How Can Urban Planning Contribute to Improved Energy Economy

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Key words: energy, city, planning

Abstract

Co-planning of urban and energy structures can reduce primary energy consumption and related emissions, even costs, as demonstrated by the co-planning case in the city of Porvoo, Finland, for example. Such new co-planning to be carried out by urban planners, typically architects, and energy planners, always engineers, together has turned to be challenging due to their different backgrounds. Five pilot training approaches adjusted to the local circumstances were implemented in U.K., Spain, Hungary and Finland, but being still underway in Germany, have provided examples how the training need can be addressed globally.

Need of Co-planning of Energy and Urban Structures

In very few planning schools in the world, the urban and regional planners are educated with understanding on energy, and on renewable energy sources (RES) and energy efficiency (EE) in particular. Based on the survey made in year 2009, only one such planning school was identified in North America (Canada) and three in Europe, namely in Germany (Stuttgart), Denmark (Arhus) and Finland (Oulu). Such combined skills of energy and urban planning have become vital while fighting Climate Change: the urban planner is the first actor in the planning process, the plans of whom will either restrict or enable optimal RES and EE implementation later on.

The traditional way is that a municipality creates a general location plan in which the buildings can be easily built and connected to roads, and defines the physical dimensions of the buildings. The building code ensures the new buildings meet the EE norms. Thereafter, the energy and water utilities connect the buildings to their infrastructure in the best way still possible. In such away, however, it may be too late to optimize the RES and EE!

In the existing urban structures we have barriers to introduce RES and EE as well as district heating (DH) and co-generation of heat and power (CHP) to integrate them to customers and power generation at high efficiency.

Therefore, training of urban planners with energy skills has been carried out as pilot training in five countries such as Germany, Hungary, Spain, U.K. and in Finland, the latter country to cover the coordination responsibility as the project with the acronym UP-RES. The acronym UP-RES stands for Urban Planners with Renewable Energy Skills.

Management Innovation - Co-planning of City and Energy Infrastructure

In the new way, the energy experts and the urban planners start working together in the general plan stage already. The impacts of various plans will be quantified in terms of energy consumption, investment and operation costs as well as emissions, which has not been the tradition in urban planning. The particular plan will be chosen for implementation, which offers the lowest lifecycle costs and emissions. In the city of Porvoo in Finland, for instance, the new urban plan that was based on maximizing the share biomass fuelled CHP and DH appeared to be the best choice from environmental point of view, and moreover, with the overall life-cycle costs much lower than the traditional plan would have caused. In other words, the new combined energy and urban planning was a win win approach from both the reduced emission and the lowest cost point of view that was highly appreciated by the local decision makers.

In the Finnish city of Porvoo, a new management approach was adopted in planning of the new urban area, named Skaftkärr. In the very initial stage of planning both the urban and energy planners were invited to work together. As the Reference Plan for their co-planning, the Skaftkärr plan from year 2007 was adopted, but assuming that passive energy houses would be used apart to those assumed in the plan of 2007. The Reference Plan was a sub-urban plan traditionally dominated by small houses to be located so that personal cars would need to be used. As heating sources in the Reference Plan, a combination of district heating, electricity and heat pumps was assumed.

Co-planning started with a few studies about how people live, move and what are their expectations. Co-operation among the urban and energy planners was not that simple in the beginning, but some time was needed for them to learn each others' way of work and thinking. A year was mentioned as a period of time that was needed to harmonize their co-operation.

Finally, the co-planning methodology provided four options to the urban scheme to be applied in Skaftkärr. All four options had the primary energy consumption and the emissions 30-70% lower than the Reference Plan.

The four options generated by the co-planning were as follows:

<u>Option 1</u>

Features:

- A dense new area that is supported by the existing city structure.
- The passive energy buildings are connected to the DH.
- Effective public and light transport routes are created to the city center.

Compared to Reference Plan:

- Primary energy consumption 40% lower
- CO_2 emissions 34% lower

<u>Option 2</u>

Features:

- Effective small-house characterized Option, where 50% of heat is based on DH and the balance of other 50% on ground water heat pumps.
- Effective public and light transport routes are created to the city center.

Compared to Reference Plan:

- Primary energy consumption 36% lower
- CO_2 emissions 31% lower

<u>Option 3</u>

Features:

- A loose land use Option, where heat and power are produced inside the buildings 100% based on RES.
- Passive energy houses.
- Traffic like in Reference Plan based on private cars and a little public transport.

Compared to Reference Plan:

- Primary energy consumption 67% lower
- CO_2 emissions 48% lower

<u>Option 4</u>

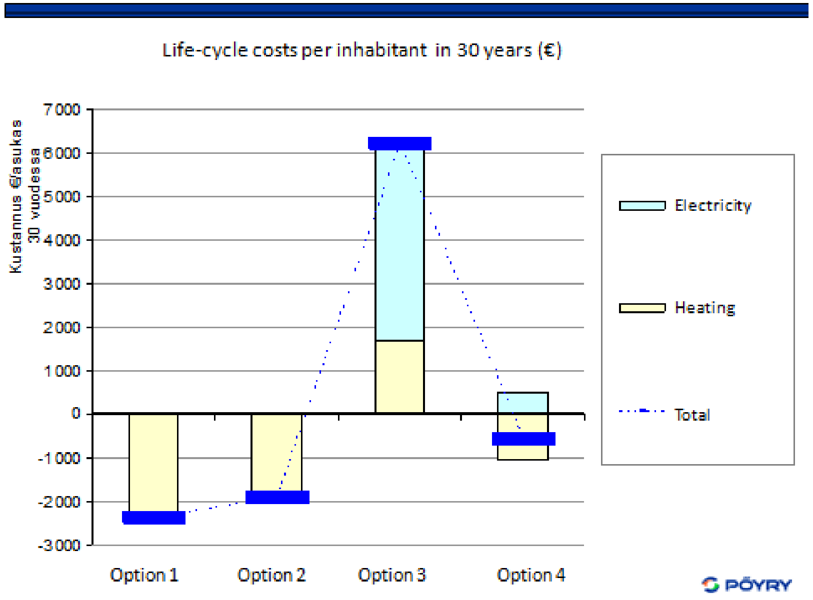
Features:

- Community type land use Option, in which the focus was on reducing the need of transport and by locating working places and services in the area.
- Effective public and light transport routes are created to the city center.
- Passive energy houses served 100% by solar heating. The area will supply solar heating to all citizens of Porvoo.

Compared to Reference Plan:

- Primary energy consumption 45% lower
- CO_2 emissions 62% lower

The life-cycle costs of the four options in terms of Euro per inhabitant during 30 years to come are presented in the next picture. In three of four options the life cycle costs were lower than in Option 3. In the latter one, the investment costs of RE as well as the individual heat pumps using the electricity produced in the building itself became extremely high.



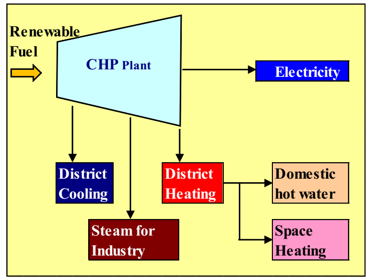
The final option selected for implementation was based on prioritizing light and public transport (biking highway, for instance), using district heating in most buildings and enabling solar heating to be used later on. District heating as the primary source in Porvoo is a special case as 92% of the heat energy in Porvoo is from the co-generation of heat and power (CHP) plant, the fuel of which is 70% from biomass (wood chips).

The city management of Porvoo was happy with the results as well, as the infrastructure costs (streets, pipelines, etc.) were substantially reduced as well.

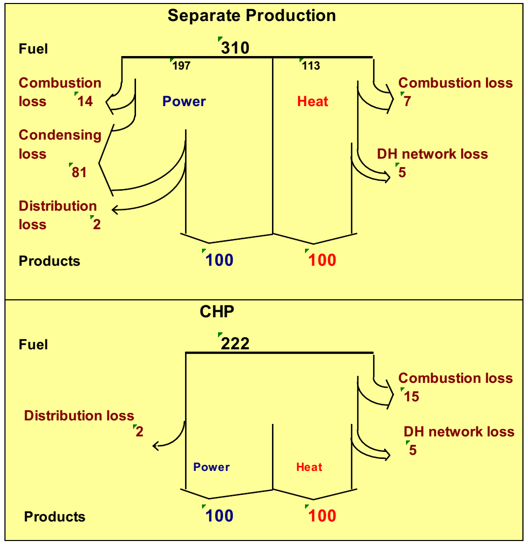
The new co-planning approach in Porvoo was supported and monitored by the Finnish Ministry of Environment and the Finnish Innovation Fund - Sitra. The co-planning approach is currently expanding to other cities in Finland, sooner or later maybe to other cities in Europe as well. Such expansion, however, will need training similar to that used in UP-RES pilot courses and adjusted to local conditions and country specific differences.

Why District Heating is Essential to Renewable Energy Expansion?

District heating is an important asset to allow renewable fuels to be used in large scale, at high efficiency and low emissions. DH also enable combined heat and power (CHP) to be used.



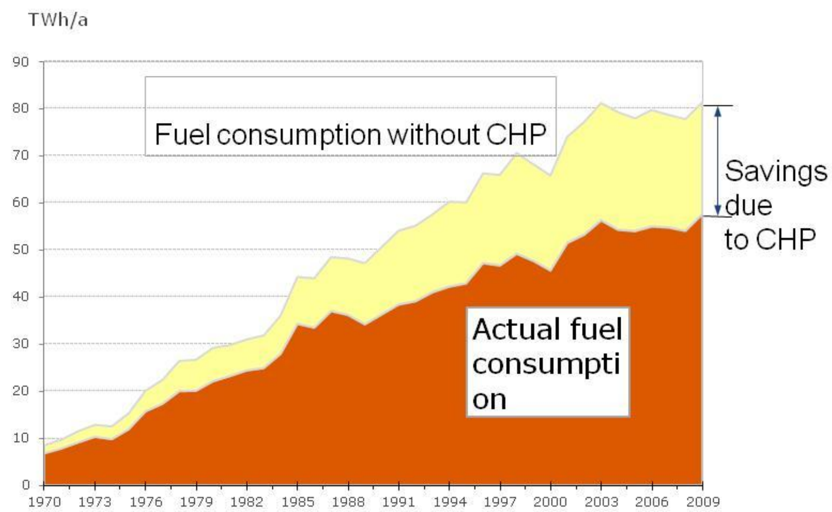
By means of CHP, about 30% savings in primary energy consumption can be achieved relative to its alternatives, typically a condensing power plant and a heat only boiler. An example of Sankey diagrams is presented below.



In year 2010, for instance, Finland of the population of 5.4 million has achieved the fuel savings without and with CHP amounting to 3.7 million metric ton, equivalent to about 700 kg per inhabitant less than without CHP. The consecutive CO_2 savings in year 2010 equaled to 2,400 kg per inhabitant. Similar figures can be produced from any country exercising CHP in a large scale.

CHP, however, requires the heat load to exist. Both the industrial heat load or district heating of the nearby community can function as heat load of CHP.

District heating and CHP are both capital intensive. The economy of district heating depends on the heat load density. As a rule of thumb, that is based on several economic analyses of the author carried out in a number of cases in Central and Eastern Europe, the linear heat load density in terms of supplied heat energy per network length should be equal to or higher than 2 MWh/m. If the density is below 1 MWh/m, the system may not be economically justified to district heating. With the values between 1 and 2, the least cost analysis shall be carried out between district heating and its most realistic alternative.



Picture 1: Fuel consumption in Finland with and without CHP since year 1970 (source: The Finnish Energy Industries, www.energia.fi).

CHP is the only way to generate electric energy at any thermal power plant whether coal or gas fired or even nuclear at such a high energy efficiency as about 90%. The respective power-only generation would yield an efficiency well below 50%.

DH and CHP together is a unique approach to integrate various fuels and waste energy sources to energy supply of a community and at a high efficiency. In Helsinki, Finland, for instance, DH covers 93% of the total heating energy demand in the city while the rest comprises individual heat pumps, oil and electric heating. The DH services are provided through 1,230 km of underground heating networks to more than 10,000 customers (buildings) connected to the integral DH system. More than 90% of the annual DH energy of about 7 TWh is produced by CHP. Therefore, the annual (!) energy efficiency of CHP exceeds 90% which is one of highest in the world. In the integral DH system, there are 7 large CHP units, 5 large heat pumps and more than 10 peak load boilers connected in order to have load dispatch. In Helsinki, despite being the coldest capital in the EU, the district cooling (DC) system is expanding fast, in year 2012 being the third largest DC system in Europe. Due to highly integrated DH, DC and CHP, several international organizations have ranked Helsinki as the best practice energy system.

Economic DH implementation requires effective co-operation of the urban and energy planners in order to maximize the heat load density but to keep the community functional and nice to live.

Country Specific Differences

Designing and implementing the training depends on the local circumstances, and should therefore be adjusted to the local needs and conditions. The awareness and establishment level of various RES components in the five countries is different as illustrated in Table below:

RES	Initial	Scarce	Dense	Established
Solar	FI	UK	DE, HU	ES
Wind	FI	UK	ES, HU	DE
Biomass	ES, HU	DE, UK		FI
Waste heat	ES, HU, UK		FI, DE	
District heating	ES , UK	HU	DE	FI
District cooling	HU, UK	DE, ES	FI	
Level:	Awareness	Knowledge	Competence	Professional practice

District heating and cooling , for instance, is a well established practise in Finland, but neither in U.K. nor Spain. On the other hand, solar and wind power are largely used in Spain and Germany, but are still at a very initial stage in Finland.

For instance, different approaches were taken in the five countries, in which the pilot training was carried out, include the following:

- In Finland, there was the 9 month 'long' course taught to urban and regional planners. The course consisted of 8 modules each of two days duration from Fall 2011 to Spring 2012. The trained planners now work in the different parts of the country to adjust their plans to adopt new features that favor RE and EE. The training of 20 CETS took place in Aalto university.
- In Hungary, the long pilot course was organized as a normal university course to students. The course having had lasted 9 months as well as comprised even 60 ECTS credits was organized at University of Debrecen.
- In Germany, the long two-year lasting long has started to both urban and energy planners combined. The benefit of educating both professions to together is expected to create mutual understanding on the way of thinking, terms and objectives, way of working. All training takes place in Frankfurt.
- In Spain, the long course of 9 months duration both for students and officers of urban planning was organized in Barcelona.
- In the United Kingdom, there were no such long course, but 20 charettes of three days each were organized in different cities of the country. To each charette, the local stakeholders such as city planners, developers, politicians, energy experts were collected to learn the main features of Climate Change oriented urban planning. Based on the outcome, the attending stakeholders were asked to select a real planning case in their city to which RE and EE could be incorporated.

In the five countries above, the pilot training covers about 500 experts, which can be considered a decent start towards co-planning of energy and urban structures in the future.

Learning Objectives of Training

There is very little tradition of spatial planners and energy experts working together anywhere in the world. Their educational backgrounds (physical versus visual sciences) and their linguistic backgrounds are different, which creates a communication barrier between the two professions.

The training was focused on introducing the energy technologies, together with the opportunities and implications associated with them from the urban planning perspective.

Trainees

The trainees comprised urban and regional planners and developers working in city planning offices, regional councils, planning schools, construction and consulting companies. In Germany in particular, energy experts were also invited to participate the pilot training. Moreover, in U.K. all key stakeholders who would need to work closely with the planners in developing future energy systems were also invited – notably including environmental, sustainability and housing professionals.

In all five partner countries, the UP-RES materials and methodologies will be used for Master level education as well.

Pilot Training Approach

The structure of the long pilot courses comprises ten modules, from M1 to M10. Each module typically consisted of two days of training.

The module titles are as follows:

M1	SUSTAINABILITY CONCEPTS IN REGIONAL AND URBAN PLANNING: A HOLISTIC VISION
M2	ENERGY. FORMS - TRANSFORMATION - MARKET OUTLOOK
M3	ENERGY DEMAND REDUCTION STRATEGIES: POTENTIAL IN URBAN PLANNING
M4	ENERGY DEMAND REDUCTION STRATEGIES: POTENTIAL IN NEW BUILDINGS AND REFURBISHMENT
M5	ENERGY RESOURCES AND RENEWABLE ENERGY TECHNOLOGIES
M6	ENERGY DISTRIBUTION: DISTRICT HEATING AND COOLING
M7	THE RIGHT SCALE FOR EVERY ENERGY CONCEPT: HEAT AND COOL DENSITY (DEMAND SIDE), POTENTIAL ON SUPPLY SIDE
M8	NEW MANAGEMENT CONCEPTS IN THE ENERGY MARKET
M9	ENERGY PLANNING
M10	NEW TRANSPORT MODELS AND URBAN AND INTERURBAN MOBILITY

Example of Training Module

Here is an example of the contents of a training module. It is a combination of delivered lectures, team work, and a site visit.

M5	**ENERGY RESOURCES AND RENEWABLE ENERGY TECNOLOGIES**
Fasilitator: N.N.	**13.-14.2.2012**
Time	**<u>1st Day: Familiarization with RES</u>**
9.00-9.15	Introduction to Module Topics
9.15-10.30	Presentation of RES technologies and applications
10.30-10.45	*Break*
10.45-12.00	Based on the presentation, five groups of trainees search for information from Internet. One group specifically for solar electric, solar heat, wind, biomass and the fifth group for waste to energy.

12.00-12.45	*Break*
12.45-14.00	Five groups continue
14.00-14.15	*Break*
14.15-15.30	Presentation of the results of five group works
15.30-16.00	Conclusion
	2nd Day: Rural Energy Supply
9.00-10.30	Local economy: impacts of RES on rural economy and survival
10.30-10.45	*Break*
10.45-12.00	Off-grid village based on RES (Kempele, Finland)
12.00-12.45	*Break*
12.45-14.00	Agricultural waste to liquid fuel
14.00-14.15	*Break*
14.15-16.15	Excursion to a bio mass fuelled CHP plant

Training Methods

In the pilot training several methodologies were applied, as follows:

- Facilitator to be chosen for each module to link the learned energy issues to urban planning
- Lectures based on slides and discussions
- Excursions both locally and internationally to best practice locations
- Exercises carried out by the trainees in small groups and individually about issues combining RES and EE to spatial planning
- Distance learning
- Movies (Inconvenient Truth, District Cooling,..)
- Expert panel (clinic) advisory services to support the trainees to carry out their exercises

Training Material in 10 Languages

The major deliverable of the pilot training is the compilation of the selected material to a training package. The training package can be used in other planning schools in Europe as it has been translated to 10 languages. The package comprises the material of ten modules in about 300 slides and explanatory texts. The package is freely downloadable in English, Finnish, French, German, Hungarian, Italian, Polish, Romanian, Spanish and Swedish.

The pilot training is a part of Intelligent Energy Europe (IEE/EACI) research program that promotes RES access on the energy market. The other partners of UP-RES are the universities of Augsburg and Debrecen, University of Technology in Munich, The District Heating Association in Germany - AGFW (Frankfurt), Building Research Establishment (BRE) Ltd (Watford), and SAaS (Barcelona).

Conclusions

The comprehensive training package made available in ten European languages is aimed at supporting other planning schools in Europe to design their own training of urban and energy infrastructure planner to work together towards more sustainable communities.

Sources of information:

The training material package of UP-RES project: http://aaltopro2.aalto.fi/projects/up-res

The Skaftkärr case in the city of Porvoo, Finland: http://www.skaftkarr.fi/en

Helsinki Energy utility: www.helen.fi

AESOP - Association of European Schools of Planning: http://www.aesop-planning.eu