# Brief outline and the expected outcomes

## Estimation of the Cost of Energy Not Served

Probabilistic estimation of Energy Not Served (ENS) and the economic cost of this ENS are used in the Generation planning process, that target minimization of the system cost including cost of ENS.

At the moment the Transmission Licensee (Ceylon Electricity Board- CEB) used 0.745 USD/kWh as cost of ENS in the draft Least Cost Generation Expansion Plan 2020-2039, that is escaladed for inflation from figure specified in the generation Planning Code (USD 0.5/kWh in 2011) approved by the Public Utilities Commission of Sri Lanka (PUCSL). Neither the figure specified by PUCSL nor the figure used by CEB, is scientifically set. Apart from the generation planning process, the figure is used for estimation of economic cost of load shedding, interruptions, etc

Though survey based approaches by Prof. Priyantha D.C. Wijayatunga et al in 2002 (SARIE Energy study) and by D.P. Colambage et al (University of Moratuwa) in 2015, have come up with wide rage for cost of ENS for Sri Lanka.

The researcher is expected to study the below mentioned areas;

- The typical planned and unplanned interruptions prevalent in Sri Lanka
- Models/ methods used to estimate cost of ENS
- Selection of a method / model to estimate cost of ENS for Sri Lanka
- The cost incurred by different sectors (like industry, hotel ,commercial, houses, etc) for typical duration of the planned / unplanned interruptions
    - Investments and operating costs of backup generations
    - Material losses, etc
    - Loss of business
    - Inconvenience
- Willingness to pay for minimum interruptions
- Relationship of socio economic parameters with the cost of ENS

The researcher is expected to estimate/ derive the following using surveys or otherwise;

- Cost of ENS for each sector and representative (on average) cost of ENS figure for Sri Lanka
- Econometric (or similar) model linking the cost of ENS estimated above with the socio-economic indicators like income, GDP, etc so that the cost of ENS figure can be updated using those parameters in future

## Annex 2

# Setting System Reliability Criteria for Generation Planning

Generation Reserve Margin - RM (at the critical period of each planning year) and annual Loss of Load Probability (LOLP) tolerance limits (for each planning year) for generation planning purposes needs to be determined based on desired system reliability levels in future.

Neither the current RM and LOLP limit imposed by PUCSL nor the figures used by CEB for the draft Generation Expansion Plan 2020-2039 are set following scientific study.

The Researcher is expected to study the following at minimum;

- international practices related to planning level system reliability criteria, while considering local conditions;
    - system size,
    - demand forecast and short term forecast accuracy
    - increasing penetration of intermittent sources of generation – Wind and Solar,
    - diminishing yet heavy reliance on hydro power,
    - dominance of irrigation requirements in dispatching hydro power,
    - possible interconnection to Indian grid,
    - reliability of existing generators,
    - load curve characteristics,
- reliability level desired by the consumers, etc

Using the above studies/ modeling exercises the researcher is expected to;

- Establish planning level reliability criteria for Sri Lanka
- Advise on the frequency for revision of such criteria in future

## Annex 3

# Grid Integration Limit for Intermittent Sources

The amount of intermittent Renewable Energy (Solar and Wind) based generation that could be absorbed to the grid has been disputed many times, while CEB has been maintaining 20% as the upper limit. An independent network study could be carried out to establish the limit and to identify the other network improvements required to increase it further.

The researcher is expected to study the following at minimum;

- Identify area where large scale intermittent sources could be connected to the grid, including rooftop systems
- The existing and future transmission network (20 year horizon) and conduct stability studies to identify the integration limits for intermittent sources.
- The impact of curtailment on the absorption limits determined above
- The existing grid code related to intermittent sources and the roof top system limits imposed by the distribution licensees
- International practices on integration of intermittent sources and their applicability to a small system like Sri Lanka
- Implications of possible integration with Indian grid (asynchronous V synchronous)

The researcher is expected to identify/ recommend the following;

- Grid absorption limits for intermittent sources with and without curtailment during 2020-2040
- Interventions/ improvements required in the grid (grid code, etc) to increase the absorption limit, that are economically viable considering decreasing cost trend of intermittent sources.

## Annex 4

# Grid Operation with Distributed Generation

With the introduction of more and larger scale intermittent sources (Wind and Solar), roof top systems and mass scale Electric Vehicle deployment, the system operation associates a substantial issue in future and thus review of the intermittent source integration codes, inverter standards, control, etc may be required. The operational issues may be tackled with two approaches, 1) control systems that enable smooth operation of the grid, 2) investing in grid infrastructure to compensate for intermittent and distributed generation.

On grid storage, behind the meter storage, inverter level control at the distribution control centers, demand response schemes, intermittent source generation forecasting, flexible ancillary service procurement, improved inverter standards and interconnection standards are some of the options that could be explored to tackle grid issues with the absorption of more intermittent sources in the system.

The researcher is expected model Sri Lanka grid over 20 years and;

- Review the existing grid and distribution codes and recommend changes to suit a future with 40% or more intermittent sources in the grid
- Review viability of the possible grid investments that may be required to meet the ambitious Renewable Energy (80%) targets.
- Propose gird/ distribution system operation strategies to ensure acceptable reliability

## Annex 5

# Transmission System Study

During the past decade Sri Lanka had several blackouts that were partly due to poor reliability of the transmission system. CEB is preparing a 10 year transmission development plans, which has ambitious investments plans that are rarely implemented on time due to financial and other constraints. CEB has been complaining about a weakness in the southern gird and has been highlighting that when procuring emergency power over the last decade. Several independent studies in past revealed that the model parameters used by CEB needs improvement in order to accurately model the system, especially the dynamic parameters.

The researcher is expected to;

- Derive an accurate transmission system model that can accurately replicate the system conditions under a disturbance.
- Recommend a procedure to update the transmission models/ parameters frequently, so that the system is predictable.
- Scrutinize the issue in the southern grid and suggest investment alternatives to quickly rectify that, if any
- Scrutinize the latest transmission plan of CEB and suggest improvements to ensure system reliability and prudency of future investments.