Action and influence of the multiple decision levels over the whole energy chain

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Conference paper presented at the 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29th – October 3rd 2009, Dubrovnik, Croatia
Organisers: University of Zagreb, Zagreb, Croatia and Insituto Superior Tecnico, Lisbon, Portugal

ABSTRACT

This study concentrates on determining how to implement the legal framework at different institutional levels in an integrated approach for the planning and management of energy systems in urban areas. There are mainly five levels of decision able to influence the performances of urban zone in a Swiss city, namely the international, national, cantonal, municipal and individual levels.
The objective of this study is to develop an evaluation grid, which will be used to identify the influence of each decision level over the different energy chain levels (primary, intermediate, final, useful energy and energy services).
The results showed that beyond the constraints imposed by national and cantonal laws, ambitious energy-climate policies adopted by each level of governance certainly offer a lot of opportunities for the sustainable and energy-efficient development of urban areas. New regulations and associated instruments give to local decision-makers a set of arguments that can be used in a complementary way.

KEYWORDS

Territory energy planning and policy; Energy policy implementing instruments; Energy Chain; Insitutional levels

INTRODUCTION

The beginning of the 21st Century has been marked by the collective awareness of the finite state of fossil resources and global warming. These pressing issues and especially climate change, led governments and local authorities to adopt ambitious energy-climate policies, aimed at decreasing greenhouse gas emissions and primary energy consumption.
Considering that about 70% of the world primary energy consumption arises from towns [1], more specifically from the transportation and buildings sectors, the latter will play a central role in

reduction of primary energy consumption and in possible climate change mitigation actions. Technically, performances of urban energy system, are mainly influenced by demand-side dynamics (buildings characteristics, heating systems, electrical equipment, behaviour of final users, aso.), supply-side availability (waste energy resources, decentralized energy conversion systems, energy networks, aso.), as well as by the management of the whole system [2].
Simulation and optimization computing tools have been developed, notably at Ecole Polytechnique Fédérale de Lausanne (EPFL), and have allowed significant gains in understanding both demand – and supply side dynamics in urban areas [3, 4]. The project "Innovative tools for the planning and the management of energy systems in urban area" (MEU project), based on a strong partnership with four Swiss cities, aims at federating these existing models and methods, in order to develop and validate an integrated approach for the planning and management of energy systems in urban areas. The approach of this project – funded by the Swiss Federal Office of Energy, the Swiss gas industry and four partner cities - is based on the:

- development of a unified data model, enabling to thoroughly structure relevant energy data for a urban zone
- analysis and implementation of new regulations (laws, subsidies, aso.), at national, cantonal and local level
- aggregation of existing multi-scale methods and models
- development of a decision-making software tool, concretizing the developed data model and methods

The first part of this project concentrates on determining how to implement the legal framework at different institutional levels in our methodology. There are mainly five levels of decision able to influence the performances of urban zone in a Swiss city, namely the European, national, cantonal, municipal and individual levels.
The objective of this study is to develop an evaluation grid, which will be used to identify the influence of each decision level over the different energy chain levels (primary, intermediate, final and useful energy), using Switzerland and its institutional levels as a test-case. We shall concentrate exclusively on energy, voluntarily omitting mobility-related issues.

CONTEXT AND DEFINITIONS

In March 2007, the European Union's Member States agree on the « 3X20 » to meet the EU's energy and climate goal 20% objectives: curbing their CO_2 emissions, reducing fossil fuels consumption, as well as increasing the share of renewable sources by 2020.
Switzerland's specific objectives by 2020 are threefold: curbing its fossil energies' consumption by 1.5% per year compared to 2000, stabilizing electric consumption at the 2006 level and increasing by 50% the share of renewable sources to global energy consumption.
The legal framework, that is the body of structural tools elaborated and implemented at each governance level, aims to implement national, local and municipal energy policies at the scale of territories.
The first studies carried out within the framework of the "Management of urban energy systems" ("MEU") project considered the analysis of the legal framework. The analysis focused on the possibilities of integrating the various decision-making levels (institutional or personal) within the energy planning's methodology that is currently being developed.
To achieve this objective, two research tasks were carried out: 1) Determining which structural tools (legal and regulatory) impact directly on energy consumptions in urban areas. 2) Defining the impact of such tools on the energy chain characterising an urban energy system. In Switzerland there are five decision-making levels that can impact on the energetic performances of an urban area: International Policy; the Swiss Confederation; Cantons (States); municipalities and both physical/moral persons.

International Policy

Switzerland's foreign energy policy has three main goals: Ensuring the security of energy supply, keeping a competitive energy market and promoting an efficient and eco-friendly energy use. Most multilateral agreements that were drawn by the Swiss Confederation focus on the two above-mentioned first points. The latter is mainly covered by the Kyoto Protocol.

Switzerland is a Member State of the International Energy Agency (IEA). The IEA was originally created by industrialized countries as a response to the 1973 oil crisis. Its activities are now extended to all energy agents and to energy efficiency; Member States have adopted "shared goals" in 1993 concerning the social and ecological aspects of a sustainable energy policy. The IEA scrutinises the energy policy of each Member State every four years. The organisation also provides advices and directives. IEA members also exchange their respective experiences to promote a sustainable energy development.

Switzerland has ratified the Energy Chart as well as 45 other Western European countries. The Energy Chart is a regulatory convention on trade, transit, investments and environmental aspects related to energy development. It largely contributes to develop energy efficiency guidelines.

Eventually the main and only legally binding international instrument for sustainable energy development is the Kyoto Protocol held by the United Nations Framework Convention on Climate Change (UNFCCC) in 1998. It defines a legal framework for climate protection with greenhouse-gas emission objectives for each industrialized signatory country. Three flexibility mechanisms have been set to achieve these objectives. These are economic and financial instruments whose aim is to reduce GHG emissions when the overall costs are low. Each signatory country receives emission quotas matching its emission target. The quotas can then be exchanged on an international market: this is called the "cap and trade system". The two other flexibility mechanisms allow countries to finance climate protection project abroad, whether in industrialised or in developing countries. According to the Kyoto Protocol, Switzerland has to reduce by 8% its greenhouse gases emissions between 2008 and 2012, compared to the level of 1990.

Europe. There is no specific agreement on energy policy between Switzerland and the European Union. However, a free trade agreement has been concluded to facilitate the trade of energy and energy technologies between the two parties. In addition, several agreements on energy trade have been drawn with neighbour countries such as France, Germany, Italy, etc. Furthermore, European foreign energy policy is essential for Switzerland: even if Switzerland is not part of the European Union, it is actually a key actor on the European energy market. Switzerland is a turntable for gas and electricity markets. Simultaneously, the country depends on its neighbours for gas, petrol and electricity supply. On the one hand, Switzerland can take advantages of the European energy policy and its development efforts but on the other hand, it is indirectly submitted to the EU directives if it wants to hold its position on the energy market.

Eventually, Swiss municipalities can be part of European programs such as the Covenant of Mayors [5]. This European Commission's initiative fosters European cities to fight against climate change by implementing local sustainable energy policies. The signatories commit to reaching at least the targets set in the "Energy for a Changing World" package on their territory, i.e. to reduce by 20% their CO2 emissions by 2020, by reducing fossil fuels consumption by 20% and increasing the share of renewable sources up to 20% in the energy mix. The signatory cities have to present a so-called Sustainable Energy Actions Plan to the European Commission. Then, they can benefit from technical and financial supports namely from the European Commission Joint Research Centre, the European Investment Bank and all the supporting structures to the covenant. Possible measures should be considered in all sectors, public and private, and in all realms: built environment and new constructions, municipal infrastructure, local renewable sources, urban planning, mobility, etc.

Table 1: List of instruments / Rules at international level

	Instruments / Rules	Legal Basis	Objectives
International	**Kyoto's protocol**	UNFCCC	Reduce by 8% overall Swiss GHG emission between 2008 and 2012 (compared 1990 level)
	Energy Chart		Joint elaboration of sustainable energy policy guidelines
	Covenant of Mayors	European Commission	Reduce at least by 20% GHG emissions by increasing renewable energy share up to 20% and reducing fossil fuel consumption by 20%

Swiss confederation's Internal Energy Policy

The Swiss authorities set the general framework and rules for energy development in order to ensure the energy supply security and lead the country towards a sustainable energy development. This is implemented through several laws whose main are the depletion of fossil fuel consumptions and CO2 emissions, the development of energy efficiency, the limitation of electric consumptions, the maintaining the use of hydro power use and eventually the promotion of both heat recovery and renewable resources use.

The legal bases are mainly the CO_2 Act, the Energy Act (LEne) [6], the Law on Electricity Supply and Electric Installations (LApEl) [7] and their implementation ordinances[8, 9]. The law provides for the implementation of several instruments such as the CO2 tax, the cost-covering remuneration for electricity, the mandatory labelling of appliances and vehicles, etc.

Table 2: List of instruments / Rules at national level

	Instruments / Rules	Legal Basis	Objectives
Confederation	**Cost-covering remuneration for feed-in electricity to the grid (CRF)**	LEne	5400GWh of renewable electricity by 2030
	CO2 Tax	CO2 Act	Kyoto's target : -10% of GHG emissions by 2012 compared to 1990 level
	Climate Cent	CO2 Act	To compensate GHG emissions due to mobility by funding climate protection projects inland and abroad
	Requirements and labelling on appliances and engines	LEne + OEne	Stabilisation of home's energy consumption and incentive
	Subsidies and encouragement measures		
	- Global contribution to the cantons	LEne + OEne	Help cantons to implement their encouragement programs
	- Pilots and demonstration installations	LEne + OEne	Foster research and development activities on energy technologies
	- Swiss Energy program for municipalities		Climate: -10% of GHG emissions by 2010; Electricity: limit the increase of electricity consumption to 5%; RE: raise the part of RE to 0,5TWh for energy production and 3 TWh for heat production.

LEne. The 1998 LEne [6] defines the general principles to be applied to ensure an adequate energy supply: diversified, safe, profitable and compatible with climate protection issues. Precise guidelines introduce the way individual and companies should behave toward energy conversion and use matters. Furthermore, this law promotes an economical and rational energy use, energy efficiency and the resorts to local and renewable resources. It also specifies that the annual renewable electricity production needs to be increased in 2030 by at least 5'400 GWh compared to the level of 2000. The annual hydropower production needs to be increased by 2'000 GWh compared to the level of 2000. Finally, homes'final energy consumption must be stabilised until 2030. For example, this ordinance to this law (OEne) [8] forces electricity distributors to provide the customers with an assessment of the origin of the electricity supplied. It also imposes on manufacturers to clearly indicate the specific energy consumption of devices and vehicles. Indeed the Swiss authorities can impose minimum energy performance levels on devices, vehicles imports and manufacturing. The LEne stipulates that the Swiss Confederation supports information, advices and training programs, research and development on the issues of energy technology, energy saving and heat recovery measures. These various activities are carried out in close collaboration with the Cantons, through diverse promotion and subsidy schemes. The main example is the Swiss Energy for Municipalities program, whose aim is to help municipalities to implement the LEne directives.

LApEL. The 2007 LApEl [7] defines specific rules related to electricity development. It is meant to ensure electricity supply throughout the country with high reliability and according to sustainable development principles. The competitiveness of the Swiss electricity sector should be maintained and strengthened. The ordinance to this law (OApEl) [9] sets the detailed rules of application of the LApEl. For instance, the OApEl introduces a considerable instrument so-called cost-covering remuneration (CRF) aimed to increase the share of renewable electricity. It is a 250 million Swiss Francs fund available each year for remunerating renewable electricity feed-in to the grid. This measure can be applied to every renewable technology. The electricity is remunerated at a price that offsets the production costs compared to the market price. Then prices are defined for each technology. Of course, a producer who finances his facility through the CRF option cannot sell the power on the green electricity market. This is a very common way to finance domestic facilities such as photovoltaic panels.

CO2 Act. Switzerland has set a CO2 Act [10] based on both voluntary and regulatory tools. This a key factor to ensure optimal efficiency (as explained by Lee et al. [11]). The law includes an emission trading scheme that encourages companies to invest in energy saving and renewable technologies and forces them to comply to their emission targets. The energy policy focuses on reducing fossil based fuel consumption: fossil sources' CO2 emissions need to be reduced by 10% from its 1990 level (equivalent to 8% of the overall GHG emissions). Every energy-related fossil fuel purchase, excluding transport fuel, is submitted to the CO2 tax [12], as well as for legal and physical persons. The benefits of this tax are redistributed to the population through health insurance funds and to the companies through pension funds (called "AVS"). The companies emitting large C02 amounts can be exempted from tax payment: as compensation, the company takes a legally binding commitment on the reduction of its emissions. A plan for the consistent emission reductions with precise targets is described in an objective agreement with the Swiss Federal Office of Environment (SFOEN). If the target is not reached, the company will have to pay all the taxes and its interests over a defined time period. A tax-exempt company will obviously be excluded from the redistribution plan. The CO2 tax performs two major roles: an incitement to reduce fossil fuels consumption for those who pay the CO2 tax and a legal binding for exempted companies to reach their emission targets. Towns and cities can also decide to be exempted from the tax.

The Climate Cent Foundation. The CO2 Act provides voluntary measures especially for the economic sector. The Climate Cent Foundation is as an initiative of the Swiss Oil Federation to compensate GHG emissions due to mobility. A 1.5 cent tax is collected on every liter of transport fuel import. This tax represents around 100 million Swiss francs per year. This amount is invested in climate protection projects in Switzerland and abroad. Projects conducted in Switzerland through the Climate Cent Foundation mainly focus on energy saving measures, energy efficiency and renewable energy development.

Cantons :

The Swiss Confederation entails twenty six states, namely Cantons, each one headed by an executive government and a legislative parliament. This political structure induces twenty six possible state legislations, regarding states competencies.
In the realm of energy, as defined within the Swiss Constitution and the LEne, the Cantons have the competence to measure the energetic performances of buildings. Then, they need to create within their legislations a legal framework promoting energy efficiency and renewable energy use for buildings.

Table 3: List of instruments / Rules at cantonal level

	Instruments / Rules	Legal Basis	Objectives
Cantons	**Buildings energy prescriptions**		
	- Building insulation and consumption standards	Lene, MoPEC	To promote energy saving measures in buildings
	- Maximum share of non-renewable energy in buildings' heat consumption	Lene, MoPEC	To promote local renewable energy
	- Requirements on energy conversions equipments	Lene, MoPEC	To increase energy efficiency of buildings equipments
	- Energy performance of buildings certificate (EPBC)	MoPEC	To improve transparency of real estate market and to promote buildings refurbishment
	- Specific requirements towards power plants fired with fossil fuels	Lene, LApEl MoPEC	Mandatory evaluation of the recovery of waste heat
	- Requirements on lighting, cooling and ventilation systems	MoPEC	To promote energy saving measures in buildings
	- Control of energy consumptions for new buildings		Monitoring of energies consumptions for large buildings
	Land use		
	- Increased land use allowance for energy efficient buildings	MoPEC	To increase the number of energy efficient buildings (labelled)
	- Land use regulation for renewable energy plants	LCEne	To coordinate and optimize land use for renewable energy plants
	Subsidies and encouragement measures		
	- Energy savings	MoPEC	Encourage energy efficiency
	- Renewable energy and heat recovery	MoPEC	Encourage use of renewable energy and heat waste
	- Information, advice and marketing in energy domain	MoPEC	Training and information about energy domain, for professionals and individuals
	- Energy efficiency labels for buildings		Encourage energy efficiency measures in buildings by attributing quality certificate

In order to harmonize in the most efficient way the various Cantons' energy laws, the Swiss Conference of State Energy Directors (EnDK) decided to elaborate a "State Module of energy prescriptions" in 1992 (namely "Module de Prescriptions Energétiques des Cantons, MoPEC"(in French). This MoPEC, reviewed twice and updated since its first version, is composed of eight basis or optional modules: Basis modules have to be introduced in each Energy State laws (Namely "Loi Cantonale sur l'Energie: LCEne"); optional modules could be introduced in specific states laws (in this case, they have to correspond to MoPEC modules). Then, MoPEC allows Cantons to edit harmonized energy laws regarding the eight considered modules. Cantons may also implement other specific articles not written in the MoPEC.
Furthermore, as previously mentioned, The Swiss Confederation subsidies every year a global contribution intended to encourage Cantons' measures. They are then accountable to allocate these funds through specific programs, with at least fifty percent subisidising individuals' projects.

Municipalities :

Switzerland includes more than 2800 municipalities, a large amount for a country having seven million inhabitants. Like Cantons, Swiss municipalities are headed by an executive government and a legislative parliament. The latter is especially in charge of local regulation enactment and executive powers have to elaborate local policies, including in the realm of energy.
Globally Swiss municipalities have wide competencies and a large autonomy in terms of land use, buildings and construction regulation, local renewable resources management and much more in other realms.
In this study, local energy policy has been considered as punctual measures decided by local government to achieve specific objectives. For example, monitoring of biggest municipal buildings, aiming at decreasing municipal energy consumption and energy costs, is a local policy measure. If such measure is institutionalized, and then applied to all municipal building, local government will have to enact a local regulation that has to be approved by local parliament.
However, in terms of harmonization, no transparent basis exists as standard regulations for municipalities. The Swiss authorities have implemented an initiative to improve local energy policies using best practices: the program Swiss Energy for Municipalities has developed a label named "Cités de l'énergie" based on the European energy award© (eea©) process. This instrument facilitates the implementation of local and transversal energy policies, using a standard list of more than 350 potential sustainable energy measures.
This Swiss and European process, namely eea©, include measures in the following realms: land use, buildings and installations, Supply and "depollution", mobility, internal organization, and communication.
Eventually, according to LEne and MoPEC, energy planning is a local competency in all Swiss Cantons, except the case of the Canton of Geneva. Municipalities have competencies to enforce energy master plans (energy plan including energy networks, availability of renewable resources, etc.), in cooperation with local energy distributors.
These two specific competencies, local energy policies enforcement and energy planning competencies provide municipal authorities with a key role in terms of energy planning and management.

Table 4: List of instruments / Rules at municipal level

	Instruments / Rules	Legal Basis	Objectives
Municipalities	**Land use and energy planning**		
	- Energy master plan	MoPEC, Local regulation	Define specific supply areas of energy networks and areas for local renewable energy use
	- Building energy requirements and control (maximum heat consumptions and share of non renewable energy, etc.)	Local regulation	To promote energy saving measures in buildings and the use of local renewable energy
	- Mandatory connection of buildings to district heating networks supplied with renewable energies	MoPEC, Local regulation	Increase economical efficiency of district heating; decrease local CO2 emissions and primary energy consumption for heating and hot water
	Municipal own buildings / installations management		
	- Energy consumption accounting / management	Local policy	To monitor buildings energy consumptions and react to installations failures
	- Municipal buildings refurbishment plan	Local policy	Increase municipal energy efficiency and decrease long term energy costs
	- Public lighting plan	Local policy	Increase municipal energy efficiency and decrease energy costs
	Energy supply		
	- Production and distribution of local renewable energy or waste heat recovery (heat, electricity, etc.)	Local Policy	To promote and increase renewable energy use
	- Integration of high efficiency installations (Cogeneration, district heating, etc.)	Local policy	To promote and increase city energy efficiency
	- Non renewable energy taxes	LApEL	Decrease energy consumptions and funding sustainable projects
	Subsidies and encouragement measures		
	- Energy savings	Local regulation	Encourage energy efficiency
	- Renewable energy and heat recovery	Local regulation	Encourage use of renewable energy and heat waste
	- Information, advice and marketing in energy domain	Local regulation	Training and information about energy domain
	- Energy efficiency labels for buildings	Local regulation	Encourage energy efficiency measures in buildings by attributing quality

Legal and physical persons

Finally, at the lowest scale, individuals can largely influence energy consumption at every stage of the energy chain: this mainly resorts to ecological awareness. The first basic efficient measure concerns behavioural changes to avoid over-consumption: there are many everyday actions that can already significantly reduce the intensity of energy services. Then comes the choices made between the different available energy supply options such as gas boilers or district heating. To go further, it is always possible to reduce energy consumptions by investing in high-performance building insulation, energy-efficient conversion equipments and appliances, aso. Of course, these voluntary measures concern individuals as well as corporations and public agencies.

Table 5: List of instruments / Rules at persons level

	Instruments / Rules	Objectives
Confederation	**Behaviour : avoiding energy over-consumptions**	Decrease the necessary end-use service related energy
	Energy supply option selection	Reduce intermediate energy consumption by judicious choices of energy supply agents
	Efficient building insulation	Reduce building heating demand
	Energy efficient appliances	Decrease electricity consumption
	Efficient energy conversion equipments	Reduce final energy consumption by investing in high efficiency equipments (heat pump,…)
	Local renewable energy production	Reduce primary energy consumption by using local renewable resources

The chain of transformation of energy : stepwise losses

As stated by the first law of thermodynamics, energy can neither be produced nor, properly speaking, consumed. Energy can only be transformed from one form to another, each transformation step unavoidably involving various degrees of losses. Thus, the various forms of energy can be viewed as a chain of levels from “raw” energy down to the services which it allows to deliver to all sectors of human society [13].

The first level is called primary energy and regroups all energy sources or energy potentials as encountered in nature such as fossil fuel deposits or solar radiation : these energy sources must usually undergo many transformation processes – each of them implying losses – before becoming energy vectors conditioned for distribution, i.e. reaching the second level dubbed as intermediate energy level. This is the level to which electricity at the exit of a power plant or refined oil products belong. Distributed energy is finally turned into so-called useful energy, such as mechanical energy or heat at a given temperature, which is the energy ultimately allowing the delivery of end-use services.

All the energy chain levels present significant margins of improvement in terms of reduction of the losses, notably at the transformation and the transport level. Therefore, a global goal of primary energy consumption reduction without decrease of the present end-use services level – such as the one envisioned in the 2’000 watts society concept – can only be attained by addressing the potential savings which can be performed at *each* level down to the primary energy sources.

A few and indicative cases can be given to illustrate this statement. For example, the production of electricity of a coal- or gas-fired power plant can be significantly increased (i.e. raising the efficiency of the transformation from the intermediary to the distributed energy level) by installing a so-called combined cycle turbines. Another example is given in the automotive sector where brake energy recovery systems or hybrid propulsion systems can significantly lower the overall fuel consumption, thus decreasing the losses between the useful energy level and the end-use services levels. The evoked savings are not performed by putting in place far-fetched and expensive technologies, but by implementing technically mature and economically sound solutions. Conversely, other savings potential sources – such as sustainable hydrogen production or heat recovery on low-temperature industrial processes - will only be attained on a longer-term basis, since they still require significant additional R & D and/or demonstrable ROIs. Finally and contrary to public perception, all levels of the energy chain can be influenced by even simple political or corporate strategic options : the approach presented below is precisely intended to analyze such systemic interactions.

METHODS

A multi-entry matrix has been developed, which can be used as a global evaluation grid able to analyze policies at different institutional/decisional levels over the energy performances of urban areas.

More specifically, the five decisional levels of the Swiss institutional construction outlined above are the first entries of the matrix. Indeed, policies or decisions affecting the energy consumption are enacted at all of these five levels. However, these policies usually only address or affect one specific level of the energy chain, for example the final energy consumption. The corresponding matrix entries will therefore be given by the five levels of the energy chain, namely primary, intermediate, final and useful energy, as well as energy services. The latter five categories are of course carefully defined using the internationally accepted definitions applied, e.g., by the IEA.

Each studied urban zone will give rise to its own specific multi-entry matrix. The latter will then allow to cross-evaluate energy-related policies in terms of effective reduction of the energy consumption in an urban zone. How is a national law implemented in a specific town and how does it fit in the already existing local regulations or with decisions taken by individuals? Conversely, is a municipal engagement in terms of primary energy consumption reduction hindering or favouring the application of various energy conversion technologies? These are the kind of issues that we will be able to take into consideration in the case-studies provided by the four partner towns of our project. Indeed, the analysis through the multi-entry matrix will allow to compare the results or the expected impact of various energy planning or policy strategies adopted by local authorities, such as the creation of a fund for renewable energies or the extension of a centralized district heating network.

Moreover, the multi-entry matrix may been applied to different energy conversion technologies currently used in urban zones such as centralized district heating or electrical heat pumps, for which we know the efficiencies between the energy levels from primary to final energy. This allows to highlight where the largest potential in terms of energy efficiency lies for a specific technology. Correspondingly, this analysis is able to indicate which decisional level should enact regulations or other policy steps, in order to foster such technologies.

Table 6: multi-entry matrix

	International	National	Cantons	Municipal	Person
Energy servicies		**Inc.** :Swiss Energy	**Inc. :**Information and advice		**D. :**Behaviour : avoiding energy over-consumption
Useful Energy	**Inc :**Energy Chart	**R./Inv.** :Appl. and engines requirements and labelling **Inv.** :Climate Cent **Inv. :**Pilot and demo. **Inc./Inv.** :Swiss Energy	**R. :**Building construction standards **R.** :Requirements on lighting, cooling, ventilation systems **Inc.** :land use allowance for energy efficient buildings **Inc./Inv. :**energy saving **Inc. :**Information **Inc./Inv** :energy labels for buildings	**R. :**Building energy efficiency standards **Inv. :**Municipal buildings refurbishment plan **Inv.** :Public lighting plan	**Inv.** :Efficient building insulation **Inv.** :Energy efficient appliances
Final / distributed energy	**Inc :**Energy Chart	**R. :**CO2 Tax **Inv.** :Climate Cent **Inv. :**Pilot and demo. **Inc./Inv.** :Swiss Energy	**R.** :Requirements on energy conversion equipments **R.** :Control of energy consumption on new buildings **Inc. :**Information	**D.** :Building energy consumption counting **R.** :Non-renewable energy tax	**Inv.** :Efficient energy conversion equipments
Intermediate Energy	**Inc :**Energy Chart **R.** :Kyoto's protocol	**Inv.** :Climate Cent **Inc./Inv.** :Swiss Energy	**R.** :Requirements on fossil fuel power plants **Inc. :**Information	**R. :**Energy master plan **R.** :Mandatory connection to energy networks **Inv. :**High efficiency conversion systems	**D. :**Energy supply options selection
Primary Energy / resources	**Inc :**Energy Chart **Inc :**Covenant of Mayors	**R./Inv. :**CRF **Inc./Inv.** :Swiss Energy	**R.** :Maximum of non-renewable in heating consumption **Inc.** :EPBC **Inc./Inv. :**Renewable energy and waste heat recovery **Inc. :**Information	**Inv.** :Production and distribution of local renewable energy and waste heat recovery	**Inv**. :Local renewable energy use

RESULTS

This study concentrates on the development of a multi-entry matrix, qualifying the legal framework of Switzerland applied to the five levels of the energy chain. Switzerland being a federal country, Swiss legal framework is an excellent example of complexity, in terms of multi-level legislative tools, of significant differences among specific cantonal laws and of delegation of competencies to the lower government levels. For example, urban planning is in the realm of competencies of municipalities in the French-speaking part of Switzerland, except in the Canton of Geneva where urban planning is a cantonal competence. Due to the fact that Switzerland is not a member of the EU, the weak point of Swiss legal framework example is that Swiss local actors are not eligible in European funding programs assigned to support cities in the implementation of their local energy-climate policies, with a notable exception of Concerto Project (included in European Framework

Program). Furthermore, one of the partner cities of MEU project is actively involved in a concerto project (http://holistic-ne.ch/en/).

In the context of the MEU project presented in the introduction, local energy policies of the four partner cities, namely La Chaux-de-Fonds, Lausanne, Martigny and Neuchâtel have been analyzed through the multi-entry matrix. We hereby provide a few examples stemming from these towns, as an illustration of its ability to highlight the energy level impact of local actions.

- In 1984, following a local industrial will, the municipality of Martigny decided to develop a high-efficiency district heating network supplied by natural gas. Aiming at avoiding unproductive competition between natural gas network and projected district heating, the municipality in collaboration with local utilities and the Ecole Polytechnique Federale de Lausanne (EPFL) have elaborated an energy master plan. According to Canton du Valais Energy Law, this energy master plan has been implemented as local regulation and implies the supply of only one network energy for heating (natural gas, district heating or electricity for heat pumps) in each area of the city territory. After more than twenty years of operation, local utilities, namely Sinergy SA, decided to equip its district heating with a centralized wood co-generation unit. The main arguments supporting this decision were the energy objectives of the municipality, the subsidies given at a national level by climate cent foundation and by Canton du Valais, as well as the cantonal energy law, which specifies that a municipality can impose the connexion of buildings to a district heating, if the used resource is at least 20% renewable.
- The City of Neuchâtel is one of the most ambitious Swiss municipality, in terms of local energy policy. Neuchâtel was the first French-speaking municipality of Switzerland to get labeled as « Cité de l'énergie », in 1995. Eleven years later, Neuchâtel obtained another label attesting excellence at European level : european energy award gold®. This label has been attributed to the city as a reward to its local energy policy and actions realized in the field of energy savings and local renewable energy production. The City of Neuchâtel has notably enacted in his local regulation specific standards for building heat energy consumption: buildings built on the city territory have to be 20 percent more efficient as cantonal standards. They can be built with a 20 percent more efficient insulation, or have to integrate a renewable production installation, able to supply at least 20 percent of building heat consumption.
- The City of La Chaux-de-Fonds has been the first Swiss city to install a district heating network in the 1920s. The latter has continued to develop over the years and in the late 1980s, the local authorities have decided, on one hand, to significantly increase its size and to feed it through the urban waste incineration plant, which has been thoroughly modernized. Thus, more than a third of the local population is heated through the district heating network, which extends all over the town : this can be considered as a major feat since La Chaux-de-Fonds, a major industrial center of the French-speaking part of Switzerland - is one of the highest towns in continental Europe. A co-generation unit is further coupled to the incineration plant, in order to optimize the balance between heat generation and demand through electricity production. Thus, a strong local political will and investment decisions have allowed this town to significantly steer its primary energy consumption to a local and renewable energy source.
- The City of Lausanne is the second-largest town in the French-speaking part of Switzerland and has also acted nationally as a pioneer in the energy field, notably as fara as district heating is concerned. It also holds the prestigious european energy award gold® label. This town its own utilities company, which is one of the largest in Switzerland and which produces a substantial part of its electricity with hydropower and wind power plants. Through a tax on the local electricity tariffs, the City of Lausanne feeds two funds, namely one dedicated to supporting projects aiming at a more rational use of energy and the

promotion of renewable energies and one dedicated to broader sustainability actions. The spectrum of funded projects shows a remarkable diversity and a substantial impact potential, in terms of reduction of energy consumption and shift from non-sustainable energy sources.

Based on these examples and on other studied cases, it has clearly emerged that the constructs positively influencing intermediate and primary energy consumptions are mainly the result of multi-level actions, based on specific regulations, public subsidies and local energy policies. Simultaneously it is mainly the lowest and most ambitious level of decision which influences useful and final energy consumptions: a motivated person or group of individuals who decides to construct a building with better energy standards than the regulation imposed by municipalities or canton. Moreover, that kind of individuals will tend to behave in a sustainable way, with the aim of decreasing consumption of energy services (thermal comfort, lightning, health, aso.).

CONCLUSIONS

The success of energy planning in urban areas depends on the ability of local decision-makers to integrate a sum of complex and dissociated elements: cleantech opportunities, use of local and renewable energy resources, life cycle costs, environmental performances, regulatory and legal framework, aso.

Beyond the constraints imposed by national and cantonal laws, ambitious energy-climate policies adopted by each level of governance certainly offer a lot of opportunities for the sustainable and energy-efficient development of urban areas. New regulations and associated tools give to local decision-makers, both public and private, a set of arguments that can be used in a complementary way during the project planning and realization phases, as well as along all the steps of the decision process.

In this sense, the multi-entry matrix developed in this study can be used as a magnifying glass, which allows to analyze the possibilities of actions and the potential impact of each level of decision over the whole energy chain.

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