DERri
Distributed Energy Resources
Research Infrastructures

ANNEX 2: TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

Use-Project Acronym	ETAIzmir
User-Project Title	Determination of Inverter Conversion Efficiency Weighting Factors for Izmir
Main-scientific field	Renewable Energy
Specific-Discipline	Power Electronics

Lead User of the Proposing Team:

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Position in Organization	Head of Dept.

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

Additional Users in the Proposing Team:

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Activity type and legal status* of Organization	(1)
Position in Organization	Res. Asst.

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

(Repeat for all Users)

Date of submission	10 May 2011
Re-submission	YES_____ NO__X___
Proposed Host TA Facility	AIT
Starting date (proposed)	04 July 2011

Summary of proposed research

Inverter efficiencies are considered to be a combination of both conversion and MPPT efficiencies. MPPT efficiencies of the inverters are highly dependent on the DC Input voltage and thus, solar irradiation and its fluctuations. That is why, an approach of using weighted efficiency equations for determining effective efficiencies of PV inverters became a standard procedure.

The recent European Standard for measuring PV inverter efficiency (EN 50530) puts European Efficiency and CEC efficiency formulas as rules. On the other hand, these formulas represent the solar irradiation profile at their respective geographical locations (Trier, GE and CA, USA).

The research topic proposed is to study irradiation profile of Izmir, TR and developing a regional weighted efficiency formula. This formula is to be used to determine energy yields of some commercial inverters through simulations and the results will be compared to Europe and CEC efficiencies. Research includes the derivation of histogram(s) based on the occurrence frequencies of specific irradiation levels as nodes according to annual high resolution solar irradiation data of Izmir.

State-of-the-Art

Rolf Hotopp introduced (1991) a weighted efficiency formula for PV inverters, taking irradiation properties into account. In time, this approach has been adopted as a more convenient way to compare PV inverters since it gives more realistic values for energy yields of PV systems.

California Energy Commission (CEC) has introduced another weighted efficiency formula in 2004 since the previous one was not suitable for their solar irradiation profile.

EN 50530, approved by CENELEC by 2010, recognizes these two formulas as reference for efficiency calculations. EN 50530 also noted the fact that the DC voltage affects the conversion efficiency besides the MPPT efficiency.

Weighted efficiency seems to be generally accepted worldwide in comparing the inverters for their energy yields. On the other hand, different irradiation profiles of different geographical positions should be paid attention to, since the yields are important.

References:

- TS EN 50530 “Overall efficiency of grid connected photovoltaic inverters”, IEC/TSE, 2010.
- TS EN 61683 Photovoltaic systems – Power conditioners – Procedure for measuring efficiency, IEC, 1999.
- B. Burger et. al., “Are we benchmarking PV inverters on basis of outdated definitions if the European and CEC efficiency?”, EUPVSEC, Hamburg, 2009
- B. Bletterie, R. Bründlinger, H. Häberlin, F. Baumgartner, H. Schmidt, B. Burger, G. Klein, M. Alonso Abella, „Redefinition of the European efficiency – finding the compromise between simplicity and accuracy“, 23rd EU PVSEC, Valencia, 2008
- V. Salas, E. Olías, M. Alonso-Abellá, F. Chenlo, “Analysis between Energy Efficiency and European Efficiency” Proceedings of ISES World Congress 2007 (Vol. I – Vol. V) 2009, 4, 1590-1594, DOI: 10.1007/978-3-540-75997-3_327
- M. Valentini, A. Raducu, D. Sera, R. Teodoroscu, “PV inverter test setup for European

efficiency, static and dynamic MPPT efficiency evaluation" *Optimization of Electrical and Electronic Equipment, 2008. OPTIM 2008. 11th International Conference on*, vol., no., pp.433-438, 22-24 May 2008

Detailed Description of proposed project:

Objectives

This research aims to see how a different irradiation profile affects the energy yield of a PV inverter. Putting a proper equation for MPPT efficiency of PV inverters operated in Izmir is the main goal of the project. Having this as major motive, first step is to evaluate the irradiation data statistically.

The raw data should be evaluated within the scope of getting a PV array simulation sequence. Since this evaluation is of high importance for the purpose of this research, studies had better be conducted in supervision of an experienced team and in their infrastructures.

Expected Outcome

For Izmir is geographically in the middle of Turkey on north-south axis, resulting weighting factors can be proposed to be used for Turkey general. Determination of the irradiation pattern and the weighting factors dependently will help programming MPPT routines of the PV inverters for Turkish market. PV electricity is a quite new issue in Turkey on grid application level and related legislation is still maturing. So during this period, it is very timely to have such an outcome with a possible impact of increasing energy yield of PV systems being installed in Turkey.

Fundamental Scientific and Technical value and interest

The proposed outcome of localized weighting factors for adjusting the MPPT behaviors of inverters could lead a geography-specific efficiency description which can be customized for certain climatic geographies.

This proposal contains more than a specific test and measurement sequence – a complete set of data analyzing, modeling and simulation, testing and reporting. In this context, the project ETAIzmir needs some expert researcher(s) and/or scientist(s) contribution along with the infrastructural requirements.

First step is statistical evaluation of the irradiation data and planned to be conducted under supervision. Main purpose of the analysis is to determine if it is necessary to use different nodes (% 10, % 20, % 30, % 50, % 75, % 100 for η_{CEC}, % 5, % 10, % 20, % 30, % 50, % 100 for η_{EU}) for the irradiation profile.

Once the weighted conversion efficiency equation determined, some commercial inverters will be measured for their efficiencies according to EN 50530 and respective yields will be calculated. These yields will be compared with the η_{CEC} and η_{EU} yields.

For the efficiency measurements, **AIT Inverter Test Laboratory** is known to be presenting a

proper infrastructure by being well equipped with 3-phase/30 kW grid-simulator, PV-array simulators, hi-performance power analyzers, precision storage oscilloscopes and various domestic PV inverters besides experienced staff. The **simulation laboratory** in the same premises is also important for the purposes of the ETAIzmir project.

Since we are at verge of establishing **Renewable Energy Technologies Center – YETMER** in the Ege University and seeking cooperation possibilities with AIT, get to know better with the laboratory requirements in the AIT is considered of further importance.

Schedule of study and the steps contained with mutual (AIT-EU) evaluation is given at the end of this application form.

Originality and Innovation of proposed research – Broader Impact

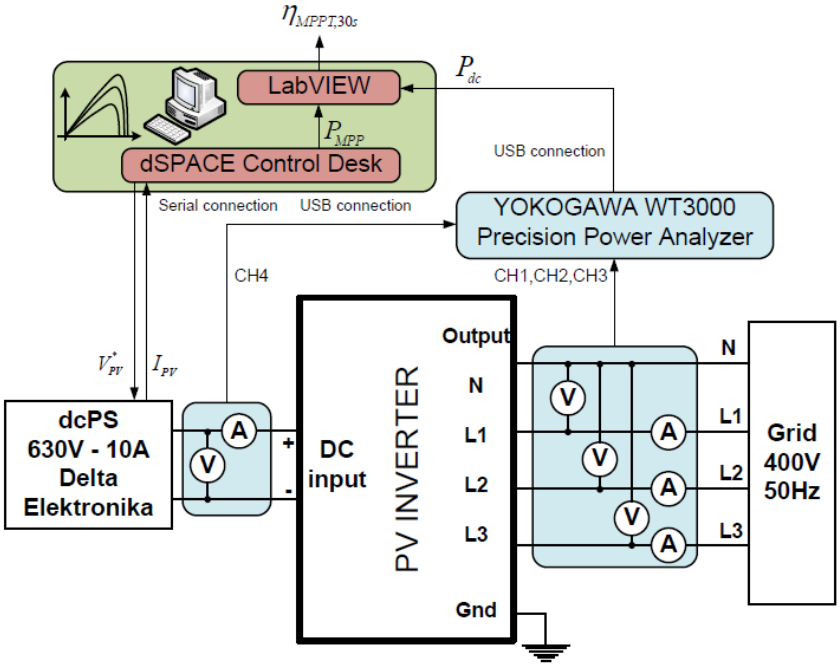
Any PV inverter-specific efficiency research is on not yet conducted in Turkey, mainly because of the absence of large scale PV penetration due to the lack of related legislation. Since Turkey is about to start installing PVPSs with the legislation and regulations, determining a local efficiency measurement criterion might have an important impact on the market development.

Determining local weighted efficiency equations could give a more effective conversion of solar energy yielding more electricity throughout the world. An “irradiation profile dependent weighting factor calculation” that is valid worldwide could be studied later on.

Proposed Host TA Infrastructure/Installation – Justification

The proposed host is Austrian Institute of Technology – AIT. Preliminary correspondence was made with the Institute and the time schedule was known by the parties.

The below is an exemplary setup for the measuring MPPT performance of a PV inverter according to EN 50530.



In this block diagram, $\eta_{MPPT,30s}$ is MPPT efficiency averaged over 30 s time intervals; I_{PV} is measured dc current and V^*_{PV} is reference dc voltage. [M. Valentini et al., 2008]

In the proposed study, we need a grid simulator, precision meters and power analyzer, PV array simulator and controller as well as the statistical evaluation software beforehand. AIT Inverter Test Laboratory offers these in their entirety. Moreover, since AIT and Ege University Solar Energy Institute is talking on collaboration possibilities, this study will create a synergy for future studies.

Synergy with ongoing research

Turkish Photovoltaic Technology Platform – UFTP is working on publishing a report on solar power electronics. The outcomes of this study would greatly contribute this report.

Turkish Standards Institution is working on translating PV related European Standards (as a member of CEN/CENELEC) and adopting/amending as necessary. The results of this study are expected to contribute these studies as well.

An additional synergy with the Renewable Energy Technologies Center – YETMER is highly expected, since there is an ongoing feasibility study for PV Inverter Test Laboratory planned to be established within the center.

The results of the proposed research would greatly contribute to the ongoing studies in EU-SEI on developing local cost-yield optimization software for Wind-PV Hybrid Power Systems.

Dissemination – Exploitation of results

The results of the study is well planned to be shared through the above mentioned channels, YETMER, TSE, UFTP.

Moreover, the proposed study is a part of a doctorate study run in Ege University Solar Energy Institute and results will be published accordingly.

Time schedule

Complete study is fit in 8 weeks, with the suggestions of Roland Bründlinger of AIT:

Week 1: Preparing weighted irradiation data for Izmir.
Week 2: Preparing weighted irradiation data for Izmir.
Week 3: Inspecting the data against η_{CEC} and η_{EURO} data.
Week 4: Theory of efficiency issues and dc dependency.
Week 5: Measurement theory and practices.
Week 6: Measurements.
Week 7: Measurements.
Week 8: Reporting.

Study is planned to be held between **July the 4th** and **August the 28th** 2011 in the AIT premises in Vienna, Austria.

Description of the proposing team

The lead user of the proposing team, Ilker Ongun, Ege University Ege Higher Vocational School Electronics Technology, Chief of Department.

Ilker Ongun is also coordinator of Turkish Photovoltaic Technology Platform – UFTP, Education and Standards Workgroup.

Ilker Ongun is the vice president of PV Mirror Technical Committee of Turkish Standards Institution – MTC116 and has been commissioned for translating some PV standards into Turkish for his credited performance in the UFTP. These standards are:

- TSE CLC/TS 61836: Solar photovoltaic energy systems – Terms, definitions and symbols (published)
- TS EN 50530: Overall efficiency of grid connected photovoltaic inverters (in process)
- TS EN 50524: Data sheet and name plate for photovoltaic inverters (in process)
- TS EN 61683: Photovoltaic systems – Power conditioners- Procedure for measuring efficiency (IEC 61683:1999) (in process)
- TS HD 60364-7-712: Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems (in process)

Firat Salmanoglu, the additional user will be attending the study in **first two weeks**, during the statistical evaluations.

Firat Salmanoglu is a research scientist in Ege University Solar Energy Institute, focused on mathematical modeling of Wind-PV Hybrid power systems on the basis of cost and energy production optimization.