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The NREL-118 Test System: an overview

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The NREL-118 Test System

- Introduced in the article

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- "a new publicly available version of the IEEE 118–bus test system"
- "based on the transmission representation (buses and lines) of the IEEE 118-bus test system, with a reconfigured generation represen- tation using three regions of the US Western Interconnection"
- "allow researchers to model a test power system using detailed transmission, generation, load, wind, and solar data"

An Extended IEEE 118-Bus Test System With High Renewable Penetration

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Abstract—**This article describes a new publicly available version of the IEEE 118–bus test system, named NREL-118. The database is based on the transmission representation (buses and lines) of the IEEE 118-bus test system, with a reconfigured generation representation using three regions of the US Western Interconnection from the latest Western Electricity Coordination Council (WECC) 2024 Common Case [Transmission expansion planning home and Grid-View WECC database]. Time-synchronous hourly load, wind, and solar time series are provided for one year. The public database presented and described in this manuscript will allow researchers to model a test power system using detailed transmission, generation, load, wind, and solar data. This database includes key additional features that add to the current IEEE 118-bus test model, such as the inclusion of ten generation technologies with different heat rate functions, minimum stable levels and ramping rates, GHG emissions rates, regulation and contingency reserves, and hourly time series data for one full year for load, wind, and solar generation.**

Index Terms—**Electric grid database, load forecasts, renewable energy data, renewable forecasts, test power system.**

I. Introduction

DETAILED and reliable public databases of test power systems are highly valuable for researchers to conduct studies on new technologies and to test new algorithms. Many researchers use these databases for a number of important areas of power systems operations and planning, including: unit commitment, economic dispatch, congestion management, optimized allocation of distributed generation, fault detection, among many others. However, there are a number of fundamental limitations associated with many current test systems, such as: including only very brief periods of time, having generally smaller systems than those seen in practice, and other aspects that make many practitioners view them as "unrealistic." While test systems have limitations due to assumptions and simplifications, the models can inform electricity planning and market operation stakeholders, as well as policy makers, on the sensitivity of the system to critical variables. For example, some of the limitations of the models can include simplifications of the transmission lines or power generators –e.g. uniform transmission lines' capacities, or generators following linear heat input functions with very low voltage stable levels. Also, assumptions of dispatch modeling design can neglect power purchase agreements or ancillary services incentives. Despite the fact that these shortcomings can lead to errors, the use of reasonable assumptions can reduce the computational resource requirement and provide valid answers.

Test systems have been widely used in the research community because they provide standard public data, valuable for testing new algorithms, technologies, and control schemes. For example, Venkatesh *et al.* [2] test economic load dispatch models in the IEEE 14- [3] 30- [4] and 118-bus [5] systems. Zhao *et al.* [6] apply a stochastic economic dispatch model that includes wind generation and electric vehicles, and Yalcinoz and Short [7] apply a neural network approach to solve an economic dispatch model with transmission capacity constraints, in the IEEE 118-bus test system. Wang *et al.* [8] solve a security-constrained unit commitment problem that takes into account wind power intermittency in a 6-bus test system and in the IEEE 118-bus test system. Happ [9] presents an algorithm to solve a general optimal power dispatch problem using the Jacobian matrix, and applies it in a 9-bus test system and the IEEE 118-bus test system, noting that the results of the latter system are more representative of larger systems. Reid and Hasdorff [10] formulate the economic dispatch model as a quadratic programming problem, solve it using Wolfe's algorithm, and apply it in the IEEE 5-, 14-, 30-, 57- and 118-bus test systems. Fu *et al.* [11] apply an AC corrective/preventive contingency model based on a security-constrained unit commitment model in six case studies, formulated in, among others, the IEEE 118-bus test system and the 1168-bus system.

In addition, Hazra *et al.* [12] apply a multi-objective optimization technique for the congestion management problem to the IEEE 30- and 118-bus test systems, and the Northern Region Electricity Board, India (NERB) 390-bus test system. Wang and Nehrir [13] use the IEEE 6-bus test system [14], an IEEE 30-bus test system [4] and a subset of it to verify theoretical optimization methods for placing distributed generation. Zhao and Abur [15] use the IEEE 118-bus test system [5] and the 4520-bus ERCOT system to implement a state estimator for large power systems containing several control areas. Stott and Alsaç [16]

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Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

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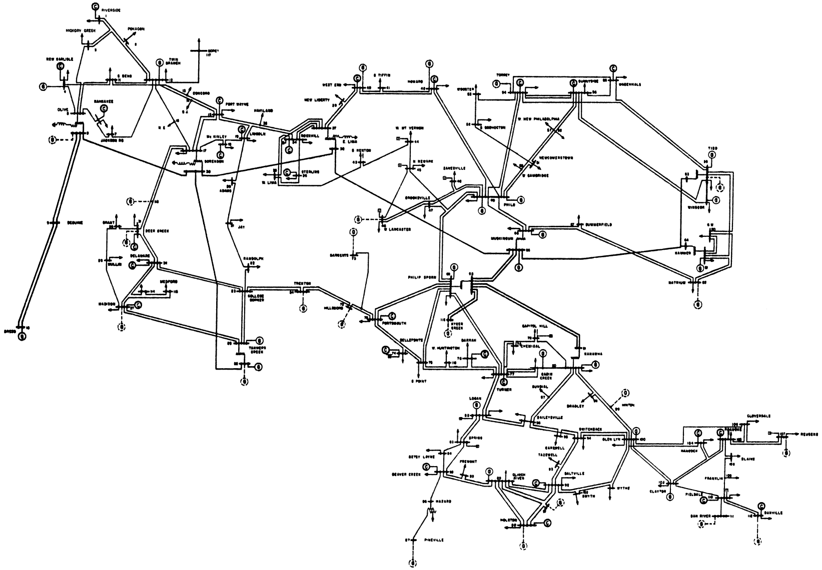
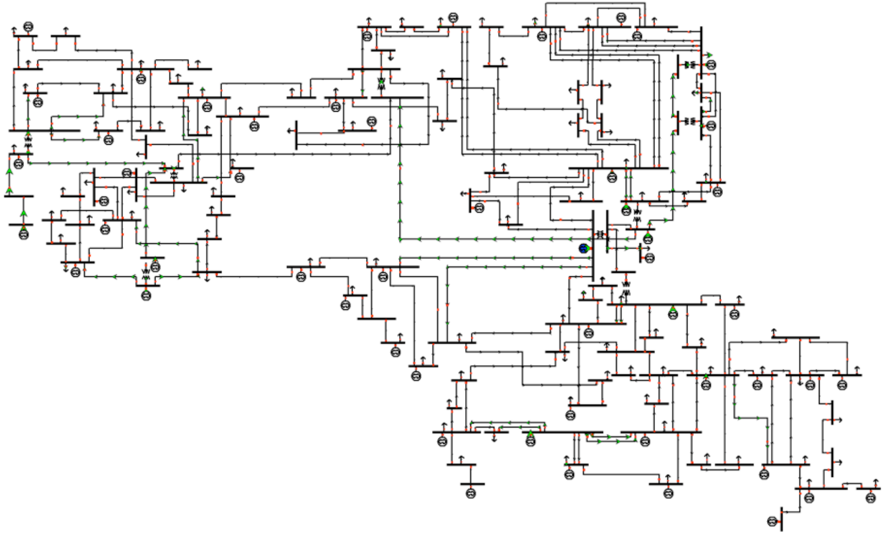
What is the IEEE 118 test system?

1963



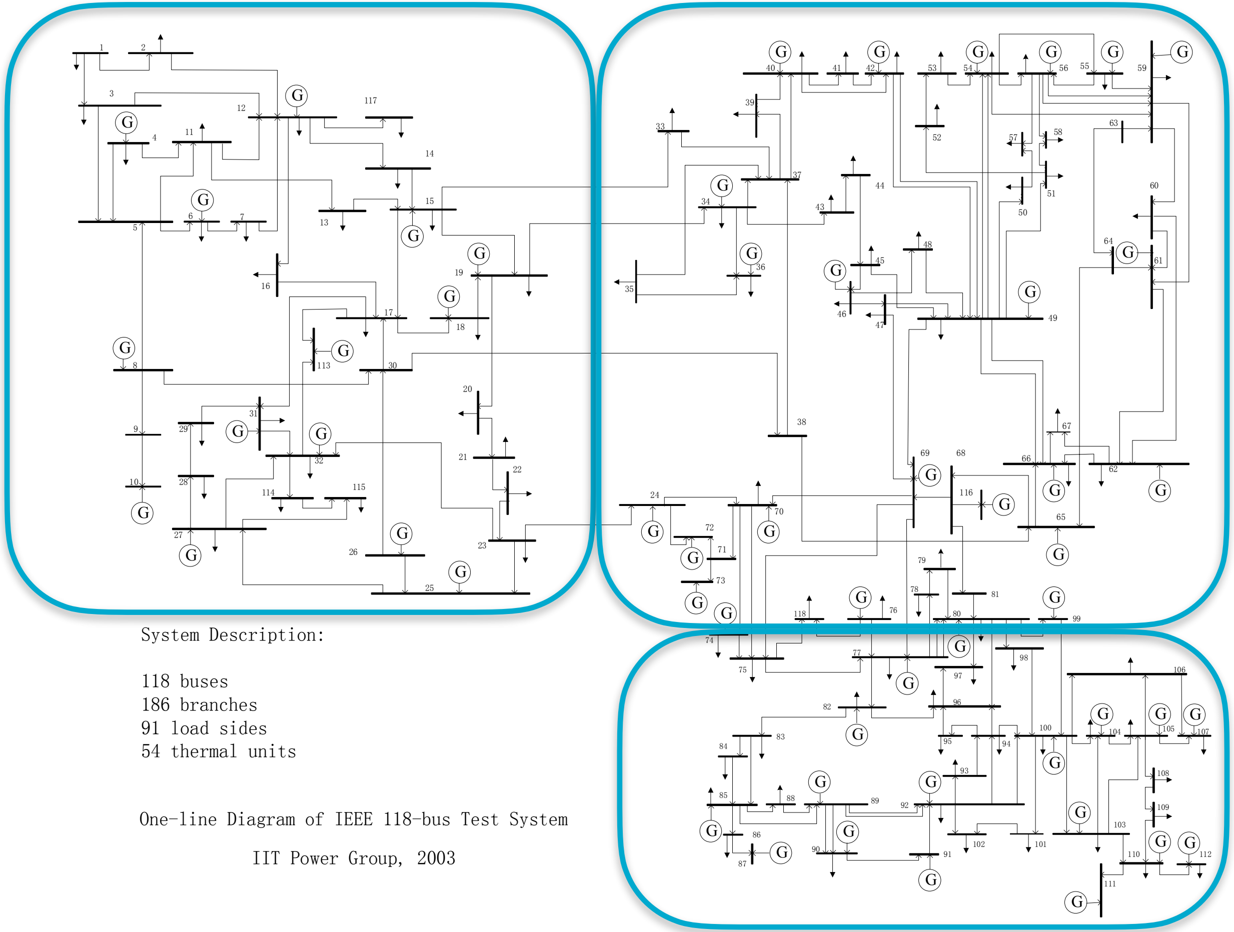


https://labs.ece.uw.edu/pstca/pf118/pg_tca118bus.htm

https://electricgrids.engr.tamu.edu/electric-grid-test-cases/ieee-118-bus-system/

What is the IEEE 118 test system?

2003



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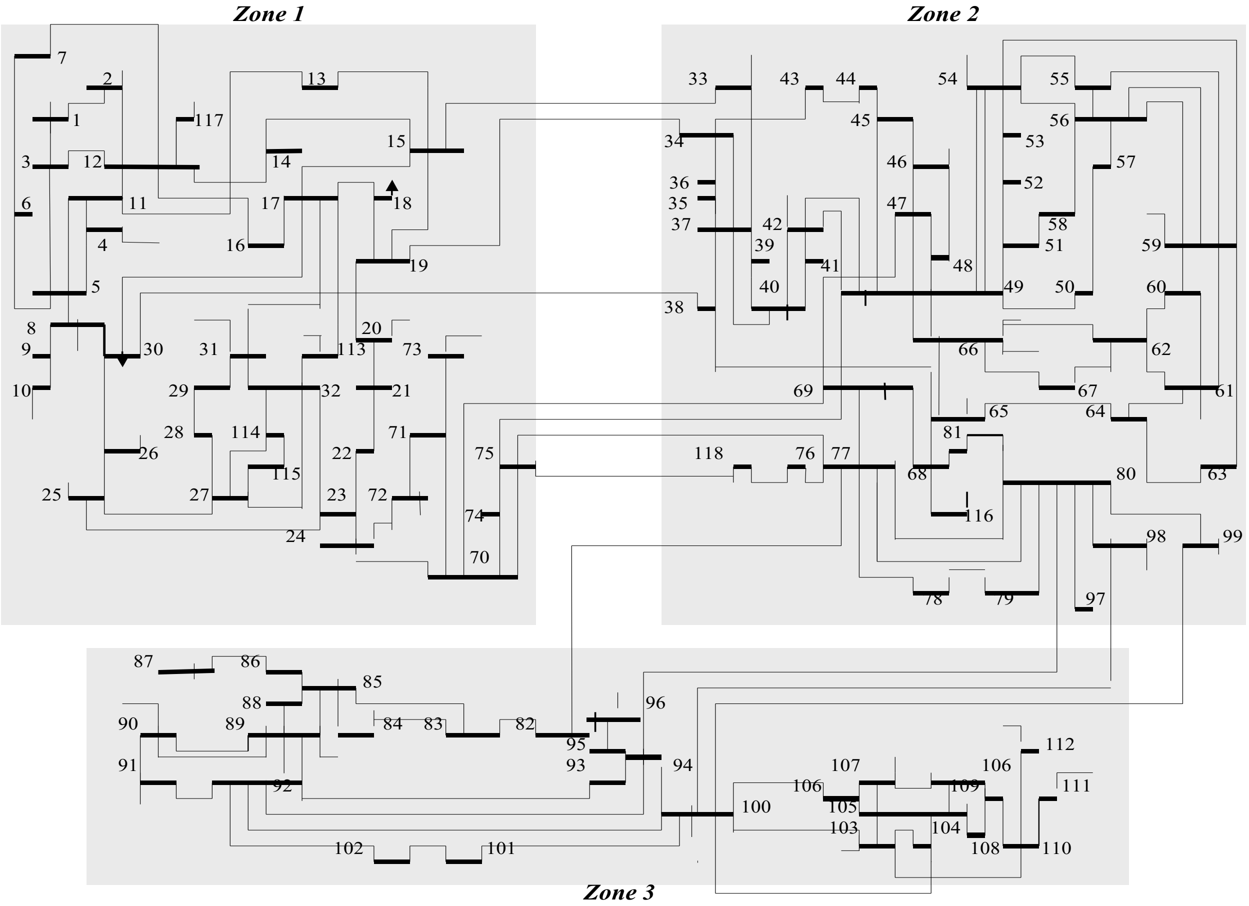
What is the IEEE 118 test system?

2004



http://motor.ece.iit.edu/data/

BASIC CHARACTERISTICS OF THE NREL-118 TEST SYSTEM DATABASE

Characteristics	Peak Load	Total installed Capacity (MW)	Number of Generators
IEEE 118 IIT 2004	**6,000 MW (One day, hourly)**	**7,220**	**54 generators**
NREL-118 2015	**19,800 MW (annual, hourly)**	**24,600**	**327 generators**
Region 1	*9,700*	*10,523*	*136*
Region 2	*5,200*	*5,443*	*72*
Region 3	*5,500*	*8,600*	*119*

Region 1: Pacific Gas & Electric, Bay Area

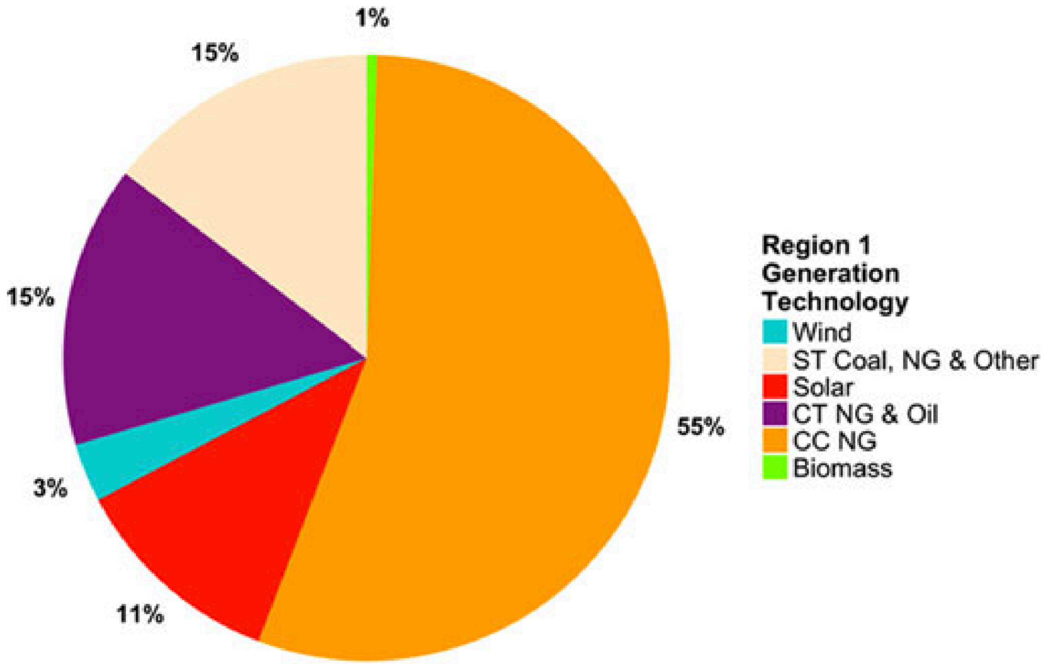


Fig. 4. Share of power generation (MW) in Region 1. The total electricity generation capacity installed is 10.5 GW.

Region 2: Sacramento Municipal Utility District

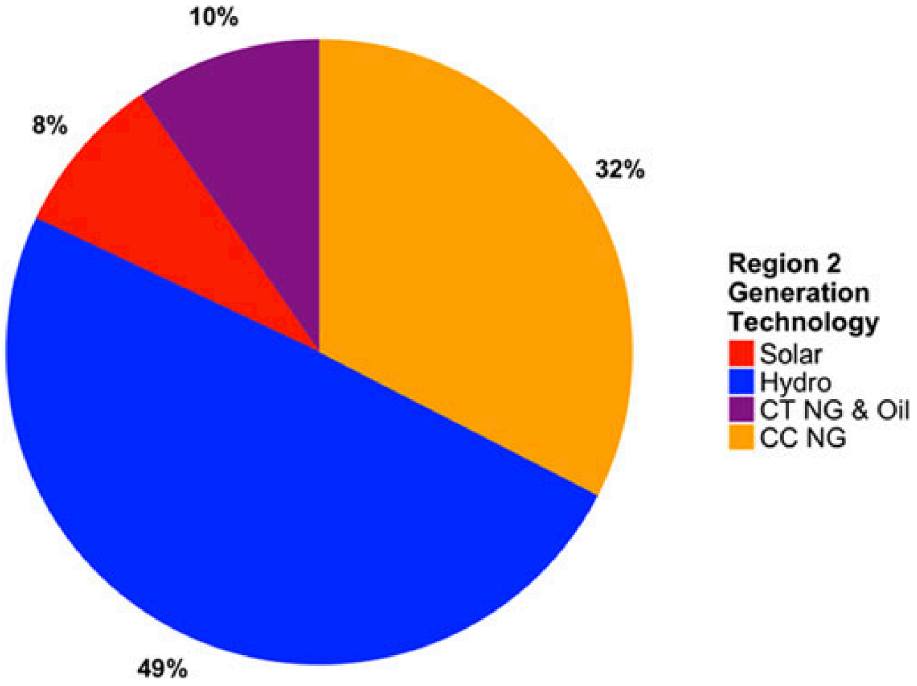


Fig. 5. Share of power generation (MW) in Region 2. The total electricity generation capacity installed is 5.4 GW.

Region 3: San Diego Gas & Electric

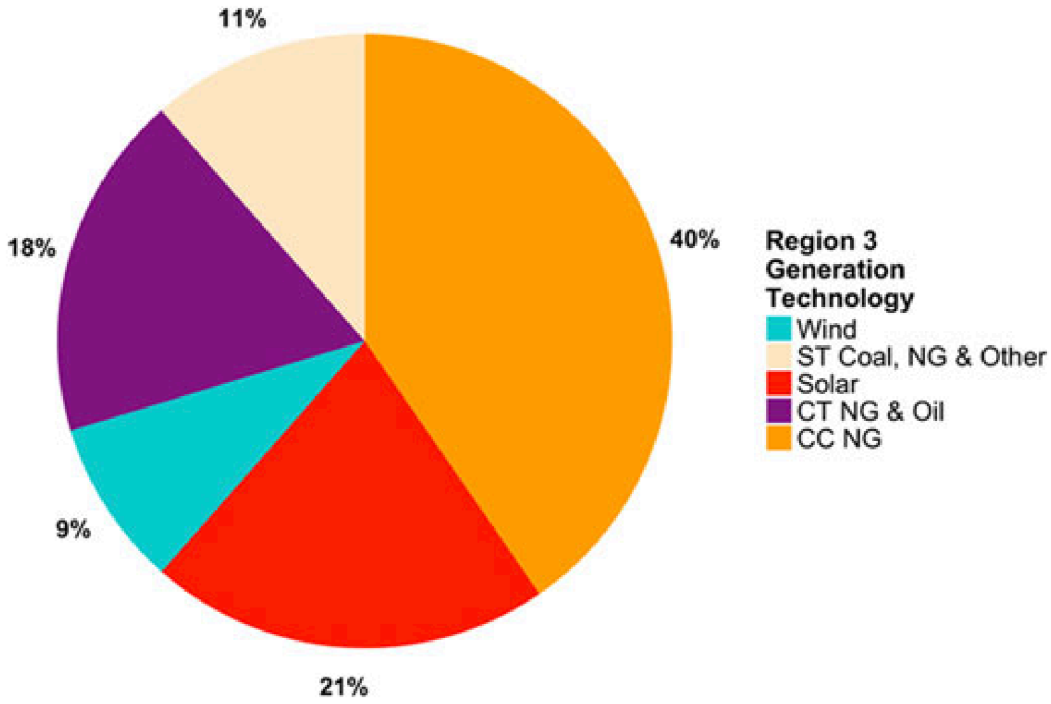


Fig. 6. Share of power generation (MW) in Region 3. The total electricity generation capacity installed is 8.6 GW.