



PSR

TSL

OVERVIEW

The **Time Series Lab (TSL)** is a renewable modeling tool that produces future synthetic scenarios of intermittent Variable Renewable Energy (VRE) sources. TSL has two main modules: The **TSL-Data** and The **TSL-Scenarios**:

TSL - DATA

Creates a "synthetic" hourly historical record by processing the information available at the MERRA-2 global reanalysis database.

TSL - SCENARIOS

Generates future VRE scenarios that are temporally and spatially correlated with hydro inflows.

To estimate the statistical model, **TSL-Scenarios** needs historical data of VRE generation, which may be a very challenging task to obtain for some hotspots. Related to that, TSL has two main functionalities:

Real historical data can be introduced by the user

A "synthetic" hourly historical based on reanalysis data of wind speed and solar irradiation can be created by TSL-Data

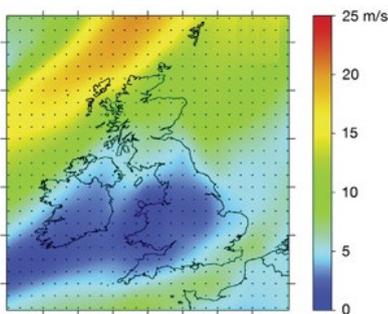


CREATING A HISTORICAL RENEWABLE RECORD

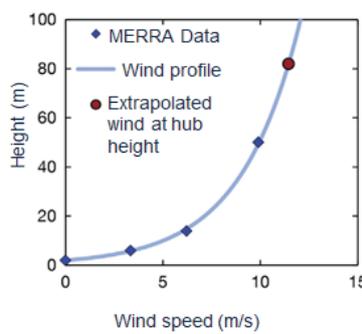
The TSL calculates the wind production through a model based on the Virtual Wind Farm (VWF) methodology. The following parameters are used to convert wind speed into energy:

 <p>The power curve of the turbine</p>	 <p>The height of the turbine</p>	 <p>The coordinate of the plant (to download the wind speed data)</p>
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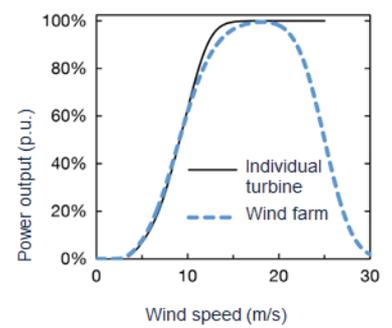
DOWNLOAD WIND SPEED DATA



EXTRAPOLATE WIND SPEED TO THE PLANT HEIGHT



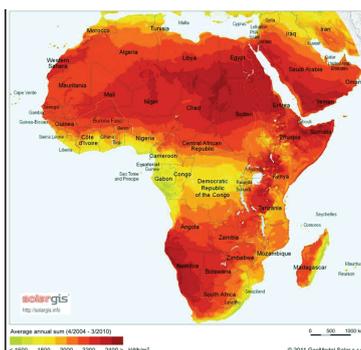
CALCULATES THE POWER OUTPUT USING THE TURBINE POWER CURVE



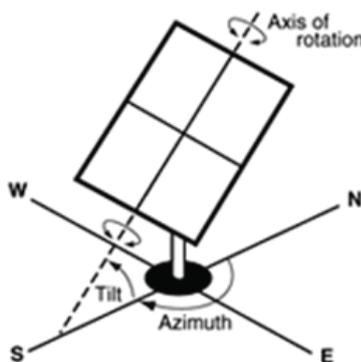
The solar production is based on the data of Global Horizontal Irradiation, i.e., the irradiation at the top of the atmosphere extracted from the reanalysis database. Taking this information into account, the GSEE (Global Solar Energy Estimator) method is applied. The following parameters are used:

 <p>The tracking system of the panel</p>	 <p>The inclination angle of the panel</p>	 <p>The coordinate of the solar plant</p>
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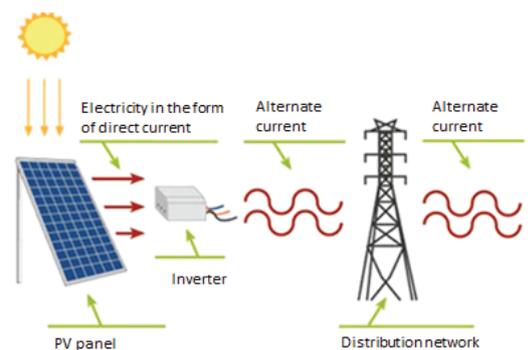
DOWNLOAD SOLAR IRRADIATION DATA



ESTIMATE POWER OUTPUT CONSIDERING EFFICIENCY AND TRACKING SYSTEM



DC -> AC CONVERSION



FINDING HOTSPOT FOR GENERIC PROJECTS

Besides providing a framework to create a “synthetic” historical data of renewable generation, the TSL provides a tool to find “hotspots” for generic wind and solar plant projects. For this task, the following tools are available:

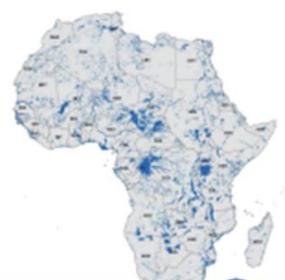
- ☑ Wind speed map for the whole world
- ☑ Solar irradiation map for the whole world
- ☑ Protected areas for the whole world
- ☑ Possibility to upload custom user-defined maps of wind speed and solar irradiation



CITIES AND URBAN AREAS



PROTECTED AREAS



WETLANDS



INCLINED LAND



AGRICULTURAL AREAS



FORESTS

The screenshot shows a software interface with a menu bar (File, Data, Scenarios), a toolbar with various icons, and a main window. The main window is divided into a table on the left and a map on the right.

Code	Name	System	Station	Technology Type	Installed capacity	Latitude
5599	BM_SE_09	SUDESTE	BM_SE_CO_1	Biomass	12500	
1653	BIOSE_A-6_18	SUDESTE	BM_SE_CO_1	Biomass	28,48	
1650	BIOSE_A-4_19	SUDESTE	BM_SE_CO_1	Biomass	13	
1655	SOLSE_A-4_19	SUDESTE	SOL_MG	Solar	40	-17.45582074885
4001	SOL_SP_1	SUDESTE	SOL_SP_1	Solar	20000	-21.96342493686
4002	SOL_SP_2	SUDESTE	SOL_SP_2	Solar	20000	-20.85881179088
4003	SOL_SP_3	SUDESTE	SOL_SP_3	Solar	20000	-22.26876403907
4004	SOL_MG_1	SUDESTE	SOL_MG_1	Solar	20000	-15.47485740268
4005	SOL_MG_2	SUDESTE	SOL_MG_2	Solar	20000	-17.56024650325
4006	SOL_MG_3	SUDESTE	SOL_MG_3	Solar	20000	-19.60119416128
4007	SOL_RJ_1	SUDESTE	SOL_RJ_1	Solar	20000	-22.87237930671
4008	SOL_ES_1	SUDESTE	SOL_ES_1	Solar	20000	-19.37334071334
5015	SOL_MS_1	SUDESTE	SOL_MS_1	Solar	20000	-19.87005983797

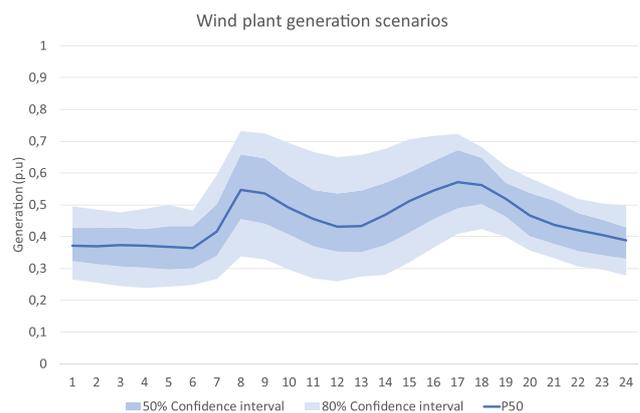
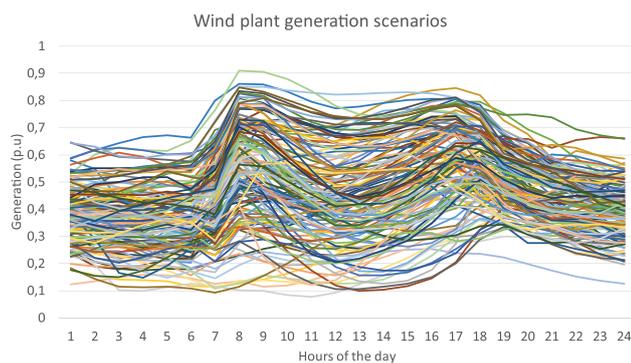
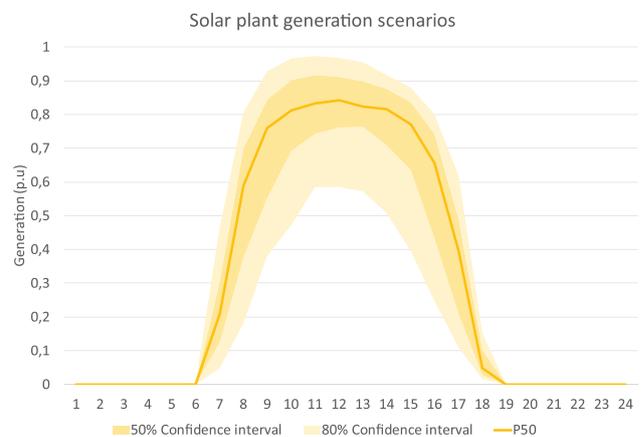
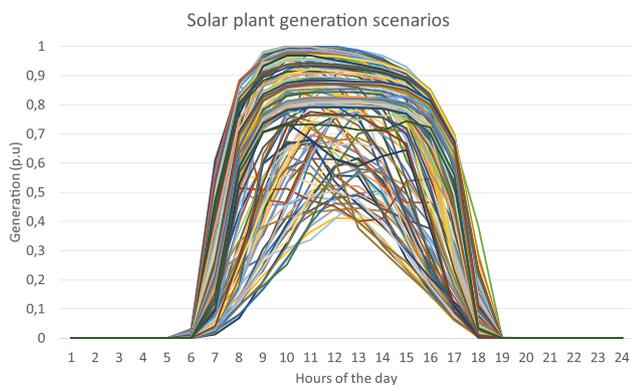
The map on the right shows South America with a color-coded wind speed overlay and several project locations marked with colored dots. A legend in the bottom right corner indicates wind speed ranges in m/s: 0-2.5, 2.5-3.6, 3.6-5.3, 5.3-6.6, 6.6-7.8, 7.8-8.8, 8.8-9.7, and 9.7+.

GENERATING SYNTHETIC RENEWABLE GENERATION SCENARIOS CORRELATED WITH HYDRO INFLOWS

Due to the spatial correlation of wind and solar generation in different regions, as well as the spatial and temporal correlations between hydro inflows and wind speed in some regions, TSL represents the joint probability distribution of all intermittent renewable and hydro resources for both existing and future plants.

The Bayesian Network methodology is a statistical model that can produce synthetic scenarios, capturing the most significant correlations existing in the historical data:

- ✓ Produce scenarios considering a joint probability distribution
- ✓ The probability distribution of each plant is numerically estimated through a non-parametric method
- ✓ Maintain temporal and spatial correlations in the synthetic scenarios being produced
- ✓ Maintain the original probability distribution of the historical record



In summary, because of the high variability and intermittency of this kind of resource, the TSL generates those scenarios with the following features:

- ✓ Hourly resolution
- ✓ Non-parametric estimation of the probability distributions
- ✓ Bayesian network methodology to capture the temporal and spatial correlations between VRE and hydro inflows



USES OF TIME SERIES LAB

The **TIME SERIES LAB (TSL)** model has been used in studies for renewable integration analysis, valuation of renewable projects and investment in new renewable projects. It is also being used in many studies involving production costing simulations and expansion planning tasks in several countries, such as Brazil, Colombia, Costa Rica, Ecuador, Mexico and others.

