SUSTAINABLE ENERGY FOR ALL BY DESIGN

Edited by Emanuela Delfino and Carlo Vezzoli

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Sustainable energy for all system design tool: the E.DRE tool, Estimator of Distributed Renewable Energy load/need and production potential

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ABSTRACT

This paper presents the adapted MSDS system design approach, method and tools, proposed by the former LeNS project with proper integration of knowledge and tools on Distributed Renewable Energy (DRE) systems design and the design process of one of the new tool developed and integrated into the method: the E.DRE tool, the Estimator of distributed renewable energy load/need and production potential.
The aim and the challenge of this research, on one hand is to enlarge the MSDS method incorporating skills and tools for designers on DRE and on the other hand to create one specific tool for designers, that is able to combine many existing tools and information on renewable energies, facilitating and supporting the design, the estimation of the energy consumption/need and of the sizing of the DRE system, by simplifying and making accessible even to those who are not DRE experts.
The E.DRE tool has been tested and evaluated during its development process with students during courses in Kenya and in Italy but also with experts in the energy sectors to lead to the final tool that is freely available on the LeNSes website.

Key Words: Design Tool, DRE system dimensioning; Method for sustainable energy for all

1. Introduction

Along the three years of the LeNSes EU funded project[31], the System Design for Sustainable Energy for All (SD4SEA) emerging discipline, has been developed: a new knowledge and know-how for designers, design educators and students dealing with the design of Sustainable Energy for All. In particular this discipline has been defined as *"the design of a Distributed Renewable Energy system of products and services, able to fulfil the demand of sustainable energy of low and middle-income people (all) - possibly including the supply of the Energy Using Products/Equipment system - based on the design of the innovative interactions of the stakeholders, where the economic and competitive interest of the providers, continuously seeks after both socio-ethically and environmentally beneficial new solutions"* (LeNSes project, 2016).

During the LeNSes project a set of tools have been designed, implemented and tested, now available for free in the Tool Section of the LeNSes project website www.lenses.polimi.it.
In the following sections, the method for system design for sustainable energy for all and the Estimator of distributed renewable energy (E.DRE) load/need and production potential tool are presented.

2. Methodology

The approach adopted to design the E.DRE tool began with a literature review and an extensive research on the existing tools and methods to design Distributed Renewable Energy (DRE). Moreover some of the selection criteria taken into account included: the free availability of the tools, ease of use and understanding from those who do not own a specific knowledge and the possibility to re-adapt or modify tools.
This step has permitted the definition of the essential design processes and requirements; the existing system design approaches, skills, method and tools developed by the former LeNS: the method for system design for sustainability (MSDS) has traced the path. The former MSDS method has been adapted, specified and merged to properly tackle the incorporation of Distributed Renewable Energy systems. In fact the merger of them has generated a new adapted and promising design method: the MSDS method for system design for sustainable energy for all.
The E.DRE tool and the MSDS methods have been extensively tested and reviewed during all its development process, both with students within different courses and with DRE professors and researchers, which brought to technical and layout improvements

2.1 The former Method for System Design for Sustainability

Some methods and tools have been developed in the last decade to support the System Design for Sustainability approaches. Among those is the Method for System Design for Sustainability (MSDS).
The MSDS method has been elaborated within the MEPSS[32] EU project, integrated with outcomes from the HiCS[33] EU project and refined within the LeNS[34] EU project. It has been used and refined during a series of company consultancy, with Tetrapack company and Kone company[35] and recently in a process of participated design within the Towards a new Intergenerational openness (TANGO) EU funded project (Culture program); four Sustainable Product-Service System has been designed for four suburban districts of Milan, and a set of videos describing them are visible at the following website: www.designtango.eu

The MSDS method aims to support and orient the entire process of system innovation development towards sustainability. It can be used by an individual designer or by a wider design team. In all cases special attention has been paid to facilitating co-designing processes both within the organisation itself (between people from different disciplinary backgrounds) and outside, bringing different socio-economic actors and end-users into play.

[31] The Learning Network on Sustainable energy systems, LeNSes EU funded project (Edulink II, 2013-2016) www.lenses.polimi.it: African-European multi-polar network of HEIs aiming at curricula development on System Design for Sustainable Energy for All (SD4SEA).
[32] MEPSS MEthodology for product Service System development (2002-2005: European project, 5th Framework Program GROWTH).
[33] HiCS Highly Customerised Solutions (2001-2004: European project, 5th Framework Program GROWTH).
[34] LeNS, the Learning Network on Sustainability, project funded by the European Union, Asia link programme (2007-2010); in particular by the Design and system Innovation for Sustainability (DIS) research group of the Design department of the Politecnico di Milano, head by Carlo Vezzoli has been the project coordinator.
35 See Cortesi S., Vezzoli C., Donghi C. 2010. Case study of the design of Eco-Efficient Product-Service-System for KONE Corporation, using the MSDS method and tools in Ceschin F., Vezzoli C., Jun Z. (edit by),Proceedings Sustainability in Design: Now! Challenges and Opportunities for Design Research, Education and Practices in the XXI Century. Greenleaf Publishing Inc, Sheffield, 2010.

The method is organised in stages, processes and sub-processes.
It is characterised by a flexible modular structure so that it can easily be adapted to the specific needs of designers /companies and to diverse design contexts and conditions.
Its modular structure is of particular interest in the:

- *Procedural stages:* all the stages can be used or certain stages can be selected according to the particular requirements of the project
- *Tools to use:* the method is accompanied by a series of tools. It is possible to select which of these to use during the designing process
- *Dimensions of sustainability:* the method takes into consideration the three dimensions of sustainability (environmental, socio-ethical and economic). It is possible to choose which dimension to operate on
- *Integration of other tools and activities:* the method is structured in such a way as to allow the integration of design tools that have not been specifically developed for it. It is also possible to modify existing activities or add new ones according to the particular requirements of the design project.

The MSDS method is modular and flexible in order to be adapted to the specific needs of the designers/companies and to different context's conditions, nevertheless it consists of four main stages:

- Strategic analysis
- Exploring opportunities
- Designing system concepts
- Designing (and engineering) system details
- Communication.

2.2 The method for system design for sustainable energy for all

The adapted MSDS method for sustainable energy for all, developed, implemented and tested within the LeNSes (EU funded) project, is the results from the integration of Distributed Renewable Energy (DRE) knowledge and tools into the former Method for system Design for Sustainability.
The MSDS method has been adapted with a focus on the important energy sector, with the aim of building up a knowledge-base and know-how for system design for sustainable energy for all.
The MSDS for sustainable energy for all method aims to support the design processes for the development of sustainable PSS applied to DRE, adaptable to specific design requirements and usable in existing design processes
It has been conceived for designers, engineers, design offices and designers within companies but is also appropriate for public institutions and NGOs.
The method maintains the same modular and flexible structure of the former MSDS method in order to keep its characteristics of adaptability to different needs and contexts.
The following table shows the aim and processes for each stage of the MSDS method with highlighted the new integrated processes to design S.PSS applied to DRE:

MSDS method for sustainable energy for all		
Phases	**Aim**	**Processes**
Strategic Analysis	To obtain the information necessary to facilitate the generation of sustainable ideas	Analyse project proposers and outline the intervention context
		Analyse the context of reference
		Analyse the carrying structure of the system
		Analyse best practices
		Determine priorities for the design intervention in view of sustainability
		Analysis of the context energy access
Exploring opportunities	To make a "catalogue" of promising strategic possibilities available, and/or a sustainability design-orienting scenario	Generate ideas orientated towards sustainability
		Generate ideas orientated towards energy for all
		Outline a sustainability oriented design scenario (visions, clusters and individual ideas orientated towards sustainability)
Designing system concepts	To determine one or more system concepts oriented towards sustainability	Select clusters and single ideas
		Develop system concepts (consisting of one or more product and service mixes that characterize the offer; the relative interaction system between the actors involved; potential environmental, socio-ethic and economic improvements)
		DRE system concept design
		Environmental, socio-ethic and economic appraisal
		DRE system concept evaluation
Design (and engineering) a system	To develop the most promising system concept(s) into the detailed	Detailed system design
		DRE development (at executive level)

	version necessary to its/their implementation	*DRE system evaluation/visualization* Environmental, socio-ethical and economic assessment
Communication	Draw up documentation to communicate the general, and above all sustainable, characteristics of the system designed	Draw up documentation in various formats

[Table 1] Overall scheme of the MSDS phases, aims and processes, adjusted to integrate the Sustainable Energy for All dimension adopted by LeNSes project.

The method includes a series of existing or adapted tools, but also new tools designed, implemented and tested specifically to design S.PSS applied to DRE within the LeNSes project.
All the tools are listed below:
Sustainability-orienting system design tools
- Sustainability Design-Orienting toolkit (SDO)
- Sustainability interaction story-spot

System design tools
- Stakeholder' System map
- Interaction table / story-board
- Satisfaction offering diagram
- Sustainable motivation matrix
- Solution element brief
- System evidences
- (S.PSS) Animatic
- Satisfaction System map

Sustainable energy for all -orienting system design tools
- Sustainability Design-Orienting Scenario (SDOS) on S.PSS&DRE
- Sustainable energy4all idea tables
- E.DRE - Estimator for Distributed Renewable Energy

Tools for S.PSS applied to DRE or general S.PSS
- S.PSS (applied to DRE) Innovation Diagram
- S.PSS (applied to DRE) concept description format

In the next paragraph one of the above mentioned tool will be described from its ideation to the implementation: the • E.DRE - Estimator for Distributed Renewable Energy tool.

3. Estimator of distributed renewable energy (E.DRE) load/need and production potential tool

The Estimator of Distributed Renewable Energy (E.DRE) load/need and production potential is a worksheet tool developed to support the design of DRE system, in order to guide the evaluation of the energy demand and need of the system concept, to assess the best system configuration and estimation of energy production potential.
The tool integrates some existing databases/websites that allow getting data required for the evaluation of the system proposed.
The E.DRE tool has been developed within the LeNSes project, to be used by designers and design students within the emerging discipline of *System Design for Sustainable Energy for All (SD4SEA)*. More precisely, it has been elaborated by the Design and system Innovation for Sustainability (DIS) Research Group[36] in the Design Dept. of the Politecnico di Milano (coordinator of the LeNSes project), along a master degree thesis[37] thanks to the technical support of Prof. James Wafula, University of Nairobi, Institute of Nuclear Science and Technology (INST); Prof. Mackay Okure, Makerere University, Mechanical Engineering Department and Dr. Gabriele Cassetti, Politecnico di Milano, Energy Department.

[36] DIS Research Group, Politecnico di Milano, Design Dept., Head Prof. Carlo Vezzoli, researchers Elisa Bacchetti, Emanuela Delfino, Han Shaohua.
[37] Master Degree thesis, Sustainable energy for all System design tools, student Micol Polon (2015), supervised by Prof. Carlo Vezzoli

3.1 The design process

The design process started with an extensive research on existing tools and methods to design DRE systems, in order to define the necessary information and the essential stages needed to design a tool that helps designers to dimension a DRE system.
The key steps are: the assessment of the availability of resources, determine the energy user need and then the design and sizing of the system. The first step to design a DRE system is to size the energy system: firstly, a "energy load/need" estimation table and a database, with the average power consumption of the most common appliances, was made. Once the most common renewable energies for distributed system (especially in low and middle-income context) were chosen, a literature review on the existing methods for sizing renewable energy systems: photovoltaic, wind power, hydropower and biomass was made. The second step was the definition of "system sizing" sheet for each type of system, where calculate the energy or gas production potential and the creation of a "power production" table that summarize the potential of the DRE system designed.
A first version of the sizing tool was made and during the System Design for Sustainable Energy for All (SD4SEA) pilot course held at the University of Nairobi, in May 2015 a technical review with the LeNSes team was carried out and several improvements on the tool layout after the feedbacks of users (students of the course).
At a later stage, a second version of the tool with some improvements was tested during the course of System design for sustainability of Politecnico di Milano, in June 2015. In this test the tool was used for size the students' concepts (in the Micol Polon thesis book). Thanks to the students some weak points were highlighted and some improvements made. Another technical review was possible thanks to the Energy department of Politecnico di Milano. Lastly, the final version of the tool and a video guide are completed and available on the www.lenses.polimi.it website in the Tool section.

3.2 DRE methods and tools research

To carry out the extensive research on existing tools and methods to design Distributed Renewable Energy (DRE), the following selection criteria have been taken into account: the free availability of the tools, ease of use and understanding and the possibility to re-adapt or modify the tool.
Below are presented some of the most promising tools identified during the research, divided into six categories:
- Access to energy and social issues;
- Energy consumption and energy need;
- Resource availability;
- Energy production;
- System engineering and evaluation;
- Life cycle assessment.

Each tools has been analysed defining the following characteristics: author, source, type of tool (online resources, software, web tool, interactive tool) and the main users (designer, final user, engineer, policy maker, decision maker). Furthermore a short description, aims and results are described and, as a conclusion, a visualization of the evaluation of the previous criteria (Free/downloadable, easy to use, understandable, adaptable/flexible).
In this paper will be presented one tool per category, the complete research on DRE tools and method is available in the Micol Polon thesis book[38]

ACCESS TO ENERGY AND SOCIAL ISSUE

- ***Gender: social inclusion in the energy sector***

Author: ESMAP
Source: www.esmap.org/node2757
Type: online resources
User of the tool: Designer; final users, other
Description and aims: Provide basic tools to energy teams for mainstreaming gender considerations into energy sector activities. Included sample questionnaires and checklists, which can be downloaded for use by task teams. Identify key gender issues, risks, constraints and opportunities associated with a proposed energy sector initiative.
Results: Key input to the development of a gender action plan with targeted activities and Monitoring and Evaluation (M&E) framework.

Free/downloadable	●●●●●
Easy to use	●●●○○
Understandable	●●○○○
Adaptable/flexible	●●●○○

[38] Master Degree thesis, Sustainable energy for all System design tools, student Micol Polon (2015), supervised by Prof. Carlo Vezzoli

ENERGY CONSUMPTION AND ENERGY NEED

- ***GE Data Visualization***

Author: U.S. Environmental Protection Agency and the Department of Energy
Source: http://visualization.geblogs.com
Type: online resources
User of the tool: Designer; final users, other
Description and aims: It is an interactive tool that aim is to visualize the energy and gas consumption (and cost) of the main household appliances.
Results: Watt/hour energy consumption; Gas consumption and energy costs visualization.

Free/downloadable	●●●●○
Easy to use	●●●●●
Understandable	●●●●●
Adaptable/flexible	●●●●○

RESOURCE AVAILABILITY

- ***Solar and Wind Energy Resource Assessment***

Author: NREL
Source: http://en.openei.org/apps/SWERA/
Type: Web tool
User of the tool: Policy makers, developers, educators, other
Description and aims: The Solar and Wind Energy Resource Assessment (SWERA) initiative brings together solar and wind energy resource data sets and analysis tools from a number of international organizations in a dynamic user-oriented environment. To search, visualize and explore solar and wind energy data.
Results: Availability of solar and wind energy resources.

Free/downloadable	●●●●●
Easy to use	●●●○○
Understandable	●●●●○
Adaptable/flexible	●●●○○

ENERGY PRODUCTION

- ***Photovoltaic Geographical Information System***

Author: European commission and the institute for energy and transport
Source: http://re.jrc.ec.europa.eu/pvgis/
Type: Interactive web tool
User of the tool: Designer, final users, policy maker, engineer
Description and aims: Provides a map-based inventory of solar energy resource and assessment of the electricity generation from photovoltaic systems in Europe, Africa, and South-West Asia.
Results: Potential of grid-connected PV systems and solar irradiation values and system optimization.

Free/downloadable	●●●●●
Easy to use	●●●●○
Understandable	●●●●○
Adaptable/flexible	●●●●○

SYSTEM ENGINEERING AND EVALUATION

- ***Homer (Hybrid Optimization of Mutiple Energy Resources)***

Author: HOMER Energy LLC
Source: http://www.homerenergy.com
Type: Software
User of the tool: Engineer
Description and aims: It Is a computer model that simplifies the task of analysis and/or designing hybrid renewable stand-alone, micro grids, or grid connected, systems.
Results: A table indicating: initial/maintenance/total costs technology or mix of technologies needed to satisfy the energy request.

Free/downloadable	●○○○○
Easy to use	●○○○○
Understandable	●●○○○
Adaptable/flexible	●●●○○

LIFE CYCLE ASSESSMENT

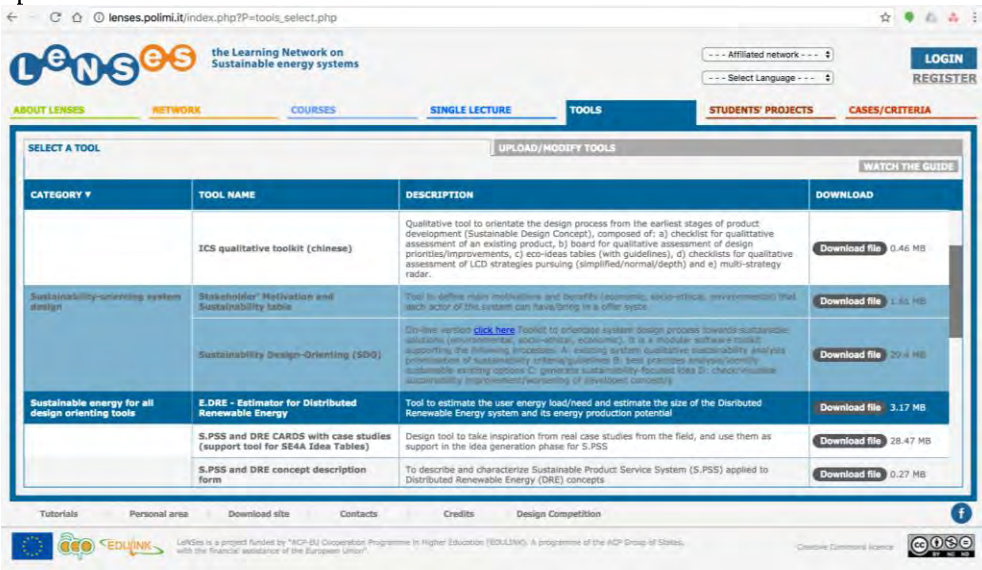
- *LCA to go*

Author: LCA to go and European Union
Source: http://tool.lca2go.eu
Type: web tool
User of the tool: Designer, other
Description and aims: Calculate abridged environmental assessment of the PV concept system design.
Results: Concept PV system improvement compared to the Electricity grid.

Free/downloadable	●○○○○
Easy to use	●○○○○
Understandable	●●○○○
Adaptable/flexible	●●●○○

3.3 Structure of the E.DRE tool

The tool is available to be downloaded at www.lenses.polimi.it, in tools section, it can be used, modified and updated.



[Figure 1] Tools section of the LeNSes platform

The E.DRE tool is a worksheet excel file composed of six main sheets:

0. *Homepage*
1. *Energy need and production*
2. *Energy using product (EUP) consumption database*
3. *Photovoltaic system sizing*
4. *Wind system sizing*
5. *Hydro system sizing*
6. *Biomass digester sizing*

Below is presented the layout of each section of the tool, functionalities and results.
The tool has been developed with the Excel software which allows embedding formulas and making automatic calculations.

0. HOMEPAGE

The homepage or cover page of the tool besides containing all the credit to the people that gave their contribution and the EU funding programme, it mainly allows you to directly start understanding the energy need and he hypothetical dimension of your system, or to first have a look at the *how it works* tutorial video.

[Figure 2] The Homepage of the E.DRE tool

1. ENERGY-NEED PRODUCTION

The first page or section of the tool it allows you to first understand which is the energy load or need of the system you are analysing or designing, in other words to understand the energy consumption of the user.

The table that you find on the left titled "energy load need" allows you to estimate the energy consumption by selecting the appliance or energy using product by the menu that you imagine in your system and the power of the appliance selected will automatically appear in the table. The appliances' database that is available in the tool represents the most common of a series of energy using products and their average consumption

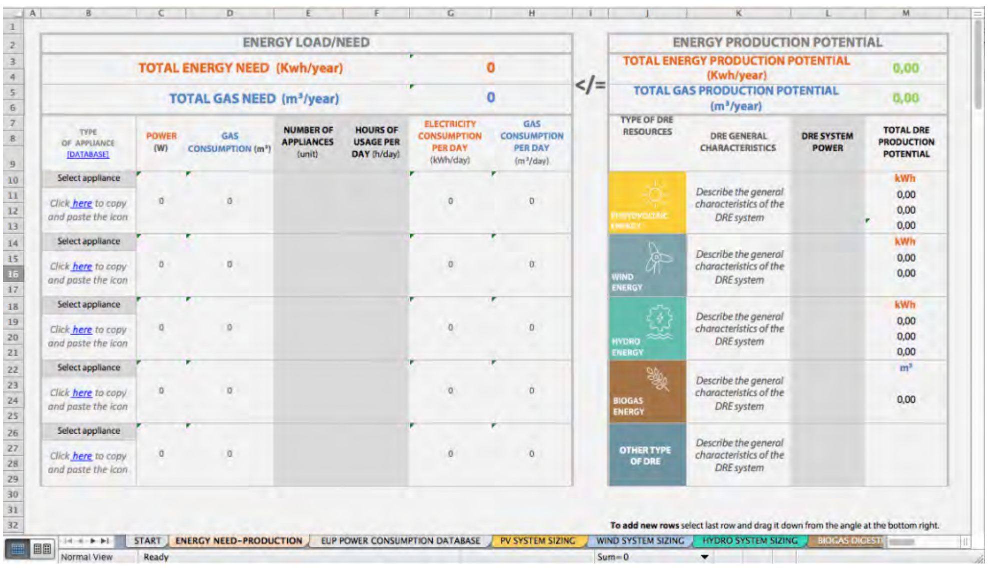
To make the table more visual and easy to read is possible to copy and paste the icon of the appliance from the database. Once all the appliances have been selected, it is possible to indicate the number of them into your system and the number of hours of usage per day, according to the user need.

Once these data are completed the tool automatically calculates the total amount of energy need in your system yearly.

The table on the right side, titled "energy production potential", allow you to select the type of Distributed Renewable Energy and to estimate the size and production of the energy system.

Once all the calculations are completed, the values that comes from these two tables must correspond, in other words:

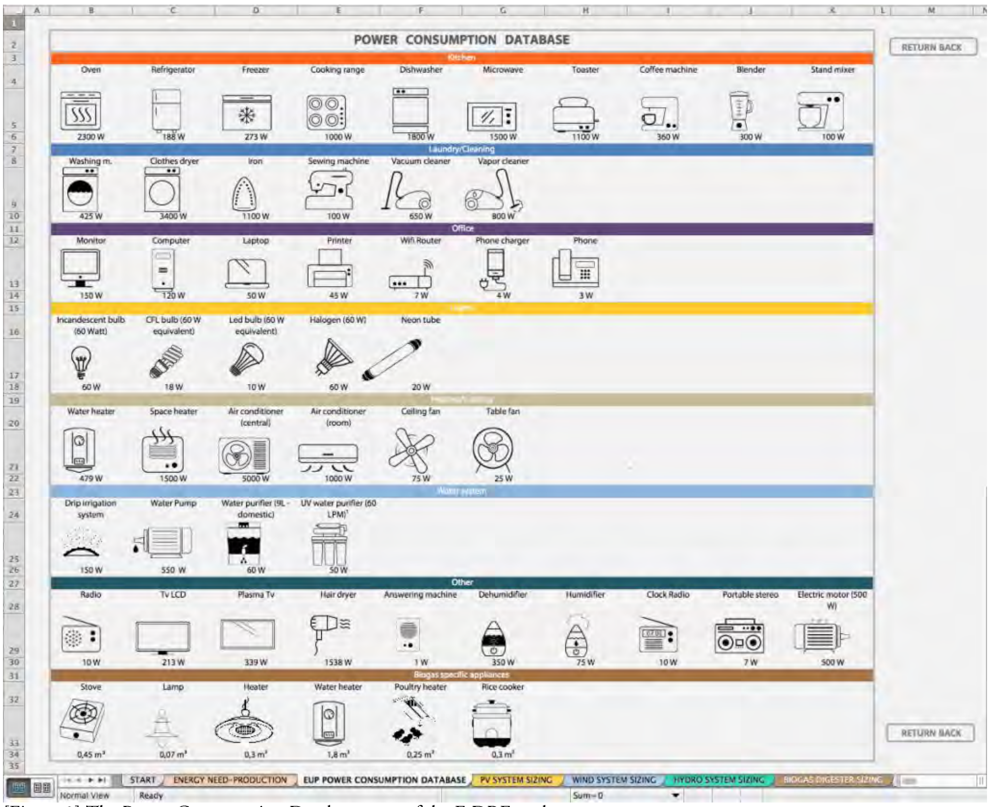
- Total Energy Production Potential (KWh/year) ≥ Total Energy Need (KWh/year) in the case of production of electricity (KWh);
- Total Gas Production Potential (m^3/year) ≥ Total Gas Need (m^3/year) in the case of production of gas (m^3).



[Figure 3] The Energy Need-Production page of the E.DRE tool

2. POWER CONSUMPTION DATABASE

The database contains the most common and the average consumption of appliances or energy using products and its symbolic icon. The database includes 8 categories of products that are using electricity, the power is expressed in Watt (W): Kitchen; Laundry/cleaning; Office; Lights; Heating/ cooling; Water system and other; and one last category that includes specific appliances for biogas systems (e.g. stove, heater) whose consumption is expressed in m^3 of gas.



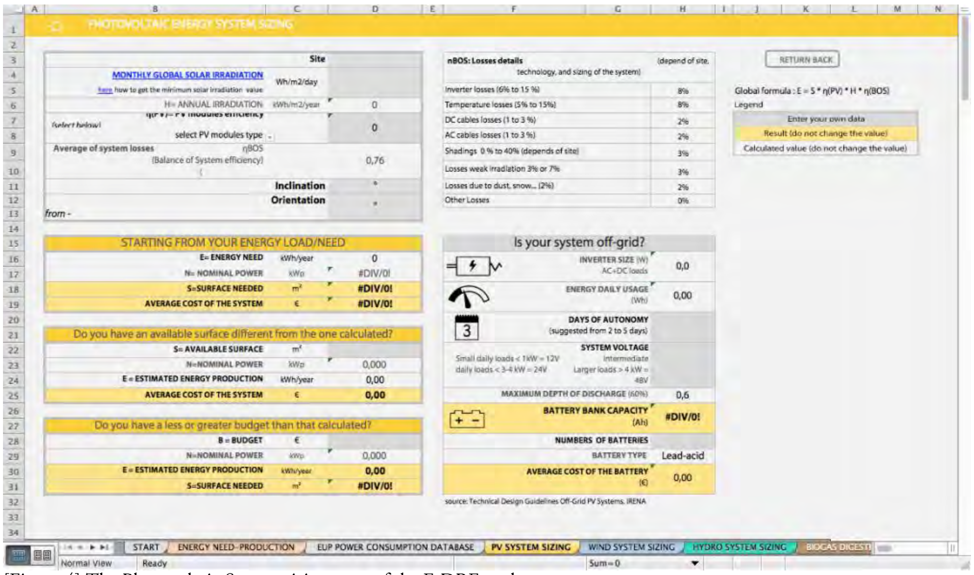
[Figure 3] The Power Consumption Database page of the E.DRE tool

3. PHOTOVOLTAIC SYSTEM SIZING

To size a photovoltaic system you first need to insert geographical data of the design intervention: the location and the solar irradiation data. To get the "monthly global solar irradiation" the tool redirect you to PVGIS website, a solar radiation free database for Europe, Africa Mediterranean Basin and South-West Asia. Afterwards the tools request you to select, by the menu, the type of photovoltaic modules between Mono-crystalline, Multi crystalline or Amorphous. This choice mainly depends on your available budget or surface.
Once these basic information are provided, the tool by default calculates the surface needed and an average cost of the system according to the energy need/consumption (user centred approach). Results are shown in yellow cells.

In case the surface to place the PV panels or the cost of the system, calculated according to the user energy need, do not correspond to your available surface or budget, the tool includes two tables to allow you to modify the size of the system:
- **Do you have a different available surface from the one calculated?** Insert in this table the available surface in square meters and automatically the energy production potential and the cost of the PV system is calculated
- **Do you have a different budget from the one calculated?** Insert in this table the available budget in euro and automatically the energy production potential and the surface of the PV system is calculated

In case you are designing a system that is off-grid, or not connected to the main or local grid, the tool includes the section **"Is your system off-grid?"** to allow you to estimate number of the bank of batteries and the cost.
To calculate the dimensioning of the batteries is necessary to insert the days of autonomy of the system; the voltage and the capacity (Ah) per each battery.
At this point the PV system sizing form is completed, return back to the energy need/production potential sheet to check if the PV production correspond to the energy need (if yes, results are in green; if not results are in red).



[Figure 4] The Photovoltaic System sizing page of the E.DRE tool

4. WIND SYSTEM SIZING

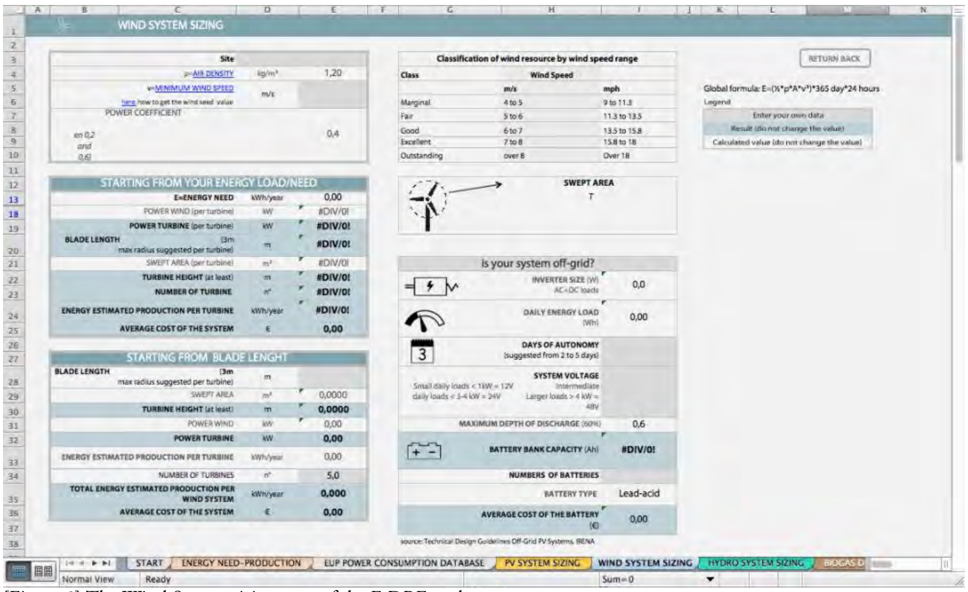
To size a Wind system you first need to insert geographical data of the design intervention: the location and the wind speed data.

To get the "minimum wind speed" the tool redirect you to SWERA[39] website, an online database and maps to get the speed wind data required for the sizing of the wind system. A quick step by step guide on how to use SWERA is available. Once these basic information are provided, the tool by default calculates the specifics of the wind system, the power turbine, blade length, height and number of turbines needed for a small system and an average cost of the system according to the energy need/consumption (user centred approach). Results are shown in light blue cells

In case you are designing a hybrid system or want to modify the blade length, use the table "STARTING FROM BLADE LENGTH": insert the length and the number of turbines, automatically the energy production potential per wind system and an average cost are calculated.

Also for the Wind system is possible to design an off-grid system, the tool includes the section **"Is your system off-grid?"** to allow you to estimate number of the bank of batteries and the cost (as the previous PV sheet).

Once the form is completed, it is possible to return back and check the production potential, if the production satisfies your need the results are green, otherwise results are red.

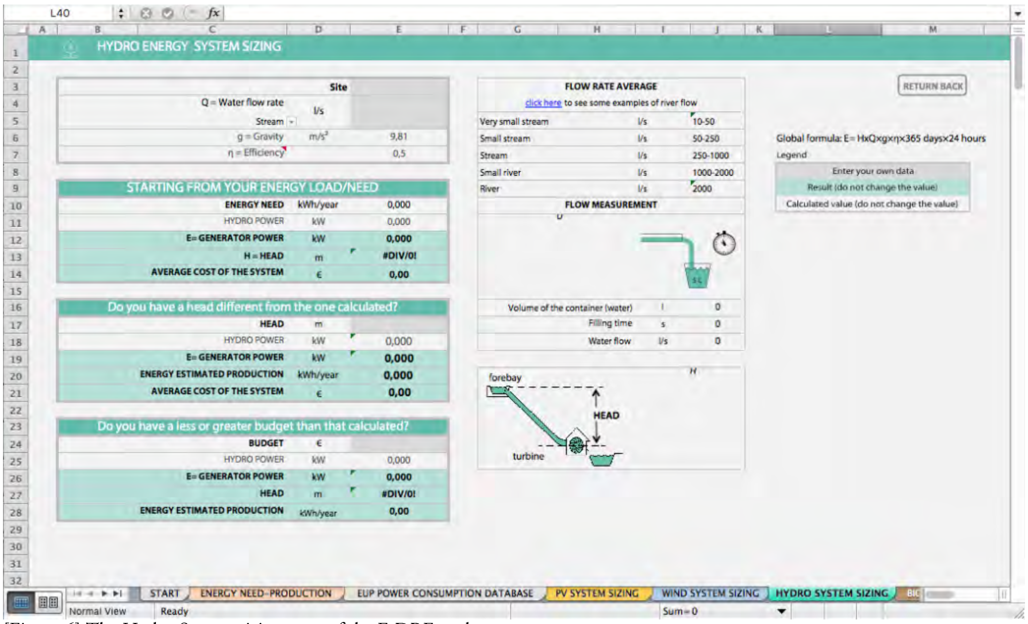


[Figure 5] The Wind System sizing page of the E.DRE tool

[39] The Solar and Wind Energy Resource Assessment (SWERA) initiative brings together solar and wind energy resource data sets and analysis tools from a number of international organizations in a dynamic user-oriented environment. The information and data provided on the site are freely available to the public and intended to support the work of policy makers, project planners, research analysts and investors. http://en.openei.org/apps/SWERA/

5. HYDRO SYSTEM SIZING

To size a Hydro system, insert the location of the design intervention and then select an average flow rate; since the flow of the rivers is not constant, in the tool a table of water flow by type of river and stream is available.
For the calculation was taken into consideration the average value per type of flow: browse and select the right flow for your location by the menu, if a specification is needed click on the hyperlink to see some example.
Once the flow is selected, the generator power, head of system and an average cost are automatically calculated.
If you are designing a hybrid system or want to modify head or cost, complete the other two table and get results.
Once the system sizing is completed, return back and check the production potential table, if the production satisfies your energy need the results are in green, otherwise results are in red.

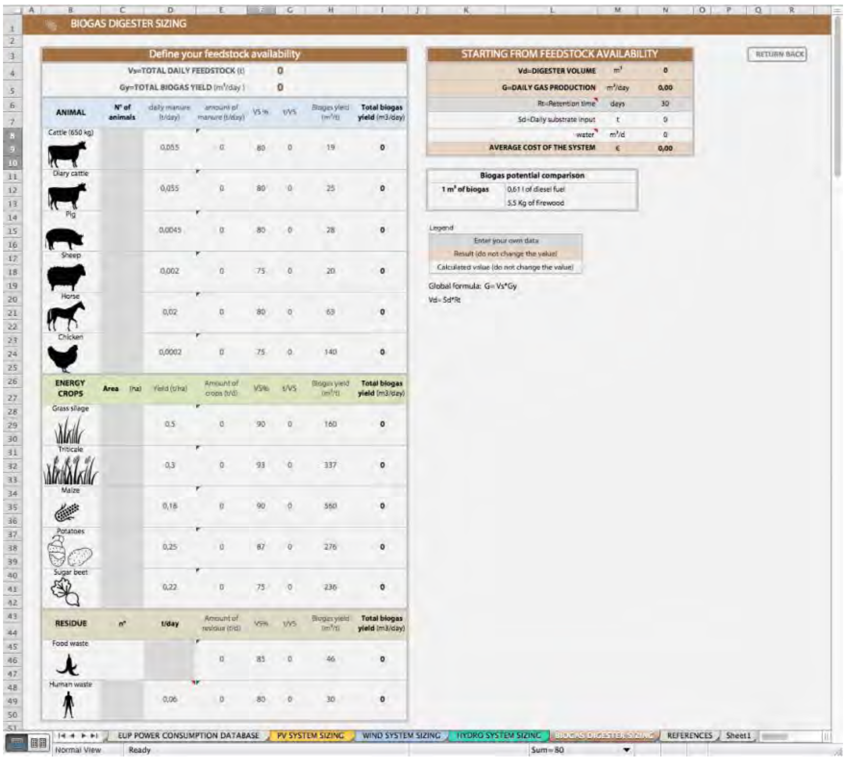


[Figure 6] The Hydro System sizing page of the E.DRE tool

6. BIOGAS DIGESTER SYSTEM SIZING

To size a biogas digester, you have to define the amount of feedstock is available per day.
The table is divided in three category (type of feedstock):
- Animals: cattle, dairy cattle, horse, pig, sheep, chicken;
- Energy crops: Grass silage, Triticale, Maize, potatoes and sugar beets;
- Residues: Food waste and Human waste.

By inserting the number of animals, hectares of crops or quantity of residues the table calculate automatically the amount of daily of feedstock. The table include the biogas yield (m^3/t) for each type of feedstock.
On the table on the right, you just need to insert the retention time to calculate the size of the digester and the daily gas production.
Now the Biogas digester size and production potential are calculated, return back and check the production potential table. If the production satisfies your gas need the result is in green, otherwise the result is in red.



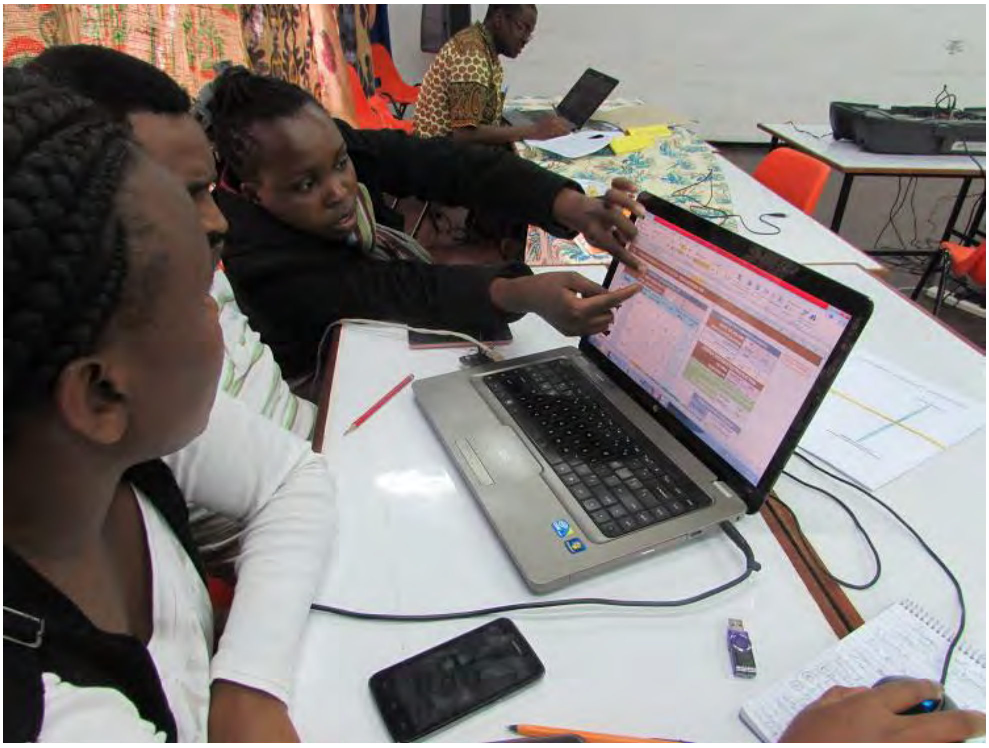
[Figure 7] The Biogas digester System sizing page of the E.DRE tool

3.4 Tool testing and results

The tool was implemented and tested several times during the courses implemented in Africa within the LeNSes project, as well within curricular courses at Politecnico di Milano.
In particular the first test took place during the pilot course of "System Design for Sustainable Energy for All (SD4SEA)" held at the University of Nairobi, in May 2015. This test lead to a technical review, thanks to the collaboration with local professor and energy expert part of the Nairobi LeNSes team.
Furthermore the students of the course had the opportunity to use the tool to dimension their own design concept and then provide feedback at the usability and layout level.
The second test took place during the course of "System design for sustainability of Politecnico di Milano" in June 2015.
The purpose of the design exercise of the course was to design a Locally-Based Sustainable Energy System, based on the promising models of Sustainable Product-Service Systems (S.PSS) and Distributed Renewable Energy (DRE), for a given theme of a given African context.
The E.DRE tool was presented and each design team used the tool to design the dimension of their system concept.
The discussion with the students has revealed few areas of improvement:

- Extend the database with a more specific products for off-grid system (e.g. water purifier);
- Add legend;
- Add specifications and guides.

Moreover, the test has highlighted, in some cases, the possibility to design a hybrid system, instead of the use only one technology (the majority of groups had designed a PV system). In fact, giving the possibility of using a tool that allow, not energy expert user, to estimate the dimension, the cost and the power production for their system design concept, it has allowed the identification of more convenient renewable energy technology (e.g. biogas system, instead of photovoltaic).
At the same period of this test, a technical review was conducted in collaboration with the Energy Department of Politecnico di Milano.



[Figure 8] Students using the S.PSS&DRE Estimator of Distributed Renewable Energy load/need and production potential

4. Conclusions

The E.DRE tool is integrated within the MSDS method to support the design process of S.PSS applied to DRE, in particular inserted at the system design (and engineering) level.
With the design and implementation of the E.DRE tool the aim was to contribute to the achievement of the broader LeNSes objective of creating a modular e-learning package of teaching materials (texts, slide shows, audio, video, etc.) and tools for designers, that design educators worldwide can download (free of charge), modify/remix and reuse (copy left).

5. Aknowledgment

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