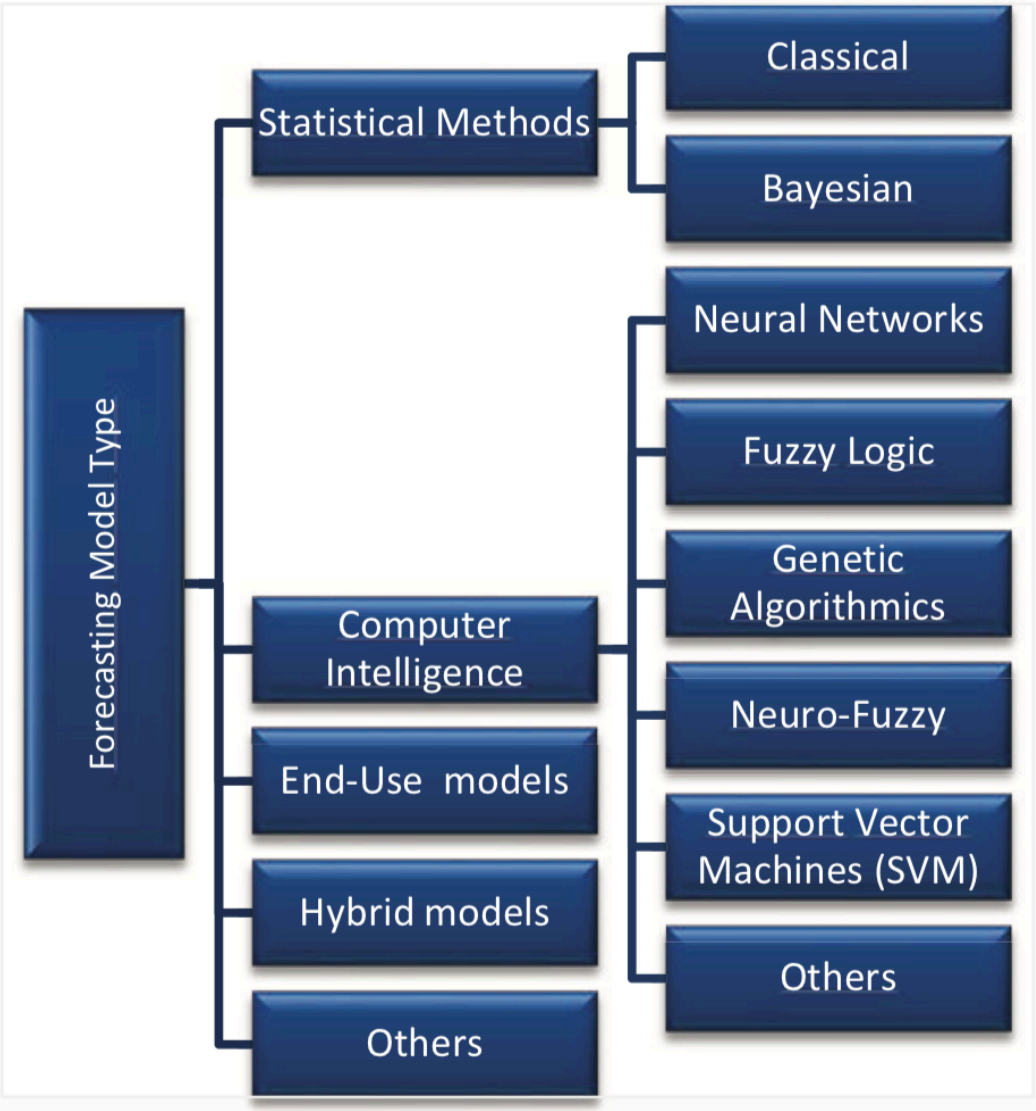
# Methodology of Long-term Forecasting

These results may be applied to short-term forecast.




The statistical methods are therefore separated on classical methods and Bayesian ones, and the classical models are divided in different types of models, from time series models, regression type models until econometric type models.[1]

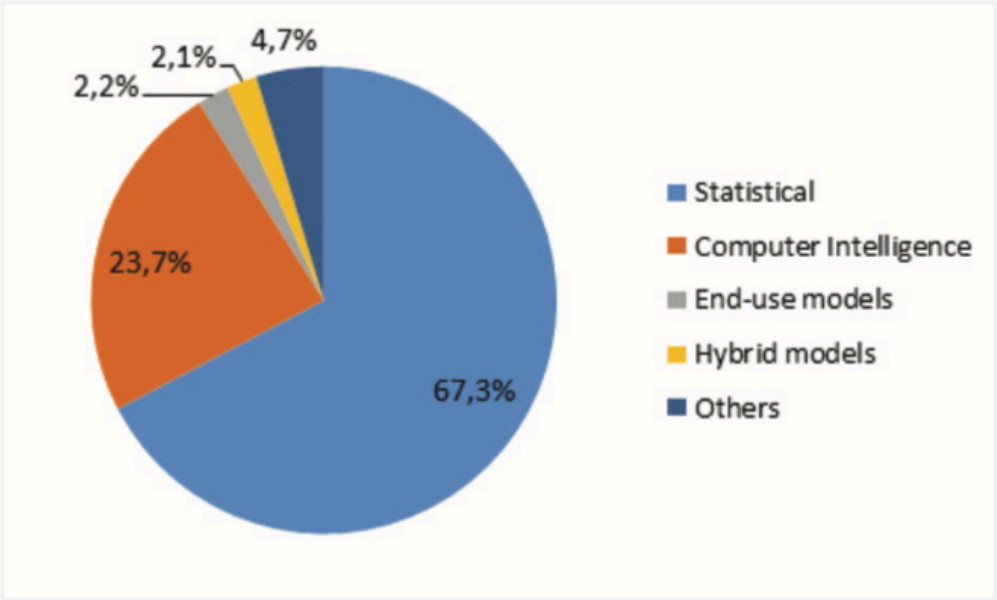
Despite the fact of having the highest number of articles published, **Energy Policy** has an average citation close to the average of the sample. **The journal Energy, Energy Conversion and Management and International Journal of Electrical Power and Energy Systems** have better average citation than the journals Energy Policy and Applied Energy, as can be seen on Table 1.

Table 1. Summary of citation analysis

| Journal | Number of articles | Total Number of Citation | Average Citation |
|---|---|---|---|
| Energy Policy | 7 | 101 | 14,43 |
| Energy | 5 | 188 | 37,60 |
| Applied Energy | 3 | 49 | 16,33 |
| Energy Conversion and Management | 3 | 86 | 28,67 |
| Energy Economics | 3 | 26 | 8,67 |
| International Journal of Electrical Power and Energy Systems | 3 | 111 | 37,00 |
| Technological Forecasting and Social Change | 3 | 26 | 8,67 |

The most cited articles are the ones which use statistical methods, almost 68%, followed by the computer intelligence models, and both together are responsible for more than 90% of all the citations. Considering just the statistical models, also regression (39.1%) and econometric (25.6%) type models are the one most cited.

The numbers of articles citations per model type follow the same trend as the model uses, as illustrated in Fig. 11. The most cited articles are the ones which use statistical methods, almost 68%, followed by the computer intelligence models, and both together are responsible for more than 90% of all the citations. Considering just the statistical models, also regression (39.1%) and econometric (25.6%) type models are the one most cited.




# Short-Term Load Forecasting (STLF)

Short-Term Load Forecasting (STLF) [2]

- The **deterministic methods** are classical causal model of load and weather variables. This includes curve fitting, data extrapolation and smoothing methods
- The **stochastic methods**model the load behavior in terms of stochastic process. Kalman

filtering, autoregressive moving averages and time series approaches fall in this category.
- **Knowledge based expert system**: based on the knowledge acquired by an expert about the past load behavior
- **ANN**
    - Feed forward network: single layer and multilayer in fully connected or non-fully connected architecture.
    - Recurrent networks: dynamic modeling of load
    - Kohnen network based day type identification and later forecasting with network
    - problems: long training sessions. convergence/stability

Time factor, weather data, consumer class, load demanded by the area, growth of the region, amount of increased load etc., are the factors which play important role in calculating the load demand.

Statistical Technique

- Mutiple regression
    - adjusted peak forecast
    - transformation technique: regression model for nominal load and a learning method for residual load
    - two trend- processing techniques for transitional seasons
    - 1 day-ahead forecasts identifying weather-insensitive and sensitive load components
- Exponential smoothing
    - optimal smoothing
    - hybrid approach : + power spectrum analysis and adaptive autoregressive modelling.
- Iterative reweighed least square

  This method utilizes the autocorrelation function and the partial autocorrelation function of the resulting differenced past load data in identifying a suboptimal model of the load dynamics. **more accurate when the errors are not Gaussian**.
    - multiplicative autoregressive model
- Adoptive load forecasting
    - Kalman filter theory (卡尔曼滤波)
    - joint Hammerstein non-linear time-varying functional relationship between load and temperature.
    - adaptive-time series model
    - composite model：nominal load, type load and residual load Kalman filter；exponentially weighted recursive least-squares method
    - autocorrelation optimization for cyclic patterns; the structure and order of the time series is adaptable to new conditions
    - a wavelet transform-Kalman filter method
- *Functional method:
    - clustering before regression: K-means and Self-organizing Maps (SOM),SVD., multiple clustering rules, Sparse Functional Regression..

    - regression techniques: spline, SVD(f-f),Projection Pursuit Regression

- Stochastic time series
    - Autoregressive (AR) model
        - adaptive autoregressive modelling technique enhanced with partial autocorrelation analysis
        - optimum threshold satisfaction algorithm.
        - two periodical autoregressive (PAR) models for hourly load forecasting.
        - *use of generalized additive models and iterative bias reduction method
    - Autoregressive moving-average (ARMA) model
        - decomposed into deterministic and stochastic load components, the latter determined by an ARMA model
        - (Weighted Recursive Least-Squares) algorithm
        - the available forecast errors are used to update the model (outperformed conventional ARMA models)
    - Autoregressive integrated moving-average (ARIMA) model
        -
            - the trend component : the growth in the system load
            - the weather parameters: weather sensitive load component
            - the ARIMA model: non-weather cyclic component of the weekly peak load.
        - seasonal ARIMA model
- Artificial Intelligent (AI) Techniques
    - Fuzzy logic

      a fuzzy logic system with centroid defuzzification can **identify and approximate any unknown dynamic system (here load) on the compact set** to arbitrary accuracy.

      The similarities in input data (L-i-L0) can be identified by different first order differences (Vk) and second-order differences (Ak),
        - hybrid approach can accurately forecast on weekdays, public holidays, and days before and after public holidays
        - fuzzy inference methods to develop a non-linear optimization
        - Automatic model identification
        - two- phase STLF methodology orthogonal least squares (OSL)

      (1) handle non-linear curves,

      (2) forecast irrespective of day type and

      (3) provide accurate forecasts in hard-to-model situations.
    - Neuro network
        - radial basis function networks
        - self-organizing maps - clustering

        - recurrent neural networks
        - feed-forward neural networks (or multilayer perceptron)

      Hippert [53] provided a comparison of large neural networks (neural networks with a large number of neurons and weights) with several classical approaches. large neural networks to perform best–not only with the smallest MAPE (2.35–2.65%)

    - Genetic algorithms
- KNOWLEDGE BASED EXPERT SYSTEM
- hybrid
    - particle swarm optimization (PSO)
    - support vector machines

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1. Gheisa R. T Esteves, Bruno Q. Bastos, Fernando L. Cyrino, Rodrigo F. Calili, Reinaldo C. Souza, Long Term Electricity Forecast: A Systematic Review, http://www.sciencedirect.com/science/article/pii/S1877050915015161 ↩

2. A. K. Srivastava, A. S. Pandey and D. Singh, "Short-term load forecasting methods: A review," *2016 International Conference on Emerging Trends in Electrical Electronics & Sustainable Energy Systems (ICETEESES)*, Sultanpur, 2016, pp. 130-138. ↩