Evaluating Energy Savings Arising from NEEAP Implementation: Lessons Learned in Croatia

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Abstract

Croatia has prepared its Energy Efficiency Master Plan in 2007 for the period 2008-2016 and its 1st National Energy Efficiency Action Plan for the period 2008-2010 in accordance to the requirements of the Energy Service Directive (ESD). With these documents, for the first time, Croatia has established a well documented and comprehensive energy efficiency policy. After three years of implementation, the 2nd NEEAP was prepared in the first half of 2011 comprising detailed evaluation of achievements. Its preparation was, *inter alia*, a valuable energy saving calculation exercise, which revealed strengths and weaknesses of the Croatian system for monitoring and evaluating overall implementation of energy efficiency policy. In the 1st NEEAP very rough *ex-ante* estimations of expected energy savings were performed, while in the 2nd NEEAP *ex-post* calculations were based on established bottom-up methods for specific programs and measures. The gap between *ex-ante* and *ex-post* energy savings estimations is significant and related to the precision of the evaluating method. Moreover, the top-down indicators as recommended by the European Commission were used to evaluate overall progress in energy efficiency at sector and national level caused not only by policy measures but by other economic and social trends as well. The results of calculation show significant differences in energy savings determined by top-down indicators and bottom-up methods.

Introduction

Energy efficiency (EE) is nowadays declared as a backbone of energy policies worldwide - it is recognized as a fastest and most cost-effective tool to decouple economic growth from the increase in energy consumption and thus to reduce greenhouse gas (GHG) emissions by cutting the amount of energy required to accomplish a particular amount of genuine energy service (Wuppertal institute at al. 2000.; IEA 2008). Despite the formal recognition of energy efficiency, the irony is that it is at the same time the most invisible and the least understood energy policy feature (Erhard-Martinez & Laitner 2008). Taking the European Union (EU) as an example - it has introduced a well thought of set of polices to achieve its EE targets (Morvaj & Bukarica 2010) and is continuously upgrading its EE policy (EC 2011), but still it is far from reaching its 20% EE improvement target by 2020. With the current legislation and policy instruments in place, a reduction of only 8.5% will be achieved (EC 2009). Even taking into account additional measures in the pipeline, at the best only 11% reductions will be achieved (EC 2009). Clearly, the EU, which is arguably one of the most advanced world region in EE efforts, will achieve at best only 50% of its declared EE targets. This leads to a conclusion that the uptake of EE policies is much slower than expected, resulting in huge potentials not being utilized.

The reasons behind the energy efficiency gap are multiple and are discussed by many authors focusing primarily on the design and implementation phases of the (ideal) policy cycle. However, lack of or inadequate monitoring and evaluation procedures are rarely discussed as a barrier to stronger employment of energy efficiency improvement (EEI) measures. Still, the well known adage “you cannot manage what you don't measure" applies in the energy efficiency policy domain more than anywhere else. Energy efficiency policy cannot be evaluated without adequate procedures for both *ex-ante* and *ex-post* measurement and verification (M&V) of energy savings. These procedures are important tools towards being more realistic in setting energy savings targets as well as in determining how successful implemented policy instruments really are and redefining them accordingly to deliver the desired results.

The cornerstone of the efforts towards achieving the EU 2020 target is the Energy Services Directive 2006/32/EC (ESD). Under this Directive, National Energy Efficiency Action Plans (NEEAPs) provide a framework for the development of a strategy at Member State (MS) level to augment energy efficiency improvement, in particular for end-use energy. The NEEAPs also provide the platform for MS to evaluate the energy savings resulting from the implementation of these strategies (JRC 2010).

This paper discusses the importance of measurement, verification and evaluation procedures in the energy efficiency policy cycle. As the authors of this paper[1] were a part of the expert consortia preparing both the 1st and 2nd NEEAP, the learning process and the evolution of these procedures in Croatia by comparing energy savings calculation methods applied in the 1st and the 2nd Croatian NEEAP is also presented. Special attention is given to the comparison of top-down and bottom-up approaches applied for evaluation of energy savings in the 2nd NEEAP.

Evaluation in Energy Efficiency Policy Cycle

For energy efficiency policy to be successful its creation has to be a learning process based on both theoretical knowledge and empirical data. This learning process can be the most appropriately described by the closed-loop process as shown in Figure 1. It consists of the following stages:

- Policy design:
    - Policy definition: objectives, targets, approaches for different target groups, legal and regulatory frameworks;
    - Policy instruments development: incentives, penalties, standards, technical assistance, financing support;
- Policy implementation: institutional framework, stakeholders, human resources, capacity and capability development, supporting infrastructure (ICT);
- Policy evaluation: monitoring of achieved results through energy statistics and energy efficiency indicators, qualitative and quantitative evaluation of policy instruments' impacts.

Conceptually, the typical energy efficiency policy cycle starts with strategic planning and determination of targets leading to the design of specific instruments to tackle different target groups, i.e. market players. The implementation of policy instruments follows and one cycle is concluded with the evaluation of policy impacts. The results of the policy evaluation process are then fed into the planning, design, and implementation processes, and the cycle repeats itself (Vine 2008). Every stage in this dynamic loop requires methodical and systematic approach.

In the energy efficiency policy cyclic loop policy evaluation has an essential position, although it might not appear so. Namely, evaluation procedures are at the same time an integral part of policy design phase as well as both parallel and consecutive activity to policy implementation.

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[1] The 1st Croatian NEEAP was prepared on behalf of the Ministry of Economy by the team of experts from various domestic (University of Zagreb, Ekonerg – Institute for Energy and Environmental Protection and Raiffeisen Consulting) and foreign (CAP SD from the Netherlands and NEPAS from Norway) institutions/companies. Authors of the paper from the University of Zagreb were the team leaders. The 2nd NEEAP was prepared by the expert consortium comprising University of Zagreb Faculty of Electrical Engineering and Computing and Energy Institute Hrvoje Požar, where all the authors were the leading experts in evaluating and (re)defining EEI measures.

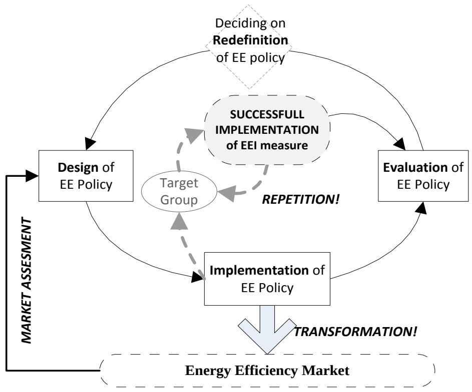

Figure 1. Dynamics of Energy Efficiency Policy (Bukarica et al. 2007)

The first step in policy design shall be establishment of a plausible theory on how a policy instrument (or a package of instruments) is expected to lead to energy efficiency improvements (Blumstein, 2000). Policy makers should have as precise as possible conception of impacts that policy instrument will deliver, prior to its implementation. This is referred to as *ex-ante* or beforehand policy evaluation. Unlike *ex-ante* evaluation of a policy, *ex-post* approach is applied after a certain time of the policy instrument implementation, effects of which should be evaluated to answer two key questions (Joosen& Harmelink 2006):

- What was the contribution of policy instrument in the realisation of policy targets (effectiveness of policy instruments)?
- What was the cost effectiveness of policy instruments, and could targets have been reached against lower costs?

Both *ex-ante* and *ex-post* evaluation need to be supported with quantitative data, i.e. with data on energy efficiency improvements actually realised by implementation of policy instruments and EEI measures. The tools used for this purpose are referred to as measurement and verification (M&V) of energy savings. M&V is absolutely crucial part of any energy efficiency policy – it captures the overall improvement in energy efficiency and assesses the impact of individual measures. M&V procedures include two major methodological approaches: top-down and bottom-up.

The top-down approach is based on national and sector-aggregated energy statistics and a set of energy efficiency indicators is used to evaluate overall savings.

A bottom-up M&V method means that energy consumption reductions obtained through the implementation of a specific EEI measure are measured in kilowatt-hours (kWh), in Joules (J) or in kilogram oil equivalent (kgoe) and added to energy savings results from other specific EEI measures to obtain an overall impact. Both approaches can be combined to appropriately and as exact as possible evaluate the success of national energy efficiency policy and the magnitude of EEI measures' impact.

Regardless to its importance, policy evaluation is often highly neglected and targets are rather based on provisional estimations than on well established methodology. This was the case in the development of Croatian 1st NEEAP in 2007 as will be briefly presented in the next chapter. However, this omission was caused by the complete lack of knowledge and experience in policy evaluation and subsequently corrected by the time of 2nd NEEAP development.

Ex-ante evaluation of energy savings in the 1st NEEAP

The 1st Croatian NEEAP was prepared in the 2007 based on the comprehensive document Energy Efficiency Master Plan[2] that covered the period from 2008 to 2016 in line with ESD requirements. With

[2] Energy Efficiency Master Plan was prepared by the team of experts (including the authors of the paper from the

these documents, for the first time, Croatia has established a well documented and comprehensive energy efficiency policy. It sets the national indicative energy efficiency target to 9% of average annual energy consumption calculated according to the energy consumption data for the period 2001-2005 and methodology set in the ESD. It also brought a package of EEI measures for each energy end-use sector (households, services, industry and transport). Ex-ante evaluation of measures' impacts showed that even higher savings could be delivered, however due to uncertainties of estimations and still not well developed conditions for energy efficiency policy implementation in Croatia, especially regarding the institutional capacities, it was recommended to keep the target on the minimal level required by the ESD. The expected energy savings of the measures envisaged in the framework of the Croatian 1st NEEAP for each of the four aforementioned most important sectors of final energy consumption are summarized in Table 1.

Table 1. Croatian national indicative target (MoE 2010)

Adopted national indicative energy savings target 2016 (PJ)		19.77
Adopted national intermediate indicative energy savings target 2010 (PJ)		6.59
Measures to improve energy efficiency planned for achieving the target	**Annual energy savings expected by end of 2010 (PJ)**	**Annual energy savings expected by end of 2016 (PJ)**
Package of measures in the residential sector	2.62	7.17
Package of measures in the tertiary sector	1.14	3.68
Package of measures in industry (non-ETS)	1.24	4.05
Package of measures in the transport sector	1.60	6.59
Total ESD energy savings expected:	6.60	21.49

The expected savings per sector are calculated for the package of measures applied to that sector. The calculation is based on the estimates of the impact of each measure made by experts engaged to prepare the NEEAP on the behalf of the Ministry of Economy (see footnotes 1 and 2). These estimates were mostly made using the extensive knowledge data base from the MURE project[3] and other available documented sources on impacts of typical EEI measures.

The principle used for *ex-ante* evaluation of energy savings resulting from an individual EEI measure will be demonstrated on several examples, some of which will be also used for demonstration of methods used for evaluations in the 2nd NEEAP. These are summarised in the Table 2.

Table 2. Selection of EEI measures from the 1st NEEAP with indication of the evaluation principle

EEI measure	**Evaluation method**
Introduction of building codes	Based on experience from US, Canada, EU countries given in the document "A comparative assessment of twenty policy instruments applied worldwide for enhancing energy efficiency in buildings" published by European Council for an Energy Efficient Economy (ECEEE) in 2007, it was estimated by experts preparing the NEEAP that this measure has a potential energy saving impact in 2016 of approximately 4% of total energy consumption[4] in the building sector (residential and service.
Energy efficiency labeling scheme of	Based on the same study it was estimated that this measure will result in savings

University of Zagreb) on the behalf of the Ministry of Economy. It was financed by the United Nations Development Programme (UNDP) as a part of program "Removing barriers to energy efficiency in Croatia". More info about the UNDP energy efficiency activities in Croatia are available at: http://www.undp.hr/show.jsp?page=51982 and http://www.energetska-efikasnost.undp.hr/

[3] ODYSSEE-MURE project information are available at: http://www.mure2.com/

[4] Energy consumption as referred hereafter related to the estimation of EEI measures' impacts actually means average energy consumption in the five year period prior to the implementation of the NEEAP based on which national indicative target was set. For Croatia, this was the period 2001-2005.

household appliances	equal to 5% of total residential electricity consumption in 2016.
Info campaigns and networks of EE info centers	This is a soft measure, the impacts of which in terms of achieved energy savings are very hard to determine. Anyhow, according to the qualitative evaluation of the impact of these measures across the MS given in the MURE data base (impact is rated 'medium'), it was estimated that expected savings in 2016 are in the amount of 2% of total sector energy consumption.
Energy Management System in the public sector	Two major programs for introduction of energy management system comprising organizational structure and information system for monitoring and analyzing energy consumption in the state and local government buildings have started at the time of 1st NEEAP development. It was assumed that these programs will produce savings in 2016 amounting to 2% of service sector energy consumption. This estimation is based on the assumption that public sector will commit through these programs to reduce its energy consumption by 5% and the share of the public sector in the total service sector consumption of 40%.
Industrial Energy Audit Scheme	Energy audits were set to be the main activity in the industry sector that was aimed at revealing potentials for energy savings based on which industrial stakeholders will make the own investment decisions. It was estimated that this will bring energy savings in 2016 amounting to 2% of total energy consumption in the sector, based on the experiences of European countries, primarily Germany, the Netherlands and Norway.
Use of cleaner vehicles	The Environmental Protection and Energy Efficiency Fund was designated to establish a scheme for subsidising the purchase of more fuel efficient vehicles. Without any indication on the number and type of the vehicles to be supported, it was estimated that the savings from this measure by 2016 would amount to 2% of total average fuel (diesel and gasoline) consumption in the transport sector.

Clearly, the uncertainties related to the evaluations made in the described manner are high and could be denoted as "expert guess". However, at that time not only that experience with M&V methods was missing, but even experience in energy efficiency in general was rather limited. This was recognised by the 1st NEEAP itself, which stated that the M&V system for determination of achieved energy savings and compliance with the targets has to be established. For that, the data collection system had to be improved, EE indicators developed, and annual progress reports on the implementation of the NEEAP published.

Therefore, the presentation of this approach is not intended to judge and criticize it, but just to show the level of efforts that needed to be done on the establishment of adequate evaluation, measurement and verification procedures. The next section of the paper presents how these procedures were introduced in Croatia in order to determine energy savings actually achieved in the period of the 1st NEEAP implementation.

Ex-post evaluation of energy savings from the 1st NEEAP

The starting point for definition of M&V methods in Croatia was recommendations from the European Commission (EC 2010). These methods comprise the recommended formulas for top-down (TD) energy efficiency indicators, bottom-up (BU) calculation models and a list of recommended average lifetimes of EEI measures and programmes for BU calculations of final energy savings. The methods recommended in this document deliver a common, but still flexible basis for the calculation of final energy savings in the scope of ESD. However, although very much welcome and helpful, these methods needed to be adjusted for national circumstances. This was performed for both TD indicators (Božić 2011) and BU methods (Bukarica, Borković et al. 2011) within the project "Capacity building for Monitoring, Verification and Evaluation (M&V&E) of the Energy Efficiency policy in South-Eastern

Europe countries in terms of the EU accession process"[5]..The main findings of this adjustment as well as calculation results are presented hereafter.

Evaluation at EEI measure level – bottom-up approach

Methodology development. The recommended BU calculation model set out in the Commission's recommendations consists of guiding principles, a set of formulas, baselines and default values for measuring final energy savings achieved through the implementation of energy efficiency improvement measures or programmes in residential (households) and tertiary (public and private organisations in the service sector) buildings, including equipment and appliances used in buildings. There are 11 typical building energy efficiency improvement measures identified and formulas for calculation of resulting energy savings recommended.

For recommended formulas to be applicable, default (baseline) values to be used within equations needed to be defined. Default values should be based on the stock or market averages, which require analysis of previous regulations (e.g. building codes), thorough knowledge of the situation in the existing building stock and availability of market sales figures on equipment and systems sold (for efficiency of e.g. heating systems or unit consumption of households appliances). In the lack of these data, which was a huge problem in Croatia, expert estimates determined through a wide consultation process with relevant stakeholders were used. Additionally, best practice examples in BU methods from other countries were used, e.g. Austrian BU based monitoring data base[6] and recommendations of the project "Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services (EMEEES)"[7] (Wuppertal Institute 2009). This process lasted for six months and has resulted in the development of the BU methods listed in the Table 3. It has to be noted that all EC recommended methods were pronounced applicable in Croatia, although they were not all used for evaluation as there were no measures defined in the 1st NEEAP or implemented otherwise that would be suitable for this kind of evaluation or for which required data would exist.

For each of these methods own national default values were determined. Although the Commission has recommended energy savings default values for household appliances, lighting and office equipments, these were not used as the stock and market situation in Croatia, as in the whole South-East Europe region, differ from the situation in the EU. In the case of lighting systems, EU default values are too high for Croatian conditions, due to lower values of average operating hours caused by better insolation and longer duration of natural lighting. On the contrary, for appliances and office equipment, these default values for Croatia needed to be set higher due to later introduction of eco-design requirements and energy efficiency labelling scheme (enforced in practice since 2007). For measures directed towards reduction of specific heat demand (SHD) in the buildings, data from the regulation in different periods of construction were used as well as available data on existing building stock conditions that confirm or deny the values prescribed in the regulation.

It is also interesting to note that for some measures, as a rule those measures that have been an important part of the NEEAP implementation, own national methods were developed. Among them are energy audits, which were probably the most utilised measure in the previous three year period. Empirical data confirmed that approximately 5% of total estimated energy saving potential was utilised

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[5] The project M&V&E is implemented in all Western Balkans countries and is officially a part of the Energy Community's Energy Efficiency Task Force work program. It is implemented with the financial support of Deutsche *Gesellschaft für Internationale Zusammenarbeit* (GIZ), Open Regional Fund for Energy Efficiency. More information on the project and its achievements can be found at the Community's web site: http://www.energy-community.org/portal/page/portal/enc_home/inst_and_meetings?event_reg.category=E12825

[6] Information about Austrian monitoring system are available at: http://www.monitoringstelle.at/

[7] Information and documents from EMEEES project are available at: http://www.evaluate-energy-savings.eu/emeees/en/evaluation_tools/index.html

only because energy audit was conducted, i.e. without undertaking any technical measure suggested by the audit. These saving were dominantly made by changes in behaviour of the employees (through information provision and education) and improved maintenance practices. Another such measure is a subsidy programme for replacement of trucks and buses with new ones complying with the Euro 5 standard.

Table 3. BU methods developed and used in Croatia

	Nr.	EEI measure	Used in 2nd NEEAP	Source of default values
EC recommended methods	1	Refurbishment measures in existing buildings	yes	Specific heat demand - SHD: national regulations from different periods System efficiency - η_{old} & η_{new}: EMEEES recommendations
	2	Insulation refurbishment measures applied to building components	no	U values: national regulation from different periods
	3	Introduction of building codes	yes	Same as for method 1.
	4	Replacement of heating supply equipment in buildings	yes	* two methods integrated in one SHD and η: same as for method 1. Specific water demand - SWD: expert analysis and modelling
	5	Installation or replacement of water heating installations		
	6	Installation or replacement of air conditioning split systems (< 12 kW)	no	Energy Efficiency Ratio - $EER_{average}$: C class EER_{new}: A class
	7	Solar water heating	yes	USAVE – national data (solar irradiation) η: same as for method 1.
	8	Replacement or new household appliances	no	Stock average: expert estimation Market average: class A Best market: class A+++(A++)
	9	Replacement or new lamps in residential buildings	no	Unitary final energy savings - UFES: national values
	10	Replacement or new lighting systems in tertiary buildings	no	UFES: national values
	11	Replacement or new office equipment	no	Average Energy Consumption - AEC_{old}: EMEEES recommendations AEC_{new}: EMEEES recommendations
National methods	1	Replacement or new public lighting systems	yes	UFES: national values
	2	Installation of heat pump	yes	Seasonal Performance Factor - SPF: according to research results from Germany
	3	Replacement or new vehicles	yes	UFES: national values
	4	Eco driving	yes	UFES: EMEEES project
	5	Energy audits	yes	UFES: national values

Case example – calculation of energy savings resulting from new building codes. Introduction of building codes was a measure with a single largest impact on achieved energy savings calculated by BU methods. In the period 1987-2006 construction in Croatia was designated by the standard prescribing maximum thermal transmittance of outer envelope, which resulted in an average specific heat demand (SHD_{old}) of 150 kWh/m^2. New building code was introduced in 2006 and has been enforced since. The maximum permissible for SHD according to that code is 51.31 to 95.01 kWh/m^2 per year for residential buildings and 16.42 to 30.40 kWh/m^3 per year for non-residential buildings, depending on the factor that takes into account the form (shape) of the building.Based on this regulation and data on actual performance of buildings a default value for SHD_{new} was determined for new residential buildings (85 kWh/m^2) and new non-residential buildings (107.5 kWh/m^2). Please note that the building code defines SHD for non-residential buildings per volume unit (m^3). This value was transferred to the value per square meter using the average storey height of 4.3 meters. This analysis provided first set of input data in the calculation formula recommended by the EC. Another set of input data are those for efficiency of heating system. Default values for efficiency of heating systems were derived from recommendations of the EMEEES project[8] and from estimations of system efficiencies for buildings constructed in the period of previous building code (1987-2006). It was estimated that the value of η_{old} ('before' situation) is 0.80. Efficiency of new heating system (η_{new}) is set to 0.848 as recommended by EMEEES project but also complying with the requirements of national technical regulation. Based on these default values it was possible to determine unitary final energy savings (UFES) using the calculation formula recommended by the EC:

$$UFES = \frac{SHD_{old}}{\eta_{old}} - \frac{SHD_{new}}{\eta_{new}}$$

Final energy savings are then determined by multiplying UFES with built surface (square meters) in the period 2006-2010. However, it has to be emphasised that we did not use the data on total surface (which were obtained from register of construction permits issued in the period 2006-2010), but estimations of heated surface of buildings (for residential buildings it was assumed that 2/3 of total surface are heated, while for non-residential buildings it is assumed that approximately 45% of total surface is usually heated). The final calculation result is given in Table 4.

Calculation results and lessons learned. Methods presented in Table 3 were used for evaluating EEI measures defined in the 1st NEEAP and implemented during the period 2008-2010. Additionally, as the ESD has been interpreted to permit, measures implemented before 2007, so called 'early measures', were taken into account as well. The above presented case example represents early action, as the new building code was introduced already in 2006 - hence all buildings built according to this building code contribute to the savings achieved in 2010. However, it was not specifically determined how many buildings were built before 2008 – only total number of buildings (i.e. square meters) built until the end of 2010 was known and used for calculation. For some measures, like for financial support from the Environmental Protection and Energy Efficiency Fund it was possible to clearly determine the share of early actions, which was considerable (57% of all saving achieved through financial support is attributed to early actions). Anyhow, the most of the measures in the 1st NEEAP were not early measures, hence the distinction between them and measures implemented in period 2008-2010 was not specifically addressed in the 2nd NEEAP.

When calculating energy savings from all EEI measures using BU methods, the results obtained represent gross total annual savings. In order to know the real (net) impact of policy measures, double counting should be avoided and multiplier effects of measures taken into account as stipulated by the ESD. Double counting could have occurred as the same measure could be reported by different parties obliged to implement/support energy efficiency improvements. There were cases when one EEI project received incentives from two parties, usually from the Environmental Protection and Energy Efficiency Fund and local authority; hence was reported twice. However, in the reporting requirements it was clearly asked to specify sources of financing, which enabled that the savings from these projects were accounted only once and attributed to only one obliged party. It is assumed that double counting was avoided this way to a large extent, although we cannot be absolutely sure that there wasn't any. ESD also stipulates the necessity to evaluate multiplier effects of measures, i.e. their influence on the market. Although some multiplier effects have been noticed, especially in the public lighting systems, there was not enough data to quantify the magnitude of this effect. The third issue that is causing the difference between gross and net impacts is free-riding effect. The free rider effect was not specifically treated in the calculation of savings – this issue is considered to be already addressed with the financial support policy (mainly provided by the above mentioned Fund), which always requires beneficiary to participate with own financial means in EEI investment in certain share and also requires significant amount of administrative

[8] Source: http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_WP42_Method_4_resboilers_080609.pdf

paper work, which in practice leads to situation that only those really needing financial support to close the financing framework of the project are benefiting from the support.

The calculation results as well as their comparison with the results of *ex-ante* estimations only for selected EEI measures (from Table 2) performed in the manner described in the previous sections are given in the Table 4.

Table 4. Comparison of energy savings evaluated ex-ante (without established methodology) and ex-post (with BU methods) for selected EEI measures

EEI measure	**Ex-ante energy savings in 2010 (PJ)**	**Ex-post energy savings in 2010 (PJ)**
Introduction of building codes	1.35	2.16
Energy efficiency labeling of household appliances	0.51	Not possible to determine
Info campaigns and networks of EE info centers	0.77	Not possible to determine
Energy Management System in the public sector	0.40	0.54
Industrial Energy Audit Scheme	0.14	0.03
Use of cleaner vehicles	0.21	0.07

Several interesting annotations can be made based on the calculation (evaluation) results given in the Table 4:

1. The BU method for evaluation of new building codes effects is very powerful. It is based on the analysis that gives the answer to the question: “What would be energy consumption of buildings built since the enforcement of the new building code, if this code was not adopted, but the construction of the same amount of square meters was done according to the previously existing building codes?” Hence, these savings are not possible to capture by metering or by energy statistics (as new constructions inevitably increases the overall energy consumption).

2. Energy efficiency labelling schemes certainly have effect on consumers’ choices. It was demonstrated by the public opinion survey demonstrating that 7.8% more citizens were using A-category home appliances in 2010 than in 2007. However, to evaluate the actual amount of savings achieved it would be necessary to know the data about the number of sold appliances, which were not monitored in the previous period nor it was possible to gather them.

3. Soft measures like info campaigns or advising activities are very hard to evaluate in quantitative terms. In still developing EE markets, like Croatia, they are absolutely necessary, they have been conducted in the previous period and funding of these activities was substantial in comparison with funding dedicated to implementation of technical EEI measures. However, impacts in terms of energy savings, and consequently the cost effectiveness were impossible to calculate. This provoked many questions about justification of such costs. Although all experts agree that these spending are necessary to keep the society alerted to energy efficiency, there is clearly a need to establish quantitative methods for these measures as well to persuade uninformed decisions makers to their necessity.

4. The most accurate M&V method is metering energy consumption before and after implementation of every EEI measures and normalising it to a set of established referent values. In large number of Croatian public buildings comprehensive energy management system comprising organisation structure (EE teams and energy managers) supported by IT application for monitoring and analysing energy consumption was implemented, which enabled evaluation of energy savings by direct metering. It has to be noted that metering has captured mainly effects of behavioural and organisational changes in the public sector caused by intensive information, education and awareness activities, while the implementation of technical measures was limited.

5. Energy audits were the most common and, with the exception of less than dozen individual projects co-financed by the Fund and/or Croatian Bank for Reconstruction and Development, practically the only state support EEI measure for industry sector. Unfortunately, the system of monitoring after-audit activities was not established, hence there are no reliable data that could confirm the level of energy

savings achieved as a result of energy audit itself. Based on interviews with several audited companies, it could be concluded that on average energy savings amounting 5% of total estimated energy saving potential were obtained, mainly by implementing low cost measures with quick pay-back periods. This method needs to be further improved and every state supported energy audit needs to be accompanied by the follow-up reports on actually implemented measures and achieved savings. It will enable evaluating the leverage potential of energy audits.

6. The most important EEI measure for transport sector was the so called “Euro 5” programme through which 1,155 old vehicles (trucks and buses) were replaced with new ones complying with the Euro 5 standard and removed from Croatian roads. BU method developed for this purpose is based on the difference between the average fuel (diesel) consumption of an old and a new vehicle and the average distance travelled by the vehicle. While, fuel consumption is easy to determine based on manufacturers data, the default value for the travelled distance was taken from the ODYSSEE data base[9]. It turned out that *ex-ante* estimated savings were far too overestimated. Although a huge amount of money was poured down into the program (approximately €11 million) and an impressive number of vehicles were replaced during two years of program implementation, its impact on energy savings is rather small (approximately 1% of national intermediate indicative target for 2010).

Evaluation at sector and national level – top-down approach

Methodology development. As demonstrated in the previous section, not all energy savings could be captured by BU methods. Therefore, the TD indicators were also calculated and energy savings determined from the variation of the relevant indicator between the base year (2007) and the year of reporting (2010) multiplied by an indicator of activity in the final year as required by the methods recommended by the European Commission (EC 2010). For this purpose all TD indicators – preferred (P), alternative (A) and minimal (M) – as recommended by the European Commission were analysed and, if input data were available, calculated. The ability to calculate and the selection of indicators to be used for reporting of energy savings in the 2nd NEEAP is presented in the Table 5.

Table 5. Overview of TD indicators calculated and selected for reporting within the 2nd NEEAP

TD indicator	Sector	Calculated	Used for reporting
P1 – energy consumption for space heating per m2	Residential	yes	x
P2 – energy consumption for space cooling per m2		yes	x
P3 – energy consumption for water heating per inhabitant		yes	x
P4 – electricity consumption per appliance type		no	
P5 – electricity consumption for lighting		yes	x
M1 – non-electricity energy consumption per dwelling		yes	
M2 – electricity consumption per dwelling		yes	
P6 – non-electricity energy consumption in sub-sector per indicator of activity	Services	no	
P7 – electricity consumption in sub-sector per indicator of activity		no	
M3 – non-electricity energy consumption of service sector per employee (full time equivalent)		yes	x (per m^2)
M4 –electricity consumption of service sector per employee (full time equivalent)		yes	x (per m^2)
P8 – energy consumption of cars per passenger-km	Transport	yes	x
A1 for P8 – energy consumption of cars in l per 100 km driven		yes	
P9 – energy consumption of trucks and light vehicles per tone-km		yes	x
A2 for P9 – energy consumption of trucks and light vehicles per vehicle		yes	

[9] Information about the ODYSSEE data base are available at: http://www.odyssee-indicators.org/

P10 – energy consumption of passenger rail transport per passenger-km		yes	x
P11 – energy consumption of freight rail transport per tone-km		yes	x
P12 – share of public transport in total land passenger transport		yes	x
P13 – share of rail and inland waterways freight transport in total freight transport		yes	x
M5- energy consumption of road vehicles per car equivalent		yes	
M6 – energy consumption of rail transport per ton-km		yes	
M7 – energy consumption of inland waterways transport per ton-km		yes	
P14 – energy consumption of sub-sectors per unit of production	Industry	yes	x
M8 – energy consumption of sub-sectors per value added		yes	

Case example – calculation of energy savings in the service sector. The P indicators for service sector relate electricity and non-electricity energy consumption to the indicator of activity (driver of energy consumption) in a service sector sub-sector. It was not possible to calculate these indicators as there is no reliable data on the division of energy consumption in sub-sectors. Therefore, only M indicators were calculated. We have started our calculations using the formulas recommended by the EC, which relate electricity and non-electricity consumption with number of employees (in full time equivalent). The input data in calculation formula were easily obtained – electricity and non-electricity consumption from annual energy balance (for years 2007-2009, while for 2010 estimations were used) and number of full time equivalent employees from official statistics published by the Croatian Bureau of Statistics. However, calculation results provided negative savings, i.e. the value of both M3 and M4 indicators have increased in 2010 compared to 2007 resulting in negative savings (savings were -0.18 PJ calculated with M3 and -2.02. PJ for M4). Especially high rise in the value of indicator occurred for electricity consumption, probably due to large number of newly built shopping malls in the analysed period. The effect of the rise in the number of employees could not overbear the effect of rising electricity consumption. On the other hand, the number of employees is not really the best choice for energy consumption driver. In the service sector, energy consumption is closely related to the building floor area, especially heated floor area. Therefore, it was decided to calculate M indicators but per square meter of heated area. The square meters in the service sector were estimated (modelled) according to the official statistics on overall building stock (total square meters in Croatia), energy balance (share of service sector in total energy consumption), register of issued construction licences (for new buildings) and register of public buildings. The register of public buildings is established as a part of activities for energy efficiency improvement in the public sector. Apart from data on surface of public buildings it contains data on energy consumption in these buildings, starting from year 2007[10]. The input data was not the total surface but the heated surface of the buildings, which was derived from total surface using the load factor 0.45 (see also the previous example of BU calculations). This approach provided better and, in our opinion, more realistic results, i.e. M3 indicator has shown positive savings (0.33 PJ), while M4 gave still negative results (-0.23 PJ). These results are considered to be more realistic due to the effects of building codes and technical regulation for newly built buildings as well as strong activities implemented in the public sector.

Calculation results and lessons learned. The strength and advantage of TD indicators is that they rely on statistics. Having good energy statistics and statistics about the factors influencing energy consumption is the main prerequisite of their accuracy. However, it is at the same time their statistical nature that makes them inappropriate for answering the question how successful policy (instrument)

[10] There are two programs aimed at energy efficiency improvement in the public sector – “Bringing own house in order” aimed at central government buildings and “Energy management system in cities and counties” aimed at buildings owned and used by the local authorities. Both programs are part of the NEEAP and are initiated and implemented with the international support from the United Nations Development Program (UNDP).

exactly is? On the other hand, it was not possible to evaluate all EEI measures by BU methods, and some of them which were very important in the previous three year period for stimulating energy efficiency, like info campaigns, were left unevaluated. Moreover, this kind of promotion activities has triggered investments in EEI by the private sector, the effects of which were not possible to take into account as there is no obligation to report on such savings to competent authorities.

It was therefore decided to capture overall improvements in energy efficiency with TD indicators. Croatian participation in the ODYSSEE project[11] and long term practice in development of energy balance eased this task. But, it was not possible to calculate all indicators or some corrections of indicators needed to be done.

For the same reasons as discussed in the previous section, it was not possible to determine the efficiency improvements in the stock of household appliances. For that purpose, it would be necessary to make surveys among residential consumers to find out about the stock and to repeat these surveys at least every five years to capture the change in their efficiency. Other possibility is to use sales data which are obtainable for commercial surveys, if financial resources for that purpose are available (and usually they are not). Most recently, within the changes of regulation related to the energy labeling of energy using products, an obligation to suppliers of energy using products was introduced to deliver sales data to the competent authority, which is expected to improve data availability for these calculations.

As shown by the case example, due to lack of data, it was also not possible to calculate the P-level indicators for service sector, i.e. for electricity and the total of other energy consumption in different service sub-sectors. M-level indicators, that show electricity and energy consumption per square meter of useful surface were calculated instead and used for reporting purposes. M-level indicators calculated in per full time equivalent employee, as recommended by the Commission, provided negative savings, which could lead to the conclusion that there were no savings in the service sector at all, which considering the actions undertaken especially in the public sector would be false. Often, countries are also facing the problem of not knowing the exact square meters in service sector, especially in the public sector, which was the main rationale behind the Commission’s recommendations. This usual barrier was successfully removed from Croatia, as through aforementioned programs in the public sector a comprehensive register of all publicly owned property was established.

The main difference in between P and M indicators is in aggregation level. P indicators are more disaggregated, while M indicators are providing results at aggregated, whole sector level. In that respect, M indicators are capturing all influence on energy consumption such as economic crisis, commodity market and prices, structural effects and behavioral changes. P indicators are still not related to the individual policy measures (like BU methods are), but are more focused on specific sub-sector or technology, hence are more focused on capturing effects related to the technology improvements. Calculation made by both P and M level indicators confirmed this theoretical difference, as M level indicators provided higher energy savings as shown in the Table 6. Especially huge discrepancy between the results is seen in the transport sector and industry sector where M-level indicators provide approximately 4.5 times higher savings. For industry sector, this could be explained by the share and price of final products causing higher value added, hence improving energy intensity. The difference in the transport sector is probably caused by M-level indicator for road transport calculated based on energy consumption per car equivalent and not per the measure of transport activity, i.e. passenger or ton kilometers. This way the effect of continuous increase in the number of vehicles in Croatia has been captured. It had the main role in the decrease of the indicator in the analyzed period.

Table 6. Difference between P and M-level energy savings calculated with TD indicators

Sector	**P-level savings (PJ)**	**M-level savings (PJ)**
Households	4.43	4.74
Services	-	0.33

[11] Energy Institute Hrvoje Požar is partner institution in ODYSSEE.

Industry	1.21	5.76
Transport	0.46	2.03

Overall energy savings achieved

In the 2nd NEEAP achieved energy savings were calculated by both BU and TD methods as demonstrated in the previous sections. Due to inability to evaluate each and every measure with BU methods, it was decided to declare the achieved savings as calculated by TD indicators, but also to report the savings that can be attributed to individual EEI measures.

Both of these methods were further used for ex-ante estimations of future expected energy savings. Input data for calculation of TD indicators until 2016 were estimations based on modeling of future energy consumption and respective drivers[12]. For BU methods, the assumptions are made depending on the type of measure (e.g. for building codes it was assumed that it will be more stringent every three years, i.e. that the highest permissible SHD will be reduced by 20% in comparison with previous regulation while the square meters of newly built buildings is taken from the modeling of energy consumption drivers; for measures like installation of solar collectors, new windows or thermal insulation, the targets are set in square meters of installed equipment until 2016 so this data was input in ex-ante calculations, etc.). The results are given in the Table 7.

Table 7. Overall energy savings reported in the 2nd NEEAP

Sector division of target	**Sector target (GWh)**		**Achieved energy savings in 2010 (PJ)**		**Estimated energy savings in 2016 (PJ)**	
	2010	*2016*	*Total (TD)*	*From measures (BU)*	*Total (TD)*	*From measures (BU)*
Residential	2,24	6,72	4,43	1,53	12,64	9,58
Services	1,25	3,76	0,33	1,32	4,50	3,85
Industry	1,12	3,36	1,21	0,60	4,93	1,99
Transport	1,98	5,93	0,46	0,08	16,60	3,22
Total:	**6,59**	**19,77**	6,43	3,53	38,66	18,64
Percentage (%)(compared to ESD reference consumption)	**3%**	**9%**	2,9%	1,6%	17,6%	8,5%

Discussion and conclusions

Croatian experience demonstrates the importance of policy evaluation practices supported by M&V methods. Important lessons were learned during the process of M&V system establishment and especially during the preparation of 2nd NEEAP:

The most important lesson learned is that already during the definition of EEI measures within the NEEAP it has to be clearly set how the impacts of this measure will be measured and evaluated. This was the main shortage of the measures defined in the 1st NEEAP. These were redesigned with the aim of making them more specific and applicable through definition of activities envisaged to be implemented by the measure and relating the measure or individual activities of the measure with appropriate M&V method. Experiences of others used as a benchmark for ex-ante

[12] Modeling of future energy consumption and respective drivers is performed using MAED (Model for Analysis of Energy Demand) tool developed by International Atomic Energy Agency (IAEA). MAED evaluates future energy demands based on medium- to long-term scenarios of socioeconomic, technological and demographic development. More information about MAED can be found at: http://www-pub.iaea.org/MTCD/publications/PDF/CMS-18_web.pdf.

estimations of energy savings in the 1st NEEAP were the best available data source at that time. But, as many other times as well, it was once again proved that what works well in one country does not necessarily have the same effects in others. The most obvious example that confirms this statement was the measure related to the industrial energy efficiency network and voluntary agreements, which were designed according to the experiences from the Netherlands, Norway and other northern Europe countries, but which did not deliver desired results in Croatia.

Implementation of BU methods is time and resource consuming, especially if continuation of the evaluation process and reporting by obliged parties is not established. They have to be a part of IT application that will enhance the data collection process and enable automatic calculation of achieved energy savings based on the set of input data. M&V needs to be an integral part of any subsidy program in order to evaluate how effectively public money is spent on energy efficiency. The particular strength of BU methods is that they enable evaluation of individual policy measure in terms of its impacts and cost-effectiveness, which further forms a basis for redefinition of a measure in case of underachievement.

The use of TD indicators is recommended to capture overall effects of trends in energy consumption. However, as they are based on statistics, they capture the impacts of other influencing factors as well and as such are not exact indicator of the policy success. Nevertheless, they should be used at least as a plausibility check of energy savings proved by BU methods. For such a plausibility check, the TD and BU methods should be designed so as to yield comparable results. The TD indicators proposed by the EC and implemented in Croatia still take into account the structural effects and as such are not capturing the 'real' all energy savings but 'apparent total' energy savings (Wuppertal Institute 2009) and as shown in Table 7 significantly overestimate the savings in comparison with the calculations made using BU methods and modeling. The structural effects are dominant in industry and transport sector, exactly the sectors where the largest differences in calculated results are obtained.

There is obviously the need to improve M&V methods at the EU level, which will become increasingly important with the new Energy Efficiency Directive currently being discussed. The Croatian example shows that EC recommendations in this field are highly useful as a starting point in developing own M&V system. We consider the BU approach more appropriate as it enables evaluation of individual policy measures and provides a basis for their redefinition. However, due to their time and resource requirements, which are significant, it would also be useful to enhance TD indicators to provide better insight in the real savings achieved as a result of policy measures.

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