VGTU LEIDYKLA TECHNIKA

PUBLIC-PRIVATE-PEOPLE PARTNERSHIP AS A WAY TO REDUCE CARBON DIOXIDE EMISSIONS FROM RESIDENTIAL DEVELOPMENT

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ABSTRACT. This paper examines the possibility of Public-Private-People partnership (4P) model as a way to reduce carbon dioxide emissions from residential developments. The case project focuses on the energy system design as a part of urban planning. Based on the case experiences, the paper presents a 4P framework for low-carbon residential development systems. The theoretical model was tested in one specific case project, Nupurinkartano. The major findings were that the 4P framework is a relevant tool for decreasing carbon emissions when planning a new development; the applied solution delivered an energy system design that could reduce the CO_2 emissions of the development by 75%. Based on literature this paper suggests that a new development should be viewed as one system instead of several different subsystems. The paper concludes by suggesting that 4P offers an alternative approach for urban planning, specifically energy system planning, and it can deliver significant improvements in carbon efficiency.

KEYWORDS: New residential developments; Energy system planning; Public-Private-People partnership (4P); Carbon dioxide emissions

1. INTRODUCTION

Cities grow worldwide, both within their juridical borders and as commuter sheds of several independent municipalities. Kennedy et al. (2007) defined the situation where no single entity defines the rules for urban growth by term ”commuter shed”. Behind urban growth, there are urban planning processes that weigh different aspects of planning, such as house type, housing volume, traffic system, infrastructure, services, and many more, and create new residential developments. However, traditionally neither of the previous growing patterns considers urban planning process as a single system but as several, often linear, non-related sub-systems and processes, which typically include strong barriers between the responsibilities of the public and private sectors and between municipalities and inhabitants (Healey, 1998; Väyrynen, 2007).

One way of examining a residential development as a system is to study its inputs and outputs, metabolism. Ayres (1994) introduced the idea of metabolism in this context. It refers

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to energy and material flows in ecological communities. In this approach, the planning concentrates on the flows of the functional system, what it takes from outside its geographical borders, and what it returns back. For example, infrastructure services are systems that typically are operated from a remote plant, consumed in the area, with emissions again handled elsewhere. This view of regarding a system as inputs and outputs has often been used in industrial ecology (IE), ever since Ayres (1994), White (1994), and Frosch (1992) defined it. Energy systems are heterogeneous, they contain different levels and are distributed but can be studied by means of integrated assessment (IA) (Agusdinata and DeLaurentis, 2008).

Climate change mitigation and reduction of carbon emissions has a high prominence in the European Union (EU). Accordingly, the carbon influence of the housing sector has been studied vigorously. For example, Norman et al. (2006) have emphasized the significance of housing in Canada. Other studies by Bin and Dowlatabadi (2005), Munksgaard et al. (2000), Reinders et al. (2003), and Lenzen (1998) have highlighted household energy use and related greenhouse gas (GHG) emissions as the most significant indicator of environmental pressure. Household heating is estimated to represent 10 percent of the total GHG emissions in both the EU-15[1] and the EU-27[2] countries (European Environmental Agency, 2008). In northern parts of the continent, heating energy plays an even greater role in GHG emissions. In Finland, for example, household heating has a share of 21 percent (Tilastokeskus, 2008). A Europe-wide comparison has been conducted by Bürger et al. (2008), who claim that it will not be possible to meet the requirements of climate targets without increasing the use of renewable energies in heating. Due to the high influence of energy in the housing sector, there is an urgent call for a low-carbon solution for heating and cooling services.

New regulations have also been presented regarding energy efficiency and renewable energy in newbuilt houses. These include the European Commission's EU 2020 objectives (European Commission, 2005), which aim at having a higher proportion of renewable energy being used. The European Commission (2005) and other studies (Moll et al., 2005; Simola et al., 2007) have estimated that in Europe, about 40 percent of national energy use and GHG emissions are related to household services consisting of heating, production of domestic hot water and cooling.

The purpose of this study is to examine the possibility of achieving measurable results in reducing carbon emissions with a Public-Private-People partnership (4P) approach for planning low-carbon residential developments and offering an alternative path for energy system design for them. Bringing fourth P, people, to the field of planning adds complexity to formerly sequential system. This study is based on two propositions: First, that the traditional urban planning process does not effectively meet the carbon challenge of residential development; and second, that the new residential development could be viewed as a system in order to reduce the carbon emissions.

The paper uses the Public-Private-People partnership (4P) framework in urban planning and brings the future inhabitants to residential

[1] EU-15 refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[2] EU-27 refers to EU-15 plus Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia and Romania, which all joined the Union in either 2004 or 2007.

development system. A new 4P framework for an urban planning process is presented, and further, applied to the planning of a holistic energy system for a new housing development in northern Europe. The study restricts its scope to the energy system (energy production, heating, and cooling) of the residential development.

The paper is structured so that we first present a theoretical 4P framework for residential developments and residential developments as systems; then the framework is applied to a case project; and finally, the improved framework is suggested. The Case study compares two alternative scenarios for providing heating services for the new residential development. The first is business as usual and the second is the 4P-based. Finally, the overall findings relevant to the research propositions are presented and conclusions are drawn.

2. RESEARCH DESIGN AND METHODS

2.1. Research design

Research is carried out by first creating a theoretical framework of 4P based urban development system. Secondly, a case study is conducted where the theoretical framework is tested. And finally, an improved theoretical framework for residential development as a 4P-based system is presented. Flyvjberg (2006) underlines the need for studying cases that are not too common in order to be at the forefront of a scientific discipline. In addition, Allenby (2006) encourages this type of research in order to deal with complexities that are not found in nature.

A case-study approach has been adopted here. The new residential development project area of Nupurinkartano in Espoo in southern Finland is the case. The project's decision-making process during the energy system design was the main focus of observation. Nupurinkartano was selected as the case area for following reasons:

- The area had no existing energy system and was thus open for new solutions;
- The land was privately owned and the private developer also had an active role in the urban planning phase of the project; and
- The area was allocated for housing in the general plan.

Nupurinkartano was analyzed from the beginning of the urban planning project in 2005 until the approval of the detailed plan in 2009 through documents and reports produced in the planning process and the active role of the researchers themselves in the process. The active role of researchers in fact-finding for practical problem-solving in social situations can be used to improve the related quality of action (Patton, 1990; Burns, 1997). Due to this, the researchers have had an important role in the development process for the case area.

The Nupurinkartano planning process has been studied before. The focus of the studies was on customer participation and participatory planning (Staffans et al., 2009; Majamaa et al., 2008a). This study builds on the results of these previous studies and examination of the planning process and planning documents from the beginning of the urban planning project in 2005 until the approval of the detailed plan in 2009. These include the final detailed plan and plan description and proposal versions of them, formal opinions received, a more detailed level block plan, infrastructure plans and conducted surveys.

2.2. Theory: New residential developments, systems and 4P

The theoretical background of this study is related to public-private partnerships in urban planning. The urban planning framework in this study is the 4P model (Public-Private-People Partnership), an application of PPP (Public-

Private Partnership), as defined by Majamaa et al. (2008b) and Majamaa (2008). In the 4P model, there are three primary actors in urban planning: the municipality (Public), the developer (Private), and the end-users (People).

Real life phenomena, like urban planning, require not only observation and research, but informed decisions and technology solutions as well (Allenby, 2006; Ehrenfeld, 2004; Korhonen, 2004). Contemporary problems are normative, whereas science is always suggested to be positive by nature (Ehrenfeld, 2007; Allenby, 1999). This also matches Ehrenfeld's (2007) "the normative imperative of sustainability" in planning.

These basic assumptions form also the launching pad for IA, an approach to provide relevant and usable information to decision-making of complex issues (Van Asselt and Rothmans, 2002). It has been successfully used in describing energy systems by e.g. Agusdinata and DeLaurentis (2008).

New developments viewed as systems

The residential development system mixes elements of political, economic, and social decision-making with technically oriented industrial processes and urban planning. As we cannot just specify it geographically, it is more functional to approach its elements by system boundaries. Also Van Asselt and Rothmans (2002) underline this legitimation of system boundaries. Allenby (2006) and Lahti et al. (2006) distinguish system boundaries from geographical boundaries defined by political decisions, whereas Amin (2002, 67) clearly states that "Infrastructures are complex networks, geographically dispersed, nonlinear, and interacting both among themselves and with their human owners, operators and users". Ehrenfeld (2007) goes one step further, claiming that the modernist paradigm includes geo-political boundaries, whereas the sustainability paradigm has natural boundaries. This distinction is also widely admitted in the planning theories (Van Assche and Verschraegen, 2008). Herein, urban planning is understood in its inclusive form as a way in which a community affects its members' quality of life, environment, social and economic infrastructure, and not just actual plan-making (Friedmann, 2005; Lemmetty et al., 2005). Residential development as a system consists of a limited amount of actors (households) and a supply system designed for them.

Urban planning very much defines the energy system design later in the process, because system definitions are made during the urban planning phase and boundaries are formed by political decisions before the actual planning (Lahti et al., 2006). Still, urban planning is treated as planning that considers only the spatial characteristics of a certain area. Modernist planning aims at creating one 'right' solution by analyzing area qualities. However, geographical and biological surveys do not cover qualities such as the potential for producing energy locally. Korhonen (2004) emphasizes the need for inter-organizational focus, which often gets lost in the traditional urban planning process. Collaborative urban planning is about governing networks and partnerships (Agger and Löfgren, 2008).

We study the flow of energy in consumer activity and its carbon emissions in order to pursue the design of an energy production-consumption system. In residential development both thermal efficiency of dwellings and used heating technology are vital as is energy infrastructure and consumption patterns (Agusdinata and DeLaurentis, 2008). New development needs both ecosphere (nature and its elements) and technosphere (man-made environment) around it in order to get water, heat, and electricity. Emissions caused by the technosphere, such as GHG's and sewage, end up in the ecosphere. The environmental system generates all the flows and receives all the waste and emissions (Allenby, 2006). Here the new residential development acts as a major source of interaction between human (urban planning) and natural (metabolism) systems.

The residential development system overlaps with the environmental system, because it consists not only of houses, roads, and technical infrastructure, but also of the living environment and nature support system needed by inhabitants. When new homes are built in a new development, it gives us a chance to view the development as a holistic eco- and techno-system with its inputs and outputs.

4P framework for new developments

One important point of view in the decision-making process in a new residential development is the end-users. Urban planning in Europe and elsewhere has been strongly connected to rationality and power. There have traditionally been two main players: local government and the developer (Majamaa, 2008; Mäntysalo, 2002; Flyvjberg, 1998). In Finland, developer usually has a significant role in developing private-owned land (Lahdenperä, 2009; Majamaa, 2008). Recently a third actor, people, has been introduced (Majamaa et al., 2008b; Lemmetty et al., 2005). Here, "people" refers to the end users of the system, that is, the residents of the residential development.

Currently, people cannot affect system planning but are obliged to join the formed monopolies in energy and water supply (Majamaa et al., 2008a). Both interfaces, municipality–developer and developer–end user are unilateral, with information and decision-making going only downstream, and discontinuities do occur (Väyrynen, 2007). Actors and their roles in the urban planning process by Väyrynen (2007) and Majamaa (2008) are presented in Table 1.

The end users, people, are these consumers that we are bringing to our framework, as well.

3. CASE STUDY

3.1. Nupurinkartano new development and its planning process

The Nupurinkartano residential development is a greenfield area located in the municipality of Espoo and will consist of single-family, duplex, and row houses. It will be home to over 500 people. Permitted housing volume is about 28,000 square meters. Besides housing, there is only an inferior amount of about 300 sqm of permitted commercial building volume.

Land is privately owned so both the private owner and the developer have an active role in the planning process. End users and potential end users have been actively involved in the planning process of the area and have participated in the urban planning. Former reports (Staffans et al., 2009; Majamaa et al., 2008a) clearly show the desire of citizen-consumers for more sustainable new developments and different planning methods and opportunity to participate when comparing 4P and traditional urban planning.

Table 1. Actors and their roles in the urban planning process

Actor	Public (Municipality)	Private (Developer)	People (End users)
Role	– defines urban planning and infrastructure systems – controls the input flows (energy, water)	– develops area and brings new ideas to markets – delivers the project – defines technical systems for buildings	– end users of system – use energy – produce waste and generate emissions

Source: Väyrynen (2007); Majamaa (2008)

In none of the planning documents mentioned in chapter 2.1 or discussions the energy system planning played any significant role. The only point it was mentioned was in the plan proposal phase, where the opinion of energy operator was asked about energy service on the area similarly when opinions of e.g. phone networks or wastewater networks were asked from their operators.

3.2. Traditional and 4P-based urban planning processes

In the traditional situation, the developer does have only little decision-making power within the planning process as a whole. Decisions are made top down: the municipality at the top makes the important decisions affecting system level and these decisions are handed down to the developer to implement and to deal with the consequences of them. At the very bottom is the end user. So neither the end user nor the developer have the opportunity to contribute to the top-level planning decisions. The traditional process is said to be sequential and information gets lost in it (Väyrynen, 2007). The traditional urban planning process is led by the public sector, typically the municipality. It provides regulations concerning the planning, draws the plans itself, and sometimes even delivers the energy system. In the traditional process the private party, the developer, delivers the houses and their technical systems according to public sector decisions. The top-down system constrains those downstream, the developer and end user, that is. In this case, the developer tends to be investment cost-oriented and ends up choosing the option with the lowest investment cost.

People, existing and future inhabitants, are only end users of the system and have no opportunity to affect the decisions concerning the energy system design. Relationships between public and private as well as private and people are unilateral, the latter acting based on decisions made by the former. People, final users of the new development, customers of the developer and citizens of the municipality, are only involved as citizens with a possibility of leaving their comments at a certain phase in the detailed plan approval process. The only form of feedback in the traditional planning process is formal comments from people to public authority.

The traditional preference for heating systems in urban areas of Finland is district heating produced in combined heat and power (CHP) plants and delivered by a local energy operator, where available. This is a clear outcome from the planning process in Nupurinkartano as well, where local planning authorities asked only the opinion of private energy operator owning district heating network in Espoo. In the planning phase, the local energy operator stated that the Nupurinkartano area is too far from the district heating network, so the developer had to actively search for other alternatives. The usual form of a heating system would in this case be direct electric heating, due to its low investment costs and ease of delivery (Energiateollisuus, 2008a). This is a clear example of restrictions going downstream.

The Public-Private-People based process (4P) originates from Majamaa's (2008) observation that direct customer contact is missing from PPP-based urban planning process on a general level.

The 4P-based process is interactive and includes direct formal and informal relations between all P's, not only formal participation. Public-Private relations are part of typical PPP urban planning, where the private sector has an active role in plan-making and financing projects. As part of the Public-Private relations, the public party works together with the developer, who also supplies private resources to the municipality and shares the costs of planning. The private sector is responsible for the actual planning material and background studies related to planning (Majamaa, 2008). Thus PPP can also be viewed as part of 4P. In the case study the Private initiated the 4P together with the researchers in order to get more knowledge about future inhabitants' wishes.

The role of participation and local decision-making can be characterized as formal Public-People relations. The most interesting part of the 4P process is the interface between the private sector and the people - the potential end-users of the new development. This can be characterized as Private-People relations. The interface between Private and People (Private-People relations) is a novel approach in urban planning in Finland. Usually this relationship only occurs in the marketing and sales phase, after the planning has long been completed.

Figure 1 presents both traditional and 4P urban planning processes. The traditional process is sequential, so the previous actor defines the starting point, and thus the possibilities for its follower. In energy system designing, this means that the public party (municipality) makes decisions about the system, the developer chooses property level heating technology according to that, and the people have no choice left. The 4P process is interactive with direct relations between all the actors in the planning phase.

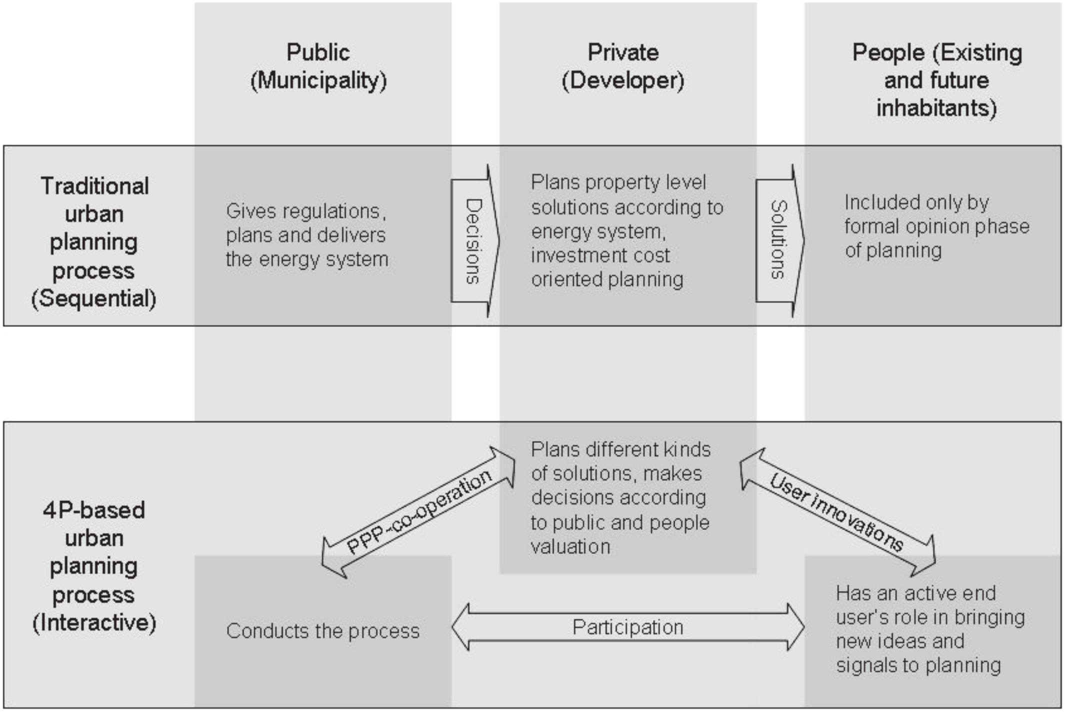

Figure 1. Traditional and 4P urban planning process, where PPP is viewed as Public-Private relationship of 4P.
The roles of the actors and interfaces between them in residential development energy system planning and urban planning

3.3. Urban planning and energy system design process in Nupurinkartano

In the 4P-based urban planning process applied in Nupurinkartano, the public conducted the planning by political decisions. The municipality, the developer, and the landowners outsourced the actual plan-making to consultants. This can be characterized as Public-Private relations.

One of the informal yet effective participation methods used for Private-People relations -- an open, unstructured, two-phase internet questionnaire -- was a completely new participation method in urban planning processes in Finland. Other methods were meetings held between people, private and public authorities, environmental groups and civil society organizations, and an internet forum (Majamaa, 2008). Authors participated in arranging informal participation mentioned here alongside with formal planning process.

The 4P process, especially the questionnaire, clearly brought out the future inhabitants' wishes for more sustainable housing (Majamaa, 2008; Staffans et al., 2009) that again led to a discussion of energy system design because its crucial role in emissions. Also, due to the inaccessibility of traditional district heating mentioned in the plan, a new energy solution was needed. The energy system design was conducted in workshops led by the developer in which the authors also participated. After several workshops and meetings between the developer, the energy operator, and the heating system provider, an alliance was formed in order to develop a sustainable energy system to deliver energy to housing in Nupurinkartano. Different possibilities were investigated during 2007. It is worth noticing that energy issues are not mentioned in the official detailed plan report or mandatory environmental impact assessment report but private and people stakeholders brought the issue to the planning.

A common understanding strengthened by the 4P process was that direct electric heating is too unsustainable a solution to survive in the consumer market in the long run. The developer did not want property-specific heating systems because of the obligation to maintain them for ten years after selling the property. A local closed-loop system using renewable energy and measurable improvements for the whole development was thus a common goal. An emission-cutting oriented, economically feasible energy system design approach was then selected and system boundaries were set by energy system requirements and not by the planning process.

At first, only options with property-specific solutions were examined. The most promising technology available from a low GHG emissions point of view was a ground heat system. Then a wider scope was selected and a decision was made to commit to research an areal ground heat system. The conceptual technology testing for the system was done by the Helsinki University of Technology and the Geological Survey of Finland. It was found that rock in Nupurinkartano is suitable for heat production and that technical systems for buildings can be designed to use a low heat resource (Foda et al., 2008; Leppäharju et al., 2008). Furthermore, it was found that adding ground cooling improves the system efficiency even more as presented in section 4. All property level solutions and centralized ground heat solution proposed in the workshops were simulated in order to get comparable quantitative data.

The formal planning process and the 4P advanced simultaneously in Nupurinkartano as presented below in Figure 2. Majamaa (2008) and Staffans et al. (2009) have already reported effects of 4P to detailed plan that enables customer to have more options in house planning phase. Also the municipality planning authorities found information gathered via 4P very useful and gave chance for new kind of methods.

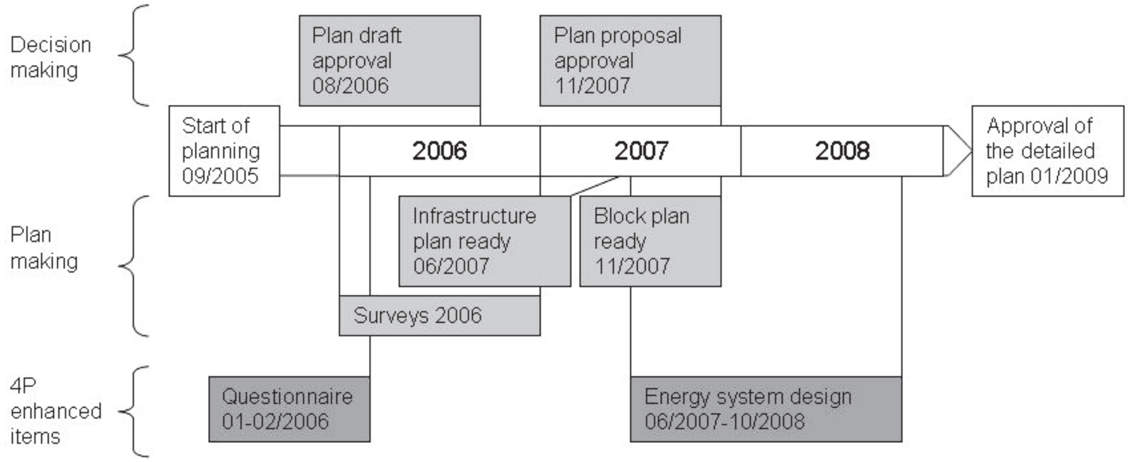

Figure 2. Timeline of formal decision making and 4P planning process in Nupurinkartano

In Nupurinkartano, development roles and interfaces were clearly 4P-based. The lack of energy issues in the formal plan fuelled the emergence of the 4P process. The private party actively sought solutions for providing an energy infrastructure and encouraged the involvement of people in the planning. Thus, a renewable heating and cooling energy system could be designed for the area. Additionally, the developer–end user interface was bilateral, a result of the 4P approach. During the research, an economically sustainable solution to deliver the system was developed.

4. RESULTS AND FINDINGS

4.1. The case-specific energy use and carbon emission simulations

The simulations were calculated separately for each optional property-specific heating system as well as for the centralized ground heat system. CO_2 emission calculations of electricity production have been done using the average of Nordic electricity pool production and coal condensate electricity (Tilastokeskus, 2005; Flyktman and Helynen, 2004; IPCC, 2001; Energiateollisuus, 2008b). The carbon calculations contain only the CO_2 emissions from the actual energy production process without earlier life-cycle phases of the energy systems. The starting values of carbon emission simulations are presented in Tables 2–5.

Table 2. CO_2 emission factors for different fuels

Fuel	CO_2 emission factor [t CO_2 /TJ]
Coal	94.6
Light fuel oil	74.,1
Natural gas	56.1

Source: Tilastokeskus (2005)

Table 3. CO_2 emission factors by electricity production types

Electricity production type	CO_2 emission factor [g CO_2/kWh]
Coal condensate (efficiency in electricity production 43%)	792
Wind, water	0
Nordic-mix (Nordic electricity pool average)	98

Source: IPCC (2001); Flyktman and Helynen (2004); Energiateollisuus (2008b)

Table 4. Heating CO_2 emission factors

Heating type	Efficiency in heat production	Fuel	CO_2 emission factor [g CO_2/kWh]
Property specific oil heating	90%	Light fuel oil	296.4
Property specific natural gas heating	95%	Natural gas	212.6
Property specific direct electric heating	100%	Nordic-mix	98.0
Property specific direct electric heating	100%	Coal condensate	792.0
Property specific direct electric heating	100%	Natural gas combi (condensate)	367.2
Property specific ground heat pump	300%	Nordic-mix	32.7
Property specific ground heat pump	300%	Coal condensate	264.0
Property specific ground heat pump	300%	Natural gas combi (condensate)	122.4
Centralized area ground heat system	400%	Nordic-mix	24.5
Centralized area ground heat system	400%	Coal condensate	198.0
Centralized area ground heat system	400%	Natural gas combi (condensate)	91.8

Source: IPCC (2001); Flyktman and Helynen (2004)

Table 5. Energy use in Nupurinkartano

Nupurinkartano energy use (domestic hot water)	1,240	MWh/a
Nupurinkartano energy use (Heating) (as per 2001 weather data)	1,493	MWh/a
Total	2,733	MWh/a

Source: Foda et al. (2008)

The results of the calculations showing the CO_2 emissions caused by heating and domestic hot water production in all of Nupurinkartano are presented in Figures 3 and 4. The areal ground heat system is the only studied system where the energy for cooling is also included in the energy consumption and CO_2 calculations.

When comparing the yearly CO_2 emissions of the heating system of the whole development, it becomes evident that direct electric heating or oil heating are clearly inferior compared to the areal ground heat solution in Nupurinkartano. Emission calculations are based on energy consumption values calculated by Foda et al. (2008) using IDA Indoor Climate and Energy 3.0 software and Earth Energy Design software. Foda et al. (2008) show that energy consumption (heating, cooling, and domestic hot water) in the area would be 97.4 kWh/sqm/year, thus achieving Finnish energy class A based on the EU directive concerning building energy efficiency (European Union, 2002).

Compared to direct electric heating, the areal ground heat system is superior in CO_2 emissions. Emissions were calculated here with the estimation that the yearly efficiency of the property-specific ground heat system is the typical 300% (meaning that one unit of electricity used in heat pumps produces three units of heat), while the efficiency of the centralized areal ground heat system is 400%. According to Leppäharju et al. (2008), the final results for the areal system could even be better than that.

The centralized system is superior to a property-specific one because it allows two compressors to be used in series while still remaining economically feasible (Foda et al., 2008).

The sensitivity of the carbon calculation was also tested with the coal condensate electricity, which has the largest CO_2 footprint of all available power production methods. Even in the case of coal condensate electricity used in the heat pumps, the areal ground heat system is the best alternative regarding CO_2 emissions, as can be seen in Figure 3.

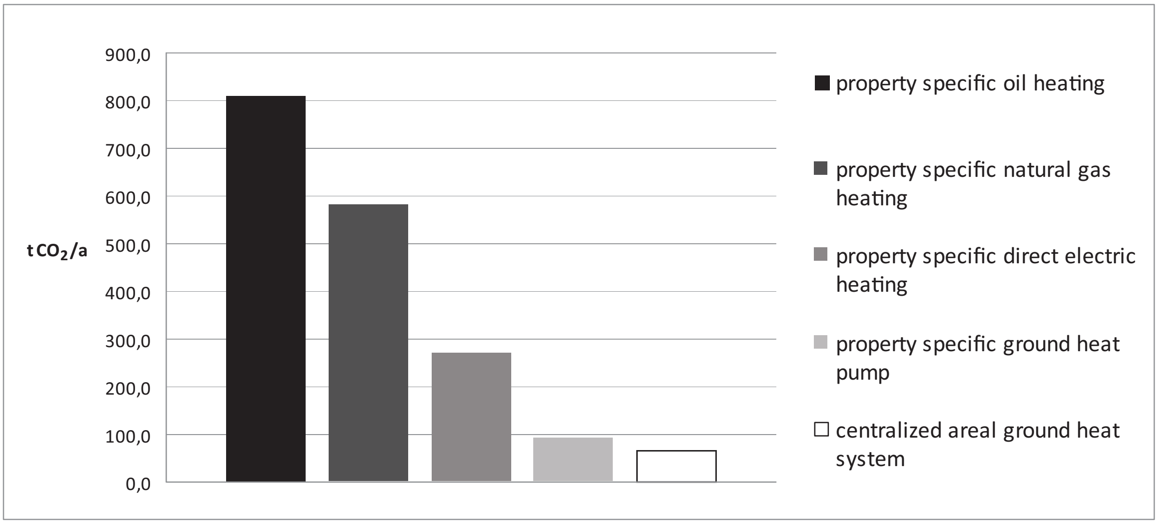

Figure 3. Yearly CO_2 emissions in Nupurinkartano when Nordic mix electricity is used to power the heat pumps

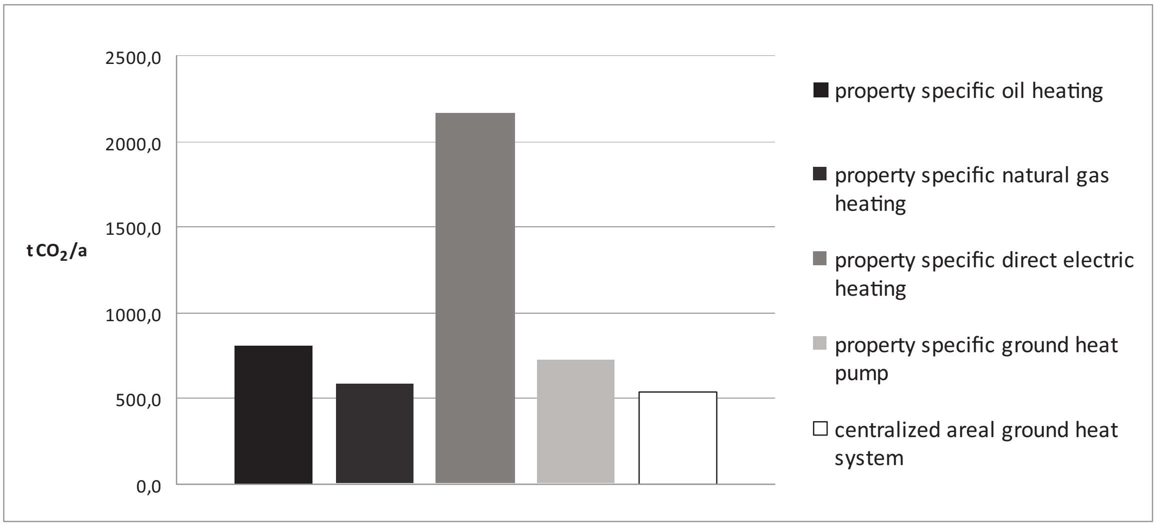

Figure 4. Yearly CO_2 emissions in Nupurinkartano when coal condensate electricity is used to power the heat pumps

In the Nupurinkartano case, the centralized areal ground heat system was the best of the simulated options. The relative carbon benefits of the centralized areal ground heat system depend on the production technology of electricity, but in all cases it provided the lowest level of CO_2 emissions. In addition, the centralized areal ground heat system adds value for the consumer because it includes cooling.

In summary, the environmental benefits of using the centralized areal ground heat system are the following:

- The new system provides 75% lower CO_2 emissions than the business-as-usual scenario;
- Even in the worst-case scenario, where coal condensate electricity is used, the ground heat system is better than heating by oil or gas; and
- Only one-fourth the electricity is used compared to direct electric heating, so CO_2 emissions are only one-fourth regardless of the way in which the electricity is produced.

4.2. The usability of 4P framework in reducing carbon emissions

Based on the case Nupurinkartano experiences, 4P can be a successful way to conduct emission oriented urban planning. Areal ground heat was selected as energy system. The local environment is included in the system because heat is produced locally. The whole urban planning process is entwined with the possibility to produce energy locally for the whole area. It is a closed-loop system with only a small amount of external energy flow representing about one-fourth of the energy produced. The advantages of ground heat are stable production even during the wintertime, a low level of CO_2 emissions, no need for a separate plant, and independence of municipal heating networks, reliable technology, and possibility of cooling. The investments in boreholes, the most expensive part of the system, can be done synchronously as residential quarters are built. For inhabitants, the system is as easy to use as traditional district heating would be. The results of energy system planning were not part of final detailed plan approved in 2009 but plan regulations were formed so that areal ground heat system could be located in the area.

The new development is viewed as one system including the local environment instead of several different subsystems or overlapping systems. Inputs and outputs are viewed on a system level, and emphasis is put on local alternatives like local energy production in Nupurinkartano. There are direct relationships between consumers, people, and producers; in the case presented, there are relationships between final energy consumers and the designers of the production system. 4P planning process of a new development helped to achieve measurable results in the case. Urban planning is actually seen as a process of controlling flows within the “system” under development, whereas traditional urban planning is a sequential planning project having no through-passing flows involved.

5. DISCUSSION

The purpose of this study is to examine the possibilities of achieving measurable results in reducing carbon emissions with a Public-Private-People partnership (4P) approach for planning low-carbon residential developments and offering an alternative path for energy system design for them. Bringing fourth P, people, to the field of planning adds complexity to system.

This research had two aims. The first was to test whether the 4P framework can lead to decreasing in carbon dioxide emissions of residential developments. The second was to consider whether the people be presented as part of the residential development system instead of being just the tail of present sequential and fragmented process.

The technical result of the study was that the tested 4P framework for the energy system design for a residential development led to a clear decrease in CO_2 emissions when compared with the business-as-usual scenario. This was also emphasized by the potential new inhabitants in previous stages of the 4P process. The decrease in carbon emissions was already hypothesised at the beginning of the study, but the magnitude of the reduction (fourfold) was still a surprise. A more conceptual result of the study was that the residential development system is improved, albeit with increased complexity, by adding 4th P.

The originality and value of this paper lie in providing a new way of thinking for urban planners, policy makers, and developers. The design of the energy system for Nupurinkartano was the first recorded instance in the research literature of 4P being used as a planning method for the energy system design of a new development.

No previous studies were found that would combine the 4P and reducing CO_2 emissions. However, some European studies exist where system level thinking and redistribution of responsibilities has led to improvements. A classical example is the Kalundborg eco-industrial park in Denmark. Ehrenfeld and Gertler (1997) have claimed that the key to success at Kalundborg was a sequence of independent, economically driven actions, but the evolutionary pattern found may not be easily transferable to greenfield developments. In this study, Nupurinkartano is a greenfield development, but the solution was introduced via economically driven actions. A study of Dutch rental apartments presented that private decision makers can significantly contribute to governmental environmental policies by improving the energy performance of their existing housing stock (Smid and Nieboer, 2008). In Nupurinkartano developer made similar strategic decisions than professional landlords in the Dutch study. Baas and Boons (2004) investigated Rotterdam harbor as an IE system. They found out that long-term growth and sustainable development combined with IE in the harbor region requires for new institutional arrangements. In Nupurinkartano, 4P can be viewed as such an institutional arrangement. Björklund et al. (1999) studied one subsystem of urban development, waste management. They stated that generation of energy is crucial in sustainable waste management. In the Stockholm case, material is turned into energy, whereas in the Nupurinkartano case, the existing local energy resource (latent ground heat) is utilized. In a study carried out in Sweden, Mahapatra and Gustavsson (2008) have noticed similar reductions in emissions as those found in the Nupurinkartano case in the ground heat system. They also emphasise that using ground heat is economically feasible.

The reduction in carbon emissions can mostly be explained by a significant system-level change in the energy system design and the widening of the system itself from property-specific to an areal system and from heating only to heating that includes cooling. Technically, the better carbon efficiency compared to the property-specific solution was achieved by a centralized solution allowing several heat pumps to be used and put in series. Also, the possibility of cooling and thus charging the rock in summertime improves the efficiency and adds value to the system. In a traditional urban planning process, the developer lacks decision-making capabilities concerning the whole planning process. The strategic management of the whole development process is much more complicated. End-users have little or no effect on their emissions and all participants feel compelled simply to choose the system that costs least. In a 4P framework, the active management of the whole process is possible.

This case study presented one 4P-based residential development. Based on a single case, it cannot be assumed that the same results would be achieved in all new residential developments. Planning cultures, legislation, and market situation differ country by country. 4P is not the only way to end up with an areal ground heat solution, nor does the solution require 4P-based residential development even if we suggested that traditional urban planning process would have led another path in this case. In traditional public authority-led planning, the solution is possible but requires the Public to act differently.

There is also a question of the role of researchers as both detached scientific observers and participant actors. We had to be able to assume responsibility and to commit personally to the information we had partly produced and the questions we have promoted or opposed with the help of that information. We have no reason to suppose that the results are unreliable. We also have made our participant status clear. On the other hand, the combining of research and practical work has also made it possible to introduce new real-life questions into this research.

The 4P framework proved to stand up to closer examination in reducing carbon dioxide emissions in one case study in the Finnish market, climate, and planning system. The areal ground heat solution presented in the study could be used elsewhere, and, the applied technology is widely available. Similarly, fairly similar external conditions can be expected to exist in new residential development projects, both in Finland and elsewhere at northern latitudes. When district heating is not available, it pays off to aim for a centralized areal solution instead of property level systems. The results may offer a fruitful alternative approach for the process in cases with similar conditions.

On a conceptual level, it seems suitable to couple a 4P framework for a residential development with the design of an energy system. However, more studies are needed for further generalizations. Further research is also needed to couple other parts of planning to the framework, such as design of other subsystems of new development (e.g., water and sewage systems, transportation systems). Similarly, a life-cycle assessment (LCA) would be needed for a more comprehensive study of the energy system. An organization-level LCA concerning the development project is thus possible only by viewing the whole energy system (Ny et al., 2006). Finally, it would also be worth researching the roles of all the actors and interdependence between them; that is, to further study PPP and 4P in urban development and the role of public authorities. Integrated assessment could well be used in this kind of study.

This kind of 4P urban planning suggests a variety of other possibilities for the future. The results of this article should be of value to developers, planning authorities, and politicians, locally and nationally. Other sustainability indicators should be included in the framework in order to create a broader framework for sustainable urban development.

6. CONCLUSIONS

This study rested on two propositions: First, that the traditional urban planning process does not effectively meet the carbon challenge of residential development; and second, that the new residential development could be viewed as a system in order to reduce the carbon emissions. The study showed that both of the suggested propositions are true in the case of residential energy systems development.

The conclusion of this case study is that 4P is a suitable framework for the energy system design of a new residential development and that it offers significant measurable improvements for urban planning. It also became clear that in the case of Nupurinkartano, the energy system planning could be fruitfully coupled with aims to reduce carbon emissions.

By examining one specific case we have suggested that following the path of IE in urban planning will help achieve results in decreasing carbon emissions. In the study, clear differences between the 4P framework and the traditional urban planning process were identified, one of those being the design of the energy system; and the other, the interaction between the developer and the end-users. Based on the results, no silver bullet could be found for achieving more sustainable new developments, but the 4P framework offers a promising approach to decrease the carbon emissions of residential developments.

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SANTRAUKA

VIEŠOJO IR PRIVATAUS SEKTORIŲ BEI ŽMONIŲ PARTNERYSTĖ KAIP BŪDAS MAŽINTI ANGLIES DVIDEGINIO EMISIJAS GYVENAMUOSIUOSE RAJONUOSE

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Šiame darbe nagrinėjama galimybė viešojo ir privataus sektorių bei žmonių partnerystės (angl. *Public-Private-People Partnership – 4P*) modelį taikyti kaip būdą mažinti anglies dvideginio emisijas gyvenamuosiuose rajonuose. Pasirinktame projekte daugiausia dėmesio skiriama energetikos sistemos projektavimui, kuris yra miestų planavimo dalis. Remiantis atvejo patirtimi, darbe pristatoma 4P struktūra, skirta mažai anglies dvideginio išmetančioms gyvenamųjų rajonų sistemoms. Teorinis modelis išmėgintas pasirinkus konkretų projektą Nupurinkartano rajone. Padaryta išvada, kad, planuojant naują rajoną, 4P struktūra – tinkama priemonė mažinti anglies dvideginio emisijas. Pritaikius šį sprendimą buvo parengtas energetikos sistemos projektas, CO_2 emisijas rajone galintis sumažinti 75 proc. Remiantis literatūros šaltiniais šiame darbe teigiama, kad naują rajoną reikėtų traktuoti kaip vieną sistemą, o ne kelis skirtingus posistemius. Darbas baigiamas teigiant, kad 4P – tai alternatyvus miestų, ypač energetikos sistemų, planavimo būdas, galintis suteikti galimybių veiksmingai mažinti anglies dvideginio emisijas.