A GUIDE TO MONITORING AND EVALUATION OF ENERGY EFFICIENCY MEASURES

RCREEE

Regional Center for Renewable Energy and Energy Efficiency

المركز الإقليمي للطاقة المتجددة وكفاءة الطاقة

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About RCREEE

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Disclaimer

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1 Introduction

The National Energy Efficiency Action Plan (NEEAP) is a planning tool to bring about market transformation towards energy efficiency, through the setting of measures. A well designed NEEAP ensures the availability of information to the relevant stakeholders

The overall design of a NEEAP should incorporate the following sections:
- EE indicative targets
- Suitable measures to achieve the targets
- An assigned responsible entity

When drafting the NEEAP, it is important to consider monitoring and evaluation at all stages of the process. Measures are grouped as per sectors. The most common sectors of electricity consumption are Residential, Industrial and commercial/Tertiary.

This guide has been prepared to accompany the document " The Arab Guidelines for Improving Electricity Efficiency and Rationalizing its Consumption at the End User." It contains several examples of NEEAP measures to assist authorities in the design, monitoring, and evaluation of their NEEAPs. It must be noted that some measures that are RE-related were included in this Guide. This may be justified by the fact that implementing these measures has essentially the same effects and behavior characteristics to EE measures. Implementing Solar Water Heaters is a typical example, and has been included in this methodology as such.

2 Design (Ex-Ante) evaluation

2.1 Why conduct design evaluation?

The NEEAP mentions electricity savings target to be achieved by the end of a certain period (the year 2020 according to the Arab guidelines). It is important to conduct design evaluation in order to assess the general design and structure of EE measures, i.e, whether they are designed in a way to achieve the stated targets.

2.2 What should be included when looking at measures?

First and foremost, countries should carry out research on existing measures, legislations, strategic plans, national plans, projects and proposals related to EE that have been conducted in the past or submitted recently.

Based upon these documents, we can ask following questions:

The below list represents the sections to be developed when describing the measures in details. It can be used as diagnostic tool to ensure that measures are SMART (Specific, Measureable, Achievable, Realistic, Time-bound) and contain a relevant amount of information for stakeholders to benefit from:

1	Title of the measure
2	Objectives
3	Description of the measure
4	Implementing agency
5	Stakeholders involved
6	Target group
7	Program cost
8	Total resource cost
9	Cost/KWh saved
10	Reduction of subsidies
11	Source of funding
12	Financial instruments
13	Awareness
14	Monitoring & Evaluation

2.2.1 Title of the measure

The title must be synthetic and clear. Does the reader understand the general idea of the measure at a glance? Is it easy to remember?

2.2.2 Objectives

The statement to be definitely avoided is "Saving electricity".
All savings measures lead to electricity savings, but this is not the ultimate reason why we wish to implement them. The objective should have a long-term viable transformative effect. The following questions can be asked:
- Is there a market component which we wish to develop?
- Do we want to bring about a change in behaviour at the consumer level?
- What is the bigger strategic vision of implementing this measure?

2.2.3 Description of the measure

The objective needs to be supported by number of activities, which are detailed as being SMART. The desired results of the implementation of the measure can be described by a certain percentage (or number) by a certain date.

- What is the current market situation?
- Are there any barriers that need to be overcome before/while/after implementation of the measure in order to obtain the expected results?
- What technology is intended to be used?
- Justify why this specific technology is the most convenient in comparison to currently used technologies (if any).

- Justify choice of the chosen technology with respect to existing alternative technologies.
- How do we intend to certify the quality of the products involved (if any)?
- Is a target plan put in place? The NEEAP evaluation is carried out on a yearly basis.

2.2.4 Implementing agency

The implementing agency is the one in charge of making sure the measure is set up and achieves its goals. The implementing agency should be able to carry out monitoring and evaluation at a later phase, and is held accountable for the measure progress.

- Who is going to carry out the actual implementation?
- Is there a single designated responsible person or contact? If yes, who is it, and what are he/her roles and responsibilities?
- Is it clear who which entity is designated as the implementing agency?

2.2.5 Stakeholders involved

Other Partners involved in implementing of the EE measures in a supportive role or negatively or positively affected by the measure

2.2.6 Target group

Target groups are the groups which are going to be directly affected or impacted as a result of the measure being implemented.

This should be considered carefully, taking into consideration which phase of the measure is being dealt with. A measure might impact a target group at the beginning phase, and impact a different target group at the maturity phase of implementation.

- What stage are we implementing the measure at?
- Who is directly involved at this point in time?
- What will be the long-term impact of the measure after a month, year, two years (time specific) period and on which target group?
- Is there a categorization of the target group, i.e. sub-group? Factors which could affect categorization could be socio-economical, climatic, geographical location, demographic etc.

2.2.7 Program cost

What is the cost of the program? The amount required to implement the program, except financial contributions and investments by the target group (beneficiaries).

- Does the program cost include a budget for awareness raising and capacity building activities?

2.2.8 Total resource cost

Program costs plus, if applicable, contributions by beneficiaries

- Does the total resource cost include all costs relating to the measure?

2.2.9 Cost/KWh saved

The cost of kWh saved is a cost-benefit factor which will help determine of the measure is economically feasible. If the cost of the kWh saved is lower than the marginal cost of kWh produced in the country, this gives a quick indication of economic feasibility.

2.2.10 Reduction of subsidies

How much electricity will be saved as a result of the measure, in kWh?
What is the amount of subsidies the state contributes to per kWh?
The reduction of subsidies after 1 year of implementing the measure would be for example:

*Reduction in subsidies = Electricity saved * price subsidy per kWh*

This can be based on expected savings values when designing the measure, and will be calculated using actual savings values in the impact monitoring and evaluation phase after implementation of the measure.

2.2.11 Source of funding

These sources are often government agencies or donor agencies. This is important to be clearly defined since it gives a direction of where to source funds from and whom to target for funding.

- Who is funding? Is the funding currently available? Or do funding agencies have to be approached?
- For how long is the funding secured?
- Are the grants/funding valid only for feasibility studies and initial phases, or for whole program?
- Are there several sources of funding? If yes, how can they be categorized?

2.2.12 Financial instruments

It is advisable at this phase to consult with specialist persons at the relevant planning/financial national institution for a more realistic approach.

- What fiscal and financial instruments such as investment grants, tax incentives, preferential interest rates, rebates, gifts contributing to the total resource costs will be involved?
- What effect will the financial instruments have on the existing market situation?
- If a consumer product/service is involved how will the financial instrument affect consumer reaction towards consumption and market dynamics?

2.2.13 Awareness

The measure should be considered as a product we wish to market. Marketing strategies should be developed and awareness campaigns devised.

- What is the budget allocated for the awareness campaigns?
- How long are they going to last?
- What communication channel/channels will be given priority?
- How will the success of the campaigns be evaluated?
- Are expected impacts short term or long term or both?
- Which target groups are targeted?

2.2.14 Monitoring & Evaluation

To be able to quantify the impact of the measure, we need factors to measure progress.

Monitoring and Evaluation is the procedure of measuring and determining the actual energy savings after implementation of the energy efficiency measure. Energy savings cannot be directly measured, since they represent an unused energy, therefore savings are usually estimated by comparing the energy use before and after implementation of the measure. This process is necessary in order to evaluate the effectiveness of the policy measure and make appropriate adjustments.

Why conduct M&V?

- Enhance the credibility of energy management projects
- Increase the confidence of donors and investors
- Encourage further investment in EE projects

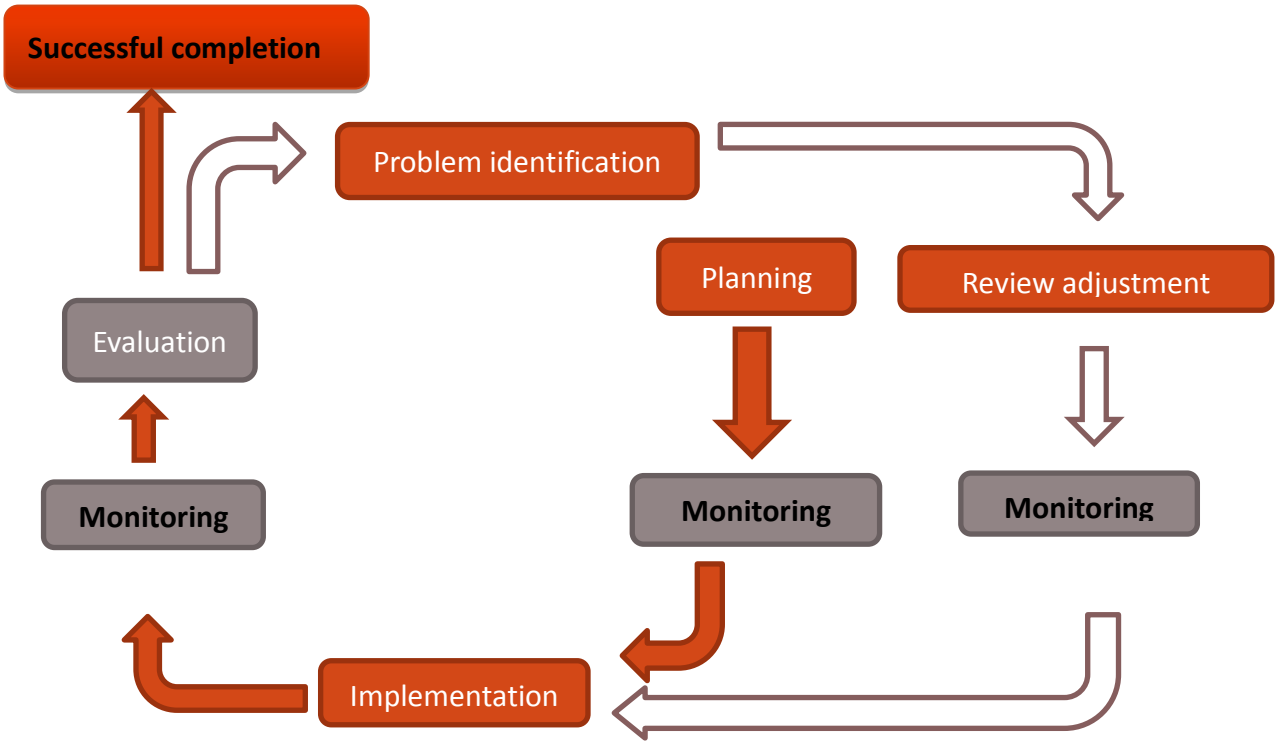
These factors should be considered while designing the measure from the start:

- What indicators will be used?
- Are the statistics used to calculate these indicators realistically collectable?
- Do we have the necessary infrastructure and human capacity to carry out this data collection and analysis process?
- What will be the budget allocated to this process? Have we considered it over the whole implementation period of the program and even after?
- Are we involved with the national statistics agency or not?
- Is this a stand-alone initiative or is it a collective input strategy?

3.1 Post-Ex Monitoring and Evaluation

The intention behind monitoring and evaluation is to inform interested parties about the performance of the national energy efficiency action plans (NEEAP's) and to improve the planning as well as the design of the future one's.

In simple terms, monitoring is the process of collecting data and information regarding the measures. Meanwhile, evaluation refers to the analysis of the data collected from the monitoring stage. Evaluation is done at three different levels: process, impact and market, which will be explained later in this document.. The evaluation process is intended to assess the measure's success or failure. In case of failure, the monitoring and evaluation process helps to identify the obstacles faced and their causes in order to be addressed in future designs.



{The diagram above illustrates the sequence of the entire process and shows where the role of Monitoring and Evaluation comes}

3.2 Basis of analyses:

This methodology is intended to assess the success or failure of a measure at three key levels, which are process, impact and market.

Process evaluation analyzes the measure's progress from design to implementation, taking into consideration the implementation plan, the financial mechanisms, capacity building activities and regulatory reform. Impact evaluation focuses on the achieved energy and financial savings as well as the greenhouse gas (GHG) emission reduction. Impact evaluation is important to assure funding and generate public support for energy efficiency programs because it provides reliable evidence of energy savings and emission reduction. Meanwhile, market evaluation assesses the market transformation resulting from the growth in demand for the EE technology or practice addressed in the measure. Market transformation is the ultimate objective of any EE measure.

Process:

- **Implementation:**
- This section monitors and evaluates whether the implementation of the measure is in accordance with the plan outlined in the NEEAP. This section is also intended to keep track of any changes or modification to the original plan.
- **Finance:**
- The finance section tracks the financial aspects of the measure. It monitors if funds have been allocated, how much of the funds have been spent, and where have they been spent. This section also monitors incentives mechanisms, if any.
- **Capacity building:**
- This section tracks how technical capacity deficits are being addressed by the implementing agency of the measure.
- **Regulation:**
- The regulation part covers the any changes in laws, regulations or codes in order to facilitate the implementation of the measure and subsequently market transformation.

Impact:

- **Energy savings:**
- …concerns the data required to calculate energy savings that differs from a measure to another.
- **Financial savings:**
- …is the amount of subsidy saved as a result of energy savings.
- **CO_2 emission reduction:**
- …regards the amount of CO_2 reduced for the total amount of energy saved provided in a form of percentage.

Market:

- **Market transformation:**
- The section about Market transformation studies the supply and demands role in shaping the market.

3.3 Calculation:

Bottom up and top down are the two main approaches to calculate energy savings from energy efficiency measures.

Top-down approach refers to the method of energy savings evaluation where *"Amount of energy savings or energy efficiency progress are calculated using national or aggregated sectorial levels of energy saving as the starting point."* (Bruno Lapillonne, 2009)

Bottom-up evaluation starts from data at the level of a single energy efficiency improvement (EEI) measure, mechanism, program, or energy service (e.g. monitoring energy savings per participant and number of participants), and then aggregates results from all EEI measures reported by a Member State to assess its total energy savings in a specific field. (Evaluate Energy Savings EU)

If it is a large scale nation-wide initiative, bottom up method can be costly, resource consuming and time-consuming, and a Top-down approach would be preferred. However, through proper data collection coordination, bottom-up can allow for a set of more accurate data that can be used to give a realistic view of energy saved. It must be noted that the two methods complement each other and can be used for cross-checking methodologies and results. Depending upon resource

mobilization (financial, human, time) and accuracy of results required, one method can be preferred over the other.

4. Energy Efficiency Measures Evaluation Template:

4.1 Replacing regular inefficient lamp with more efficient lamps

Introduction:

Measures to improve the energy efficiency of indoor lighting in the buildings sector are commonly used in EE action plans. All existing NEEAPs in the Arab region include such measures. Compact Fluorescent Light (CFL) is the most popular technology in these measures and is selected here for demonstration purposes only.

4.1.1 Questionnaires:

The questionnaire is divided into three key sections, which are process, impact and market evaluation questions. Each section contains sub units targeting specific aspects of the implementation process.

Process questionnaires:

This section aims to evaluate the measure's progress from design to implementation.

Implementation plan:

- What is the current situation with the contractors?
  - Whether it is still at the competitive bidding stage, negotiating with the contractors or undergoing the implementation phase.
- Please provide a brief description of the implementation plan for the selected approach?
- Has there been any modification in the plan?
- How many bulbs have been replaced\distributed\ installed?

Finance:

- Has the financing source been identified? If so please name the sources of funding.

- What is the incentives mechanism for the measure?
- Has the budget been allocated?
- What is the current consumed budget?
- Have funds been allocated for awareness campaigns to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?
- Have funds been allocated for capacity building activities to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?

Capacity building:

- Is there a plan for capacity building in order to develop technical knowledge about CFL's?
    - Provide a brief description of the capacity building plan.
- What is the current status of capacity building?

Regulations:

- Please provide a brief description of any regulations that have been adopted to support this measure?

Impact questionnaires:

The purpose of this section is to determine both demand and energy savings along with other co-benefits such as avoided emission.

Calculating energy savings:

- What is the power rating of the replaced bulbs?
- What is the power rating of the replacement bulbs?

- What is the average electricity consumption of households for lighting before the implementation of the measure?
- What is the average electricity consumption of households for lighting after the implementation of the measure?
- What is the number of permanently occupied dwellings before the implementation of the measure?
- What is the t number of permanently occupied dwellings after the implementation of the measure?

Other savings:

- What is the amount of financial savings?
- Did the measure achieve the expected financial savings (i.e. the savings earned after restoring the capital spent on the project.)
- By how much were GHG emissions reduced as a result of the implementation of this measure?

Market questionnaires:

This final section of questionnaire aims to assess the influence of the measure on the market.

Market transformation calculations:

- Did the market share of CFL bulbs increase as a result of the measure? By how much?
    - What was the market share of CFL bulbs before the implementation of the measure?
    - What is the market share of CFL bulbs after the implementation of the measure?
- Did local manufacturing of CFL bulbs increase as a result of the implementation of this measure?
    - What was the number of factories involved in the production of CFL technologies before the implementation of this measure?

- What is the number of factories involved in the production of CFL technologies after the implementation of this measure?

Survey:

- Has a surveys been conducted to assess the market transformation in the country?

Calculation of energy savings

There are two main approaches when it comes to calculating energy savings: there is the top down TD and the bottom up BU models.

Top Down:

Starting with the Top Down approach using $\boldsymbol{S_{CFL}}$ indicator for electricity consumed by households for lighting in $[KWh\backslash year\ per\ dwelling]$, which is the ratio between the electricity consumption of households for lighting and the number of permanently occupied dwellings. It is usually estimated via a calculation that takes into account the number of lighting points, or the average lighting power and average number of hours of lighting per year. An increase in the number of lighting points and/or in the number of hours of lighting may offset energy savings and may lead to an underestimation of these savings or to difficulty in measuring any savings.

$$\boldsymbol{S_{CFL}} = \left(\frac{\boldsymbol{EC_r}}{\boldsymbol{D_r}} - \frac{\boldsymbol{EC_t}}{\boldsymbol{D_t}}\right) \times \boldsymbol{D_t}$$

Where:

EC_r, EC_t ≡ Electricity consumption of households for lighting in referenced year and in year *t* respectively.

D_r, D_t ≡ Number of permanently occupied dwellings in referenced year and in year t respectively

Unit ≡ [kWh/year per dwelling]

Bottom Up:

The total annual energy savings achieved (kWh/year) is *calculated by multiplying the annual unitary final energy savings by the number of efficient light bulbs sold or installed for residential use*. The annual unitary final energy savings UFES_CFL are calculated by subtracting the power consumption rate of the efficient lamps sold or installed from the lamp stock average power consumption rate in the reference year.

$$\boldsymbol{TES_{CFL} = UFES_{CFL} \times N_{CFL}}$$

$$\boldsymbol{UFES_{CFL} = \frac{(P_{STOCK\_AVERAGE} - P_{CFL}) \times \eta_h \times F_{rep}}{1000}}$$

Where:

TES_{CFL}≡ Total energy savings [kWh/year].

$UFES_{CFL}$≡ Annual unitary final energy savings [kWh / unit / year]

N_{CFL} ≡ The number of efficient light bulbs sold or installed [unit].$P_{STOCK\_AVERAGE}$≡ Average power rating of the existing lighting bulbs in households [W]

P_{CFL}≡ Power rating of the promoted efficient bulb, in this case CFL [W].

η_h ≡ Average number of operating hours per year

F_{rep} ≡ Correction factor taking into consideration that a proportion of bulbs sold will not immediately replace existing bulbs $F_{rep} \leq 1$.

Example:

The examples were based on the data provided in the Egyptian NEEAP and external assumptions to illustrate the calculation.

Given:

Targeted number of CFL = 12,000,000

P_{CFL} *= 20 – 23 w*

Assumptions:

$P_{STOCK\_AVERAGE}$ *= 100 w*

P_{CFL} *= 20w*

η_h *= 8 h/day = 2920 h/year*

N_{CFL} *= 4 million after 1 year*

CFL life time = 3 years

$$TES_{CFL} = UFES_{CFL} \times N_{CFL}$$

$$UFES_{CFL} = \frac{(P_{STOCK\_AVERAGE} - P_{CFL}) \times \eta_h \times F_{rep}}{1000}$$

$$\mathbf{UFES_{CFL}} = \frac{(100 - 20) \times 8 \times 365 \times 1}{1000}$$

UFES = 233.6 kWh

$$\mathbf{TES_{CFL}} = 233.6 \times 4 \times 10^6\ kWh$$

TES_{CFL} = 934.4GWh

Recommendations:

- Since the required data for the calculation of S_CFL equation is not available for most countries in the region, it is recommended to use the bottom up approach to calculate energy savings from energy efficient lighting measures

4.2 Solar Water Heater (SWH) for domestic use:

Introduction:

Given the abundance of solar energy in the Arab region, solar water heaters represent a cost-effective energy efficiency technology for most Arab countries. Most NEEAPs in the Arab region include a measure to promote the use of this technology. In developing countries and countries in transition high start-up cost of purchase and installation exceed a great portion of the interested household's financial ability. Therefore, a suitable incentive mechanism is a necessity and it is essential for the incentive instrument to be in line with the legal framework, tax in addition to the market competition rules.

Questionnaires:

The questionnaire is divided into three key sections, which are process, impact and market evaluation questions. Each section contains a sub unit targeting a specific concern.

Process questionnaires:

This section aims to evaluate the measure's progress from design to implementation.

Implementation plan:

- Have targeted areas and types of domestic water heaters been quantified and identified?
- What is the current status of the measure?
    - Is it still in the feasibility study phase or has it moved to the implementation phase?
- What is the approach followed in the NEEAP?
    - The most common approaches are distribution, replacement and installation, etc.
- Provide a brief description of the implementation plan for the selected approach?
- Has the implementation plan been modified since the adoption of the NEEAP?
- What is the current number of SWHs that have been replaced/ distributed/ installed?

Finance:

- Name the source of funding? And specify the amount of money allocated?
- What incentive mechanism is used in the NEEAP? Tax deduction, low interest loans (soft loans) or direct subsidy?
    - If the mechanism is a soft loan, what is the interest rate and the duration of the loan
    - If the mechanism is a direct subsidy, what is the size of the subsidy?
- Is there an "incentive phase out" plan? If so, describe.
- Has the budget optimally been allocated?
- What percentage of the budget has been consumed?

- Have funds been allocated for awareness campaigns to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?
- Have funds been allocated for capacity building activities to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?

Capacity building:

- Is there a plan for capacity building in order to develop a technical knowledge about SWH?
- Provide a brief description of the capacity building plan.
- What is the current status of these planned capacity building activities?

Regulations:

- Provide a description of any regulations that have adopted regarding usage of domestic Solar Water Heaters. For example, state the type whether there is any law incorporated into building code to enforce the use of SWH in new and/or existing building etc.
- Have any of the regulations been enforced? If so point them out.

Impact questionnaire:

In order to assure funding and have the public's support for energy efficiency programs, reliable evidence of energy saving and emission reduction is essential. The impact questionnaire aims to provide this evidence.

Calculating energy savings:

- What is the average energy efficiency of the electrical water heaters?
- What is the energy consumption of households for water heating in the referenced year?
- What is the current energy consumption of households for water heating?
- What is the specific hot water demand?

Other savings:

- What is the amount of financial savings out of using SWH?
- Did the procedure meet the expected savings?
    - I.e. the savings earned after restoring the capital spent in the project.
- What is the percentage of the reduced emissions?
- What is the percentage of the peak hours load reduction?

Market questionnaires:

This final section aims to estimate the influence of the measure on the market transformation.

Market transformation:

- Did the market share of SWHs increase as a result of the measure? By how much?
    - What was the market share of SWHs before the implementation of the measure?
    - What is the market share of SWHs after the implementation of the measure?
- Did local manufacturing of SWHs increase as a result of the implementation of this measure?
    - What was the number of factories involved in the production of SWH technologies before the implementation of this measure?

- What is the number of factories involved in the production of SWH technologies after the implementation of this measure?

Survey:

- Has a survey been conducted to evaluate the market transformation as a result of this measure?

Calculations:

There are two main approaches when it comes to calculating energy savings: there is the top down TD and the bottom up BU models.

TD:

Top down approach uses the solar water heater savings S_{SWH} Indicator to calculate the saving in $[KWh\backslash year\ per\ dwelling]$, which is the ratio between the energy consumption for water heating in the residential sector and the total population. Therefore, data such as the energy consumption of water heating and the total population is essential in calculating the saving.

$$\mathbf{S_{SWH}} = \left(\frac{\mathbf{EC_r}}{\mathbf{P_r}} - \frac{\mathbf{EC_t}}{\mathbf{P_t}}\right) \times \mathbf{P_t}$$

Definition:

EC_r, EC_t ≡ Energy consumption of households for water heating in the refinance year and in year t.

P_r, P_t ≡ Total population in the reference year and in year t.

Bottom up approach for SWH will involve collecting data from each dwelling in the project. This can be very resource intensive. Unless it is a small-scale pilot project, it makes more sense to conduct top down approach for this measure, which is less resource intensive.

4.3 Standards and labeling :

Introduction:

Standards and libeling for home appliances is an important energy efficiency measure that can result in significant savings in the long run simply by redirecting the consumer's purchasing behavior towards the more efficient products. Most NEEAPs in the Arab region include S&L measures.

Questionnaires:

The questionnaire is divided into three key sections, which are process, impact and market evaluation questions. Each section contains a sub unit targeting a specific concern.

Process questionnaires:

This section aims to evaluate the measure's progress from design to implementation.

Implementation plan:

- Has a survey been conducted to evaluate the market share of appliances based on energy performance?
- Have target appliances been identified?
- What is the current status of the measure? Is it still in the feasibility study or has it moved to the implementation phase?
- Provide a brief description of the implementation plan.
- Have minimum energy performance standard (MEPS) been developed for each of the targeted appliance?
- Is there a local testing facility and is it equipped for the measure implementation?
- Have the labels been designed?
- Is there an entity in charge of printing and distributing labels? Or are the manufacturers and suppliers in charge of printing their own labels?

- Has a tracking system been created to keep track of sold appliances by energy performance rank?
- What is the time-frame for the implementation of the standards and labeling system?

Finance:

- Has the source of funding been identified? Name the source of funding? And specify the amount of money allocated?
- Is there an incentive mechanism for energy efficient appliances? What type of incentive mechanism? Tax deduction, low interest loans (soft loans) or direct subsidy?
    - ❖ If the mechanism is a soft loan, what is the interest rate and the duration of the loan
    - ❖ If the mechanism is a direct subsidy, what is the size of the subsidy?
- Is there an "incentive phase out" plan? If so, describe.
- What percentage of the allocated budget has been consumed?
- Have funds been allocated for awareness campaigns to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?
- Have funds been allocated for capacity building activities to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?

Capacity building:

- Is there a plan for capacity building in order to upgrade the technical knowledge in testing facilities and enforcement?
- Are there any capacity building measures provided to the manufacturers?
- Provide a brief description of the capacity building plan/plans.

Regulations:

- Is participation in the S&L system voluntary, mandatory?
- Do any legal documents regarding implementation of the measure and/or enforcement exist?
- Has the MEPS been developed for the appliances targeted in this measure?
- Is there a plan to pass regulation to ban the importation of un-labeled household appliances targeted in the measure?

Impact questionnaire:

In order to assure funding and have the public's support for energy efficiency programs reliable evidence of energy and financial saving as well as CO_2 emission reduction is essential and the impact questionnaire aims to provide that.

Energy savings:

- What is the average annual energy consumption of targeted appliances before the implementation of the measure?
- How many labeled appliances have been sold since the implementation of the measure? What is the number and average annual energy consumption of these sold appliances by rank?

Financial savings:

- What is the amount of financial savings?
- Did the measure achieve the expected savings? (i.e. the savings earned after restoring the capital spent in the project).

Market questionnaires:

Market transformation:

- Did the market share of energy efficient appliances increase as a result of the measure? By how much?
    - What was the market share of energy efficient appliances before the implementation of the measure?
    - What is the market share of energy efficient appliances after the implementation of the measure?
- Did local manufacturing of energy efficient appliances increase as a result of the implementation of this measure?
    - What was the number of factories involved in the production of energy efficient appliances before the implementation of this measure?
    - What is the number of factories involved in the production of energy efficient appliances after the implementation of this measure?

Survey:

- Has a survey been conducted to evaluate the market transformation towards the energy efficient appliances?

Calculations:

The main approach when it comes to calculating energy savings out of using efficient appliances is the bottom-up **BU** formula which calculates the total energy savings

BU:

The total annual energy savings per appliance type in [KWh/year], Which is the difference between the annual energy consumption of the reference year stock average and the annual energy consumption of the efficient appliances sold or installed multiplied by the number of energy efficient appliances units sold or installed.

$$TES_{S\&L} = AEC_{REFapp} \times N_{S\&L} - TAEC_{EEapp}$$

$$TAEC_{EEapp} = (AEC_A \times N_A + AEC_B \times N_B + \cdots)$$

First equation:

$TES_{S\&L}$ ≡ Total energy savings out of using efficient appliances

$AEC_{REFapp}, TAEC_{EEapp}$ ≡ Average annual energy consumption of the appliance stoke in the reference year and the energy efficient appliance in the market.

$N_{S\&L}$ ≡ The number of energy efficient appliances units sold or installed.

Second equation:

$TAEC_{EEapp}$ ≡ The total energy consumption for the labeled appliances.

AEC_A, AEC_B ≡ Annual energy consumption of the A or B labeled appliance.

N_A, N_B ≡ Number of A, B raked appliance respectively.

Example:

The examples were based on random household appliance to illustrate the use of the equation

Assumptions:

$\mathbf{AEC_{2011Hd}}$ = *1300 kWh/year*

$\mathbf{N_{S\&L}}$ = *1800*

$\mathbf{AEC_A}$ = *800 kWh/ year*

$\mathbf{N_A}$ = *1000*

$\mathbf{AEC_B}$ = *1000 kWh/year*

$\mathbf{N_B}$ = *800*

$$\mathbf{TES_{S\&L}} = \mathbf{AEC_{2011Hd}} \times \mathbf{N_{S\&L}} - \mathbf{TAEC_{EEapp}}$$

$$\mathbf{TAEC_{EEapp}} = (\mathbf{AEC_A} \times \mathbf{N_A} + \mathbf{AEC_B} \times \mathbf{N_B} + \cdots)$$

$$\mathbf{TAEC_{EEapp}} = (\mathbf{800} \times \mathbf{1000} + \mathbf{1000} \times \mathbf{800})$$

$$\mathbf{TAEC_{EEapp}} = \mathbf{1.6} \times \mathbf{10}^{\mathbf{6}}\ \boldsymbol{kWh}$$

$$\mathbf{TES_{S\&L}} = \mathbf{1300}\ \boldsymbol{kWh} \times \mathbf{1800} - (\mathbf{1.6} \times \mathbf{10}^{\mathbf{6}}\ \boldsymbol{kWh})$$

$$\mathbf{TES_{S\&L}} = \mathbf{.74}\ \boldsymbol{GWh}$$

4.4 Street lighting

Introduction:

Unnecessary yearly costs imposed by old inefficient street lighting installations could be reduced to approximately 60% simply by utilizing today's technology. Meanwhile in the Arab region we can fairly say that the majority of street lighting facilities are outdated thus highly inefficient which indicates a room for improvement.

Energy savings out of upgrading street lighting depends entirely on the underlying technology. Therefore, technology chosen should be based on good analyses.

Questionnaires:

The questionnaire is divided into three key sections, which are process, impact and market evaluation questions. Each section contains a sub unit targeting a specific concern.

Process questionnaires:

This section aims to evaluate the measure's progress from design to implementation.

Implementation plan:

- Has the area for the intervention been selected?
- Is the area selected for this measure connected to the grid? What is the current situation with the

contractors? Is the measure still at the competitive bidding or at negotiation stage?

- What is the planned approach for the implementation of this measure?
    - The most commonly used approaches are replacement and installation.
- What is type of technology will be used? Installation of photo-sensor devices, installation of PV powered bulbs, or replacement with efficient high pressure sodium lamps?
- Please provide a brief description of the implementation plan for the selected approach.
- Has there been any modification in the plan?
- What is the targeted amount of bulbs to be upgraded/ replaced or installed?
- How many bulbs have been replaced or installed?

Finance:

- Has the source of funding been identified? Name the source of funding? And specify the amount of money allocated?
- What percentage of the allocated budget has been consumed?
- Have funds been allocated for capacity building activities to support the implementation of this measure?
    - What is the amount of the allocated budget?
    - What percentage of this budget has been consumed?

Capacity building:

- Is there a plan for capacity building in order to develop a technical knowledge about installation and maintenance of the upgraded lighting system?

- Kindly provide a brief description of the capacity building plan.
- What is the current status of capacity building?

Regulations:

- Has there been any adaptation of a new street lighting code? If so kindly provide a brief description of the code.
- Does any legal document exist regarding the enforcement of the implementation?

Impact questionnaire:

In order to assure funding and have the public' s support for energy efficiency programs reliable evidence of energy saving and emission reduction is essential and the impact questionnaire aims to provide that

Calculating energy savings:

- What is the power rating of the replaced bulbs?
- What is the power rating of the replacement bulbs?
- What are the average hours of operations for street lighting?
- What are the average hours of operation after using a photo sensor?
- What is the current number of lamps underwent the procedure?

Other savings:

- What is the amount of financial savings?
- Did the procedure meet the expected savings?
  - I.e. the savings earned after restoring the capital spent in the project.
- What is the percentage of the reduced co_2 emissions?
- What is the percentage of the peak hours load reduction out of implementing this measure?

Market:

- the market section was not applicable in this stage of monitoring and evaluation due to the low and inconsistent demand, thou it could exist in the new or second NEEAPs.

Calculations:

The calculation regarding this measure depends entirely on the underlying technology and the reduction of energy related to it.

In case of installation of new photo sensors PS:

$$\boldsymbol{TES_{SL\_PS}} = \left[\frac{\boldsymbol{P_{SL}} \times \boldsymbol{\eta_h} - \boldsymbol{P_{SL}} \times \boldsymbol{\eta_{h_{PS}}}}{\mathbf{1000}}\right] \times \boldsymbol{N_{SL}}$$

Definitions:

TES_{PS}≡ Total energy savings out of installing PS in [kWh\year].

P_{SL}≡ Average power rating of existing street lighting bulbs in [W].

$\eta_h, \eta_{h_{PS}}$≡ The average number of operation hours and the average number of hours of operation after installing the photo sensor respectively.

N_{SL}≡ The number of street lighting lamps that underwent the installations.

In case of using solar energy technology PV**:**

$$\boldsymbol{TES_{SL\_PV}} = \left[\frac{\boldsymbol{P_{SL}} \times \boldsymbol{\eta_h}}{\mathbf{1000}}\right] \times \boldsymbol{N_{SL}}$$

Definitions:

TES_{PV}≡ Total energy savings out of installing PV' s in [kWh\year].

P_{SL}≡ Average power required for the existing street lighting bulbs in [W].

η_h≡ The average number of operation hours.

N_{SL}≡ The number of street lighting lamps that underwent the installations.

<u>In case of replacing inefficient lamps with more efficient ones :</u>

In the following example, High Pressure Sodium Lamp (HPSL) is selected as a more efficient lamp for demonstration purposes only.

$$\boldsymbol{TES_{SL\_HPSL} = \left[\frac{(P_{SL} - P_{HPSL})}{1000}\right] \times \eta_h \times N_{SL}}$$

Definitions:

TES_{HPSL}≡ Total energy savings out of installing HPSL in [kWh\year].

P_{SL}, P_{HPSL}≡ Average power requirement for the old street lighting bulbs, the power required for the high pressure sodium lamps respectively in [W].

η_h≡ The average number of operation hours.

N_{SL}≡ The number of street lighting lamps that underwent the installations.

Example:

Given:

P_{SL} *= 400 W*

P_{HPSL} *= 100 W*

Number of operation hours = 8 hours

Number of efficient lamps installed = 1 million

$$\boldsymbol{TES_{SL\_HPSL} = \left[\frac{(P_{SL} - P_{HPSL})}{1000}\right] \times \eta_h \times N_{SL}}$$

$$\boldsymbol{TES_{SL\_HPSL} = \left[\frac{(400 - 100)}{1000}\right] \times 8 \times 365 \times 10^6}$$

$$\boldsymbol{TES_{SL\_HPSL} = 876\ GWh}$$

Other Measures to consider

The most common measures in the existing NEEAPs were covered in this methodology. Other measures such as building insulation and EE buildings, power factor corrections (in electrical networks, and industry) etc can be included in future versions of the methodology, which were not covered here.

Conclusion

Monitoring and evaluation of measures is essential for determining the progress and effects of NEEAP measures. Market, impact and process evaluation are described in this document using examples of the most common measures, such as CFL, Street lighting and Solar Water Heaters.

In either case, monitoring and evaluation of measures should be considered from the very start during measure design, so as to accommodate for the type of data required for the evaluation phase, and also to allow an estimate of M&V program costs.

This methodology could also be used to test a measure before inserting it into a NEEAP. Answering the mentioned questions in advance will show the future concerns of the measure implementation and its share in achieving the NEEAP indicative target.

Therefore, the methodology will be a guiding document to the measures designer, executer and evaluator.

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