example, the free-energy forum doesn't give much help for development work as there are too few folks in there.

(User inventor in ASHPs and wood pellets)

The attraction of new users and new fixtures is pivotal for gaining critical mass in the competences available. While most participants in user-run forums have no explicit intention to invent or facilitate other's inventive behavior, they inadvertently provide indirect support by doing what they do. Substantial numbers of discussions, instructions, manuals, photographs,

Table 4.1 How the heat-pump forum supports heat-pump acquisition, use and user invention

<i>Forum posts</i>	<i>Typical thread topics</i>	<i>Help offered by other users</i>	<i>How it facilitates adoption</i>	<i>How it facilitates user innovation</i>
General heat-pump information; principles, costs, issues to consider	—Basic information about heat pumps —“Read this first”	—Links to and explanations of research knowledge and papers —Links to international forums —Links to educational and training web pages	—It provides the basics about benefits, suitability, and shortcomings	—It helps expand the community and its potential diversity
Acquisitions	—Which type of heat pump to select	—ROI calculators; both self-developed calculators and links to calculators elsewhere	—It lessens uncertainty —It helps in making an informed choice	—It expands the user base
Discussion on the scaling of the system	—Given the house details: What should be done? What is needed? —Could a smaller installation or combination do? —Could old heating system parts be used? —Exposing one’s plans and calculations to scrutiny	—Suggestions for alternatives —Experiences with analogous homes	—It helps in verifying calculations —It allows experience sharing —It provides support for more complex combinations —It details “Things to remember”	—It helps in acquisitions and lays down the basic technology knowledge

Discussions on installation and usage	<ul style="list-style-type: none"> —Installation costs/problems/issues —Sharing experiences of usage 	<ul style="list-style-type: none"> —Installation problem descriptions and solutions —Long follow-ups of an installation —Examples of similar problems —Suggestions for overcoming them 	<ul style="list-style-type: none"> —It supports installations —It helps readers to get to the reality of heating - provides pro-con listings for different options - It provides “community knowledge” on manufacturers and models —It provides a counterbalance to supplier information —It provides experience and advice on often complex choices 	<ul style="list-style-type: none"> —It deepens usership and competencies with S-RETs —It provides peer support for cheaper and rarer installations; it helps the growth of diversity —It expands competencies in the user base
Discussion on specific models	<ul style="list-style-type: none"> —Problems/solutions/experiences with specific models 			
Discussions on non-standard installations	<ul style="list-style-type: none"> —How to sensibly combine different S-RETs 	<ul style="list-style-type: none"> —Checking and updating members calculations —Experiences of how much work goes into the different alternatives 		

videos, links, calculators, etc., stored in the forum turn it into a shared toolbox and memory repository (Torrey et al., 2007, 2009). Further, the forum gives access to peers who contribute their insight into defining and solving posted problems, comparisons, voicing shortcomings, and taking part in the exchange of services and parts.

Non-standard installations are particularly relevant for the inventive user base, for example combinations of pellet, solar, wind, or heat-pump solutions. These projects create users that must grow quite knowledgeable about different aspects of their systems in order to make them work, and typically thus engage in peer-to-peer communications, regardless of if they personally go to the lengths of making hacks.

To summarize this section, internet forums have been important catalysts for learning how to use, adapt, and innovate for heat pumps in a cold-climate context. Peer-to-peer forums hold a special place with regard to the maintenance, proliferation, and further development of S-RETs. What becomes elaborated in the forums is not only what the technologies are and how they function, but also how they are being developed: what can be modified, how producers respond, how regulation responds, how other users embrace novelties, etc. These wider linkages are keys to proliferating the S-RETs to new types of installations and more complex installations, as well as to inventive solutions from their users.

4.3 The systems change view: affecting the market and shaping technology

4.3.1 S-RET internet forums' growth patterns

We now turn from an individual's perspective to the societal importance of S-RET related internet communities. The first internet forums for S-RETs were set up by citizen users after the first few thousand people had adopted the technology (in Finland between 2004 and 2008). The full statistics are only available at lampopumpput.info and the discussion is anchored to that forum, which appears to be quite representative of the patterns elsewhere apart from its sheer size and growth rate that exceeds the other forums.

The growth of installed stock and forum reads has then been roughly linear, with reads growing at a faster pace⁴ (see Figure 4.5, the lines in bold), so that the year 2006 had 19 reads per acquisition while by the year 2016 this had increased to 159 per acquisition (see Figure 4.5). As is common to such digital sites (Grabher and Ibert, 2014), readership has been much more numerous than instances of registering and posting questions or comments: for lampopumpput.info, the cumulative reader count exceeded 2.5 million by 2017, indicating that 1–3 million visitors visited the forum in a language area of 6 million people.⁵

The numbers of new posts and new registered users rise until 2011 (400,000 installed systems or from less than 10% to 30% of estimated maximal diffusion) and then gradually decreased to roughly the early annual levels,

Figure 4.5 Cumulative installations and user activity development in the main forum for heat pumps in Finland.

so that eventually to 5500 people, i.e., 0.1–0.5% of the readership register themselves, (see Figure 4.5). There are several simultaneous explanations for these changes. By this time, the accumulation of knowledge in the forum has become sufficient for an increasing number of new users so fewer people needed to register and post questions in order to satisfy their information needs in regard to acquiring and maintaining heat pumps. At the same time, the market developed so that merely acquainting oneself with the basics of scaling and selecting a heat pump became sufficient prior to purchase for most users. The later adopters may have also been less interested in the details of their purchases, as diffusion theory would suggest (Rogers, 2010). Yet, as the number of messages increased over the years, more pages became available for any given topic and users had more content they could read per query. The forums have also simultaneously served users contemplating the purchase of a heat pump and those who already owned a heat pump and needed to troubleshoot, improve it etc (see above section 4.2).

4.3.2 Complementing market information: “independent peer knowledge” on technology and the market

The information in the forum goes beyond a generic technology discussion aiming to educate consumers and has direct market-shaping characteristics. The forums make the available options easily accessible in terms of the choice of manufacturer, type, and model, and issues such as costs, installation, and maintenance. Each make and model has a specific section on the forum wherein users relate their experiences and suggestions, and the same goes for installation and maintenance. The forums commonly relativize manufacturers’ brochures and adverts, and countenance exaggerated claims, typically stressing reliable brands with aftercare and warranties.

To evaluate the value of such complementary information in the market formation for new technology, it is instructive to compare the situation before and after the forums gained momentum in 2007 and after they had done so in 2012. In 2007 a joint-purchase project in the small municipality of Kangasala needed to deploy nine months of part-time work and a small EU project in order to determine the suitability and cost structures of the roughly 70 heat-pump makes and models that were available then (Heiskanen et al., 2011; Martiskainen, 2014). After the forums had accumulated tens of thousands of posts, a similar search could be made in a matter of hours or at maximum, in a few days, and complemented with queries for references from people as to how they had done actual implementations. This is at once a massive gain in consumers’ capacity to make an informed decision regarding a purchase and points to the complexity of making an informed decision on new technology of medium complexity such as S-RET systems.

Further on, as discussed in Section 4.2, forum benefits are not limited to making purchases and providing guidance on installation and use. These peer

commentaries are sometimes paired with resellers seeking to assert their views as well, and the above introduced hot ring section for controversial topics and debates have kept the forum reliable without overblown censorship. When the forum scope and popularity among current and prospective consumers rose, it began to act as a community memory of both successes and failures. Together with the actions of the national industry association, the citizen forums have helped to keep the rapidly evolving market in check and to maintain its reputation among the wider public.

4.3.3 Providing evidence of realized value and counter-evidence against claims of poor performance

The performance of novel technologies tends to be subject to uncertainty, facing public counter claims made by incumbent actors as well as suffering from out-of-date representations of yield and payback times in the face of rapidly developing product characteristics (Heiskanen et al., 2017a; Murto et al., 2019a, 2019b, 2020). Information on realized and comparable settings provided by trustworthy peers can be indispensable for addressing all these market(ing) problems, particularly if the market is in the consumer domain and not served by dedicated industry analysts (Pollock and Hyysalo, 2014; Pollock and Williams, 2016).

The common internet forum practice of displaying real-time performance curves with location and site information (see above) and the provision of very detailed calculators for estimating the likely efficiency in real conditions provide references for other adopters. As most forum participants provide their location, house specifics, and equipment configuration in their signature field, their monitoring activities (spurred by peer help in setting up monitoring) aggregated a repository of real-life measurements of heat pumps across different settings and outdoor and indoor temperatures. This, in turn, has allowed surveys and other comparisons to be made through the forums and made available therein.

The primary purpose of these activities has been to go beyond the manufacturer-provided information that has been tested in the standard test conditions for which the equipment is optimized (as all devices are) and to spot inaccuracies and errors in manufacturers' data. The secondary effect has been the capacity to also countenance the claims by other parties, such as research institutes, whose studies are actively and critically discussed in a specific section of the forum.

4.3.4 Contributing to demand articulation and technical improvement

The citizen users and their discussions in internet forums further contributed to direct and indirect demand articulation for the further development of heat pumps for cold-climate markets. In the beginning of diffusion, some users advocated cheap heat pumps over the early, expensive cold-temperature models. A decade later, the colder temperature models had become the norm and

most advanced ASHPs retained a positive yield at -25°C . Large forum sections and user innovations devoted to discussions on winter performance had signaled to the importers and manufacturers that ASHP use in cold temperature called for improvement, and with the growth of the cold-temperature market size, this sent a signal to manufacturers to improve their cold-temperature models.

Another important development in demand articulation has been that citizen users began operating heat pumps along with other heating technologies. Whereas vendors and energy experts initially assumed that people would replace whatever heating they had with some S-RET, it became common to purchase an ASHP in order to complement existing heating systems that were based on oil or solid wood, as well as to complement an AWSHP and GSHP with solar thermal collectors. The resulting “hybrid heating systems” utilize the best yield time of each heating source relative to outside temperature and sunlight, which often requires working out the details and good switching points in between. Peer-to-peer information played a role in the market formation of such systems as the first vendors to sell a “technology independent assessment and renewable solutions” emerged in 2012 in Finland, over a decade after hybrid solutions started to become common. Hybrid S-RET systems also began to emerge stepwise in a pathway towards increasingly sustainable heating forms (Juntunen, 2014b).

4.3.5 Peer-to-peer internet communities within the ecology of user-side intermediaries

Consumers were not left to their own devices regarding S-RET. There were multiple other actors that mediated S-RET systems and their emerging market, forming what Stewart and Hyysalo (2008) characterized as an “ecology of intermediation.” From the user perspective, however, these potential intermediary actors remained uninterested in many aspects of the heat pumps that were important for citizen users (research and academic institutions in particular), provided partial and self-interested assessment (resellers and installers in particular), or were difficult to reach and potentially offered too generic information for actual purchasing decisions (actors such as local energy advisors and a national energy efficiency institution). Some intermediaries, such as the technical press and mass media, provided basic information, price comparisons, and tests but only rather sporadically for a continuously evolving market and without evaluations of realized performance or delivery by different vendors. In Table 4.2 we detail what different actors in this ecology of intermediation mediated and what they did not mediate to citizens regarding heat pumps in Finland. The overarching finding is that each intermediary actor takes on activities that are sensible for themselves and thus only mediates, for instance, academic or within-industry knowledge, not what would be functionally optimal for the emerging niche or citizen users. The result is that the market institutions and intermediary actors are not likely to coalesce into an optimum

Table 4.2 The ecology of Intermediaries in the Finnish heat-pump market in the period 2010–2014

<i>The intermediary in heat pumps</i>	<i>What mediates</i>	<i>To whom it primarily mediates</i>	<i>How it mediates</i>	<i>What it does not mediate to citizens</i>	<i>Extent</i>
Citizens/peers					
Local communities, friends, neighbors (see above: Heiskanen et al., 2011, 2014, 2017b)	Knowledge and information about technology and best practice, joint and coordinated purchases, experience from suppliers/installers	Peers	Personal/local contacts	Mediates very few things beyond the local area	Local
Internet forums (see above)	Providing qualifying information, influencing other actors in the market, providing empirical evidence, localizing knowledge, facilitating user-driven technical improvements, questioning regime actors	Peers (resellers)	Via internet discussion forums	The sharing of energy, work, resales	National
Public					
Local energy advisors (Heiskanen et al., 2011)	What heat pump models exist, average yields, the fit-to-site specifics	Citizens, public agencies	Direct contact	Site-specific yield information per model, recommending (or recommending against) resellers, installers, or hacks	Local
National energy efficiency agency	What heat pump models exist, average yields, the fit-to-site specifics	Citizens, public agencies	Direct contact, internet pages	Site-specific yield information per model, recommending (or recommending against) resellers, installers, or hacks	National

(Continued)

Table 4.2 Continued

<i>The intermediary in heat pumps</i>	<i>What mediates</i>	<i>To whom it primarily mediates</i>	<i>How it mediates</i>	<i>What it does not mediate to citizens</i>	<i>Extent</i>
Local authority building inspection	Installation guidelines, adequate installations for GSHPs	Architects, builders, developers (citizens)	Guidelines, inspections	Site-specific yield information per model, recommending (or recommending against) resellers, installers, or hacks	Local/national
Research institutes (Heljö and Laine, 2005)	Technology tests, authoritative research results, expertise for evaluations	Primarily for industry and academia but summaries are also provided for the public	Commissioned research, mainly for industry and research projects with public funding	Limited mediation in the consumer segment	National
Private sector					
Industry association (Heiskanen et al., 2011)	Information about technology and market development, professional training	The general public, resellers, policymakers, authorities	Trainings, internet pages	Business-sensitive information related to members	National
Resellers (see above: Heiskanen et al., 2014, 2011)	The import and resale of technology, generic information (e.g., on specifications), installer and financing contacts, installation permission forms	The general public, manufacturers	Direct interaction with customers and potential customers	Neutral information that is unbiased toward their sales items, business-sensitive information in general	National
Installers	Installation prices, installation options, installation work	Users, industry associations	Price quotas, direct contact, survey responses	Business-sensitive information (e.g., GSHP drilling depths per area), information about the environmental harm of drilling	Local

<i>The intermediary in heat pumps</i>	<i>What mediates</i>	<i>To whom it primarily mediates</i>	<i>How it mediates</i>	<i>What it does not mediate to citizens</i>	<i>Extent</i>
Real estate agents (Rinkinen and Jalas, 2017)	The valuation and price information of installed heat pumps, the influence of technology on house valuation	Via online sales portals to the general public	Negotiating and setting up prices for real estate, providing information	Technology experience; incentivized to give biased information in order to support quick property sales	Local/national
Insurance companies and incident reports	Insurance incident amounts per type and make	Authorities, resellers, vendors, building inspectors	Providing summarized numeric data, setting up norms	Limited mediation in the consumer segment	National
Media					
The technical press and magazines	Basic information, price comparisons, tests	A technically oriented public	Print and online media	Recommending (or recommending against) resellers, site-specific information (except in rare cases), sales, etc.	National
Mass media	Information on installations and example cases	All	Print and online media	Recommending (or recommending against) resellers, mediates sales only through adverts	Local/national
Professional press	Basic information, price comparisons, tests	Building professionals	Print and online media	Reaches consumers only via third parties	National

ecology regarding how citizen users could make informed acquisitions of novel technologies in the early phases of proliferation.

To summarize this section, from the systems change perspective internet communities can play an important role as user-side innovation intermediaries that ease adoption and the use of technology for the increasing number of new users, as well as being able to shape both market and technology characteristics. Whether this happens on a large scale depends on the ecology of intermediation at hand—if other actors have covered all the relevant information and support needs, there may not be a need for users to organize giving peer help or shaping market or technology characteristics. In such cases, users will likely be limited to giving only local and more limited user intermediation, as they do in virtually all other technology types.

4.4 The comparative perspective on different energy communities

4.4.1 Fostering an appreciatively critical discourse on technology

The previous sections have shown that new internet communities deserve close examination. In comparative perspective there are a few further characteristics that merit attention. The first of these characteristics is that these acceleration-phase internet peer discussions feature relatively little critical, alternative, or pro-environmental discourse. Discussions revolve around and espouse the most seemingly neutral grounds of economic gain and technological optimization or improvement. When we further interviewed active forum discussants, those with explicit environmental motivations regarded that displaying them in the forums would merely lead to unhelpful debate. This runs in contrast to many community energy settings where the critical discourse on alternative technology has been found a key characteristic (Smith et al., 2016a, 2016b). Indeed, although the internet forum discussions are about clean tech and renewable energy, topics such as the reduction of carbon emissions are almost non-existent among the 300,000 messages of the main heat-pump forum and similarly so in pellet and solar forums. When such topics are mentioned, emissions are considered a problem on a higher level or part of political decision-making. In cases where technology is concerned, the emissions discussion is focused on other domains and technologies, such as transportation and cars, instead of on housing and heating. Open climate change skepticism can even be recognized in some exchanges.

Whilst this may appear odd at first there are important social dynamics at play. On the one hand, technical internet forums are a more widespread genre than the forums related to renewable energy—similar forums exist for bicycles, loudspeakers, various software products, and so on—and the implicit and occasionally enforced code of discussion in such settings does not involve issues that could be regarded as ideological or political. On the other hand, the appeal to technicalities and economics does important work in legitimizing and normalizing the novel technology and discussions about it. As many scholars of

technology have remarked, a distinct characteristic of technology is its ability to mask political choices behind seemingly neutral, normal, and unstoppable progress (McKenzie and Wajcman, 1999). One could even argue that continuing to foster a widely critical alternative discourse on the technological options that are to be widely diffused is to strip them of the prime source of power that they may have as *technologies* within the discursive and political space of modern industrial societies. The mainstreaming and scaling up also run contrary to criticality *among citizen groups*, not just between the citizens and mainstream policy actors (Smith et al., 2016a, 2016b). The Finnish case of heat pumps indicates that such capping of critical discourse can be effective. Whereas heat pumps were disregarded by the experts regarding their suitability to the Finnish conditions throughout the 1980s and 1990s (Heiskanen et al., 2014, 2017a), by 2016 the aura of novelty had vanished. By then, heat pumps were viewed by the public and experts alike as the normal and rational choice for a heating system, and they were installed in the majority of Finnish detached houses. Throughout this time, the internet forum discussions opened and kept open the “black box” of technology in a *critical enough* manner for it to become appropriated, adjusted, and improved for the specific national context, but this was done *appreciatively enough* to protect the technology from the wholesale dismissals.

4.4.2 (Local) community energy versus distributed and dispersed energy communities

The second important aspect of the internet communities is how they contrast to traditional energy communities. Community energy activities have been commonly defined through their local participation: energy produced “by” and “for” stakeholders. In this they have an open, participatory, and collective character, even as particular projects vary in regard to just how open and participatory or local they ultimately are (Walker and Devine-Wright, 2008). In the community energy context, the community is often defined as a local unit that operates inside a limited geographical area. The community typically features a shared ownership and financing structure as well as shared decision-making rules. Often, the maintenance and further development of the S-RET is handled by the community, which contributes to the upkeep and deepening of energy competences among the community members. As noted, the community energy initiatives can further foster alternative critical discourse on technological options, which can present an important alternative to mainstream views and occasionally lead to the convergence of elements of community energy becoming adopted in mainstream energy policy (Smith et al., 2016b).

However, locality-bound community energy no longer appears to be the only important community form related to energy users. Distributed energy communities exist through shared energy production outputs over a wide area network, beyond the limits of a specific locale. Currently, these communities have emerged for medium- and large-scale renewable production units

(Juntunen & Hyysalo, 2015). Lumituuli, a wind energy company in Finland, and Solar Energy Cooperative Green Point Batensteinbad Woerden in the Netherlands, are examples of cooperatively-owned green electricity plants, owned by household investors who share the outputs of generation. Wind and solar collectives in these examples are characterized by distributed ownership, and they require only the minimal direct involvement of local people and of participants more generally beyond a small executive group engaged in the endeavor. Here, the outcome is not locally focused and the unit generates energy for wide distribution rather than for use in the locality (Cf. Walker and Devine-Wright, 2008). The recent development into smart-grids is opening the grid in new ways for peer-to-peer networking concepts and virtual power plants that can be used with small-scale production units and with renewable micro-generation technologies. The exact forms of these distributed ownership communities are multiplying as peer-to-peer networking concepts have brought new models of sharing to community energy systems (Juntunen and Hyysalo, 2015; Steinheimer et al., 2012).

The internet forums portray a digitally mediated community form in which geographically dispersed users share an interest in the same class of technology and in a digitally mediated infrastructure without committing to shared finance or produce. As described above, the locality-independent reach allows internet communities to achieve much wider networks and higher coordination effects across the user base (Grabher and Ibert, 2014; von Hippel, 2016), helping them to add momentum to accelerating the sociotechnical pathway (Heiskanen et al., 2011; Karnøe and Garud, 2012). As noted, in these settings the household users own their S-RET equipment and utilize self-generated electricity for their own consumption but are actively linked to peers who run similar technologies and thus face similar questions in acquainting themselves with the technological options, scaling the system(s), choosing from among the available brands, and combining different S-RET forms and implementing, adapting, and improving their systems. In terms of the three generations of findings on users in sociotechnical change outlined in the introduction, the community energy discourse appears rooted in the 1980s–1990s understanding of what and how citizens shape technology for themselves and others, and in so doing neglect the import of digital communities.

Table 4.3 demonstrates the key differences between the three energy community types: local community energy, distributed output sharing, and dispersed knowledge-sharing communities (Hyysalo & Juntunen, 2018). Whereas in traditional community energy all aspects are dealt with locally, in distributed wind energy the project is owned and governed together and outputs are shared within the group or sold to other users over the grid. In dispersed knowledge-sharing communities, ownership and control over production are in the hands of each household. However, in terms of knowledge-sharing and learning processes, the household can enjoy the benefits of and contribute to a wide energy community wherein members share common interests on a much wider scale than in local and distributed forms.

Table 4.3 Case examples of community energy: a local community energy project and a dispersed structure community

	<i>A locality-centered community energy project (e.g., a wind project, a solar project)</i>	<i>A distributed energy community, created through output sharing</i>	<i>A dispersed energy community through knowledge sharing</i>
Scale of the production unit	Small or medium scale	Medium (or large) scale	Decentralized small scale
Ownership of the production unit	Community owned	Community owned	Owned by households
Daily operation	By an active group inside the community (or outsourced)	By an active group inside the community (or outsourced)	By user, user responsibility
Knowledge sharing and community learning	Social learning when working together locally for a common goal	Social learning among those in the community who engage beyond mere output sharing	Individual operational work supported by the online community; characterized by common interest
The scale of the community knowledge pool	The participants in the locally owned and run community energy project and their personal networks	The engaged participants in the energy project and their personal networks	Thousands of users with similar equipment and a broad range of competences
Governance characteristics	Organized; requires a governance structure, community control	Organized; requires governance structure, community control	Household control and autonomy
The distribution of energy production	Microgrid or grid connected; primarily for a group	Microgrid or grid connected; primarily for a group	Primarily for own use; mostly grid connected

The differences can be further illustrated by adapting the well-known community energy mapping of Walker and Devine-Wright (2008; Creamer et al., 2019). Figure 4.6 illustrates how the traditional and new forms of community energy contrast with a centralized wind power utility. Community energy can be seen as producing energy by open participation (Type A in the

Figure 4.6 Mapping energy communities regarding the outcome and participation in a digitalized world.

upper right corner of Figure 4.6); others stress that community energy primarily generates energy for community benefit (Type B); whereas in practice there is greater variety between and within community energy projects (area covered by Type C). Despite these differences, all these conceptions assume that energy communities involve important citizen participation and cooperative output distribution, which must be local and open. This is not the case with the distributed energy community that features distributed output, such as a medium scale wind cooperatives (Type D), which would clearly map away from the local end and, in most empirical cases, also away from most intensive forms of participation, typically having only a limited number of active members running the cooperative whereas others are involved mainly through financing and output sharing. The dispersed energy communities, such as the internet discussion forums (Type E in Figure 4.6) map onto the graph towards being distant and private in terms of outputs, but towards being open and collaborative in terms of participation, action, learning, and cooperation.

The form of digitally dispersed knowledge-sharing forums appears to matter as well. Unlike in the S-RET communities hitherto studied, the globally

dominant form of digital user community has had a company brand focus and sole control of the forums. The study of user-run online forums indicates that company-run online forums for a single brand—for example, the Ducati motorcycle community (ducati.kontain.com) or the Apple support community (discussions.apple.com)—provide only limited usefulness from a user perspective. Before acquisition, help is needed in order to compare different competing solutions from various vendors, not just from one provider. During the use period, products are embedded in practices of everyday life and use is typically linked to other products and, in active design engagements, it is by default that users tinker with more than one manufacturer offering.

As to the factors that may drive users toward local community energy or individual S-RET deployment, the differences are not decisive. Both provide returns on investment for owners, and give local control and power to make energy generation decisions. However, some factors favor household-specific installations. Planning permissions are typically easier the smaller the production scale. In heat production, a smaller distance between generation and use results in lesser losses in energy transmission. Organizational and contractual complexity around individual installations is smaller than in medium-scale community energy, which means greater agility in the set-up process. The peer support and expertise available in internet communities has begun to compensate for the knowledge based and competency benefits the community energy previously held over individual installations. It is thus foreseeable that increasing virtual connectivity among citizen users may create new, dispersed community forms both in S-RET production and in linking producing users with those who have storage or a load (Juntunen and Hyysalo, 2015, 2018).

4.5 Chapter conclusions

S-RET internet forums enable and facilitate peer-to-peer exchanges and knowledge accumulation, which other actors in the emerging market do not, or even cannot, provide (Grabher and Ibert, 2014). Through internet communities, citizen users gain easy and quick access to technology and market information, and they gain a polycentric knowledge repository that helps balance the various self-interested assessments around new technology. This helps in scaling the system to one's heating needs, choosing from among technological options and product alternatives, and comparing different vendor offerings. The forums provide a learning environment on the S-RET and its deployment in real-life contexts, including comparing heating systems' ongoing operation and performance, troubleshooting and maintenance, and DIY projects and inventions.

The internet communities strive only if they can accumulate a sufficient mass of diverse participants, who then have the interest and competencies to

address the varying issues their peers have regarding the new technology. In this capacity they are best conceptualized as forming a boundary infrastructure (Bowker and Star, 1999), which appears effective in fostering opportunities to learn through legitimate peripheral participation and deepen competences (Lave and Wenger, 1991) and also in facilitating their participants' learning, progressing from apprenticeship to mastery across domains of competence. In this view, many inventive users are not "born" but "grow" to have the capacities, and special needs/wants that drive them toward invention. User-run internet forums are conducive to the deepening of usership and allow some of the other users to act as user-side intermediaries to aid this. An implication of this argument is that the study of user innovation would benefit from more careful treatment of the nature of communities and types of user participation. Equating user communities with innovation communities, or drawing a demarcation line between inventive and non-inventive users, masks important cross-overs and areas worth researching.

The gains consumers make through participation in the internet communities affect systems change at the aggregate level. For buyers the forums complement the information available on the market on technology and product options and add transparency and trustworthiness to the new technology through the possibility to evidence peer experiences and use similar cases as references to one's own acquisition process. The community provides a channel through which the consumer voice can become expressed regarding satisfaction with supplier offerings, as well as shortcomings and failures in sales, performance, installation, and maintenance. This complements industry association efforts to maintain the quality and trustworthiness of a growing technology field, as does the community tendency to qualify incumbent slants and calculations made by research institutes with real-life data.

The discussions, installation types, and modifications displayed by peers further contribute to demand articulation regarding further technology development. In sum, the internet communities can play a substantial role, both at the scale of the individual participant and at the aggregated scale of market and technology shaping.

In all these aspects, the locality-independent reach allows internet communities to achieve wider networks and higher coordination effects across the user base than local communities or distributed cooperatives could, and in so doing they add momentum to the accelerating sociotechnical pathway (Heiskanen et al., 2011; Karnøe and Garud, 2012). These communities also allow higher variety in participant motivations and participation goals, and require less member specialization than, for instance, open-source software development projects (von Krogh and von Hippel, 2003; Hyysalo et al., 2013b; cf. Grabher and Ibert, 2014). As a consequence, as important as the grassroots innovation movements and community energy initiatives are at the start-up phases of energy transitions (Hargreaves et al., 2013; Smith et al., 2016b), the wider proliferation of new technology benefits from different

aggregation and exposure capacities, which the more diverse orientation internet communities can create.⁶

Regarding the literature on intermediaries in innovation and transitions (Howells, 2006; Stewart and Hyysalo, 2008; Kivimaa et al., 2019a, 2019b) the peer internet communities underscore the contingencies regarding who are the actors within an emerging industrial field that take on specific user-side intermediary roles—the ecology of intermediation can take many forms and remains subject to change as the field evolves. Within such an evolving ecology, citizen users can play an important part in reconfiguring dispersed knowledge resources to locally relevant assemblages, brokering connections between peers and suppliers, and facilitating learning about new technology and relevant actors, as well as learning about being a user of a new technology. Importantly, in the world of internet-mediated connectivity, peers do not need to be physically co-located for many of these activities to become effective, unlike what was assumed by the early concepts on user-side innovation intermediaries, such as warm experts (Bakardjieva, 2005) and local experts (Stewart, 2003).

Finally, in terms of policy implications, technology-specific online forums feature several behaviors that Nye et al. (2010) hypothesized as leading to behavioral change. Inventive and actively monitoring users set an example to others by deepening engagement with energy technology, arguably leading to a higher consciousness of how much energy is consumed and how it has been produced. Easy modifications and add-ons appear to give greater ownership of and visibility to energy issues that tend to become “infrastructural” and not be considered.

With regard to facilitating internet communities themselves, it may be illusory to seek to create such discussion forums through policy measures, but allowing (often anonymous) discussions to prevail holds benefits, and some energy and climate policy actors, such as energy councilors, might offer their advice through these discussion forums, as has already happened in youth work after the realization that it is increasingly on the internet where people can nowadays be reached. Some forums may benefit from nominal support in order to cover running costs. Companies could also volunteer to further develop their best DIY ideas with a compensation scheme in place. Best arrangements in policy, co-design, and company involvement are, however, likely to vary with respect to the type of forum, technology, and user base in question. The forums examined here feature several facets relevant to those trying to set up and facilitate technology-related internet communities: segmentation of the community into separate sections to facilitate the co-existence of different user orientations, including a separate section for provocative and speculative exchanges; active but tolerant moderation, which primarily refers discussions to appropriate areas; and allowing some forms of private messaging and anonymous presence, which allows different professionals to engage in projects and speculation without reputation loss.

From a BOAP methodology perspective, the analyses of S-RET internet communities display an expansion pattern, in which the original research interest in user innovation was gradually superseded by an interest in seeking to understand how the inventive activities were embedded in internet-based peer communities. Consequently, the peer learning, competence building and peer-intermediation activities were studied more closely and it became apparent that these communities ought to be studied for their own right to understand what all happens there and to what effects. This entailed a shift from innovation studies framing toward S&TS that was better equipped for studying internet communities and characterizing them. A further expansion in the focus of investigation ensued once we moved from studying individual users and what the internet communities may offer them to wider ecologies of intermediation and the role that the user communities play in the wider sociotechnical change. This meant also bridging the study to a new set of reference literature on energy communities and energy transition to make sense of how the nature and kind of transition relevant energy communities may have changed. The concluding chapter will address in more depth how these focal shifts in research program relate to tracing the *series of configurational movements* (Hyysalo et al., 2019a) that comprise the overall import of users in sociotechnical change, but to do so we first need to zoom out more and examine the range of user activities in Finnish energy transition, which we do in the next chapter.

Notes

- 1 This chapter integrates and expands research that has previously appeared in Hyysalo, S., Juntunen, J., and Freeman, S. (2013b). Internet Forums and the Rise of the Inventive Energy User. *Science and Technology Studies*, 26 (1), 25–51, in Hyysalo, S., Juntunen, and J.K., Martiskainen, M (2018) Energy Internet forums as acceleration phase transition intermediaries. *Research Policy* 47 (5) 872–885. Short sections have also previously appeared in Hyysalo, S. and Juntunen, J.K (2018) User Innovation and peer assistance in small scale renewable energy technologies. In Davidsson & Gross (eds) *Energy in Society Reader*. Oxford University Press.
- 2 See the full discussion at <http://lampopumpput.info/foorumi/index.php?topic=1375.0>.
- 3 It is worth noting that there is hardly any single schooling that would prepare someone to have the encompassing expertise in all the system areas involved here. The professionals, too, have learned many of their skills out in the field.
- 4 One should add 20–30% more reads in the GSHP forum in order to get the full picture regarding heat pumps.
- 5 The cumulative reader count is measured from unique IP addresses. The IP addresses from an organization can show as only single address but also people can have several IP addresses from which they access the site. The rule of thumb for counting real visitors from IP addresses varies; typically, there are more visitors than IP addresses, but given the decade-long timespan here, we use a conservative and broad estimate of 1–3 million visitors.
- 6 Similar arguments have been made between locality-based user innovator communities and Internet-based open-source communities (Baldwin and von Hippel, 2011; von Hippel, 2017). Regarding energy transitions, we can also observe some carry over between user intermediation from an already widely diffused niche technology to another, such as when peer advice in heat pump Internet forums proliferates into other,

less-diffused renewables for the purpose of creating hybrid heating systems for yet higher eco-efficiency in a specific national context (Juntunen, 2014a, 2014b; Hyysalo et al., 2013b, 2017). These domestication and diffusion pathways are a research area that merits further attention. We can also conjecture that digital communities truly prosper if a critical mass of discussants can be found and are thus not likely to be as effective as the predominant form of community as local communities are in the early explorative stages of the development of alternative new technologies.