Visual Analysis of Power Plant Data for European Countries

J. Wang[1], K. Kucher[1] and A. Kerren[1,2]

[1]Department of Science and Technology, Linköping University, Sweden
[2]Department of Computer Science and Media Technology, Linnaeus University, Sweden

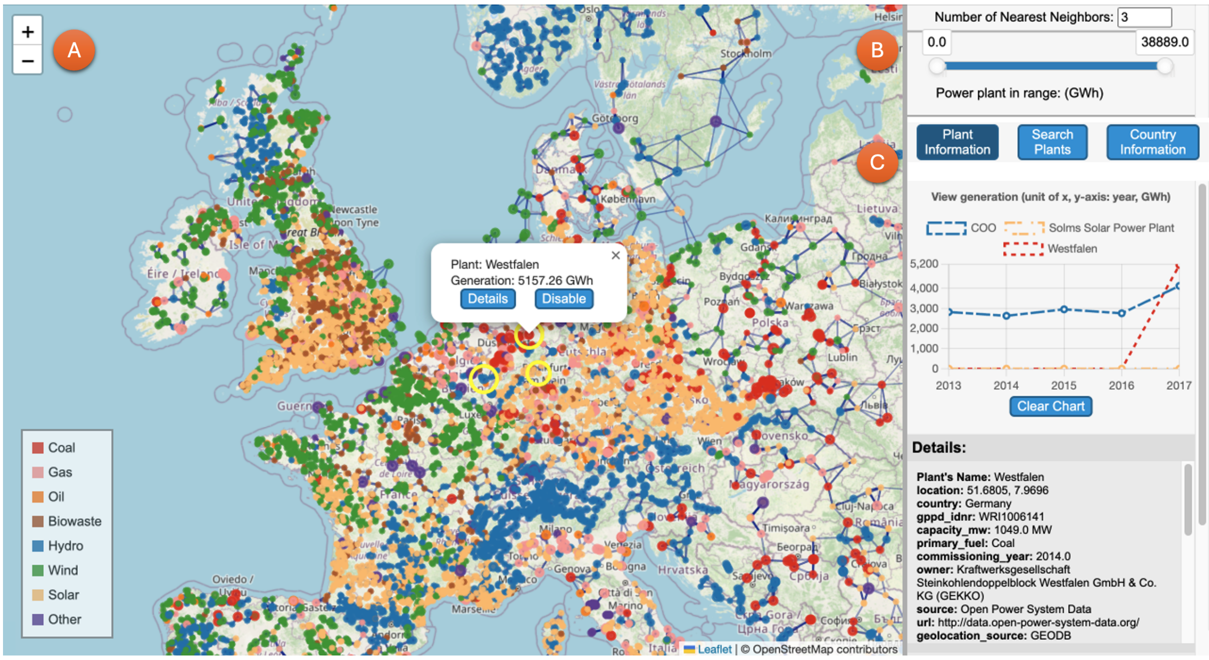

Figure 1: *Visualization of the power plant data for European countries. (A) A power plant network formed by a nearest neighbor graph. (B) Settings and filtering controls. (C) Details view for selected power plants as well as further search and filtering controls.*

Abstract

A power plant is a complex real-world system associated with rich multidimensional data relevant to its construction and activity. Thus, choosing an appropriate way to visualize power plant data is important for users to understand and explore more about such systems. Most of the approaches existing in this field support only a static representation of data from a small region. This makes it hard for the users to get an overview or explore specific power plants. In this poster abstract, we describe an interactive visualization tool designed for the analysis of power plant data in Europe. Our approach provides an overview and detail visualization approach for Global Power Plant Database entries. With this tool, users can easily find power plants, see details on demand, filter, compare, and explore the power plant outage scenarios from the nearest neighbor perspective.

CCS Concepts

• ***Human-centered computing*** $\rightarrow$ ***Information visualization; Visual analytics;***

1. Introduction

Power plants are a crucial part of the modern energy infrastructure. In order to understand the state of various power plants across space and time (as well as with respect to further multivariate data such as the respective fuel type and capacity), interactive visualization approaches are key. The foci of various researchers may be very different when considering power systems for analysis: some researchers are interested in specific fuel types or power plants in one country [KW02, ASBL16, RNU*17, MT19]; others [KVK*18] do not focus on the complexity of power plants at all, but rather

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on the transmission or users' energy requirements. By analyzing the existing related work on this topic, we discovered that several papers propose user-centered visualization methods to manage the users' personal power consumption in one house or a building [BRM10, GDJ*13, RPMSG20]. Further approaches focus on the technical details of the power plants [TC13, FK21], their control systems and efficiency [LLSG14, LWT*23], smart grids [SMDK13a, SMDK13b, LXZ*20, ZZX*20] in cities, and renewable energy sources [RFH22]. All of them have in common that they lack an overall view of the power systems, do not consider the rich multidimensional data related to the power plants, or do not specifically provide an interactive visualization tool for the users.

In this poster abstract, we introduce our visual analysis tool designed to explore power plants across European countries (see Figure 1). Compared to the existing tools, our approach provides an overview of the power plants in Europe and supports the users to see the details of each plant. Leveraging dynamic queries, users can see various views based on generation, country, or fuel type. Furthermore, our tool enables comparing power plants, indication of nearest neighbors for each facility, and searching by plant names.

2. Data and Computational Analyses

Our tool is based on the Global Database of Power Plants [BFH*18], which includes power plants from 167 countries, totaling approximately 35,000 power plants. The data set contains details of each power plant, including identifications, locations, capacities, generation methods, fuel types, and ownership information. Generation data spans five years, encompassing both estimated and actual electricity generation. According to the authors, only 24% of the power plants report their actual power generation data, and thus the data set includes estimated values in addition to the actual figures. Due to the data completeness concerns, we make use of such estimated values in this work. Additionally, for scalability reasons, we only focus on the power plants belonging to European countries for the time being.

The locations of the power plants can be used to create the node positions in our network. On the other hand, to explore the possible relations between the power plants, the distances between power plants signify potential relations. Neighboring power plants are more likely to have direct connections or transmissions compared to those far away. However, the density of power plants varies in different places on the map, and thus it may be difficult for users to find the node neighbors with the naked eye in some scenarios. To address this challenge, we employ the k-nearest neighbor algorithm [EPY97] to find the neighbors of each power plant and establish edges, thereby connecting plants and clearly showing their close proximity. Consequently, a network of power plants is constructed, providing users with a clear visualization and facilitating exploration of the possible transmission between the power plants.

3. Interactive Visualization Prototype

Our prototype tool includes a network representation of power plant data on the world map, as displayed in Figure 1(A). All the power plants are shown in this map as nodes, and according to the ranked geographical distances, all the nearest neighbors of each node (according to the current setting of k) are connected to this node as edges. The size of the nodes encodes the power generation of the respective plants. The thickness of the edges represents the distance relation between the nodes: the shorter the distance, the thicker the edges. It is more important if the two nodes are closer, so the edge will be more emphasized. Also, all the nodes and edges in the map can be clicked. Clicking a node reveals a dialog with power plant details and filtering controls. If the user clicks an edge, the length of the distance and the two ends of this edge are shown.

Within the settings and filtering controls panel (see Figure 1(B)), users have the ability to interact with the tool. They can set the number of neighbors in the k-nearest neighbors algorithm and thus investigate tighter or looser bonds between power plants. A range slider allows users to filter the power plants according to their power production. The users can also click on the legends to filter power plants according to the fuel type.

The final panel implemented in the prototype includes three tabs that show more detailed information (see Figure 1(C)), thus allowing the users to search for specific power plants and to examine the summaries of the power generation for each country included in the data set. Three buttons are shown on the top that are used to switch between different displays. By clicking the Plant Information button, a line chart and detailed information about the selected nodes will be shown. The line chart shows the generation of power plants from 2013 to 2017 (as available within the currently used data set), and the color of the lines is decided by the fuel types of the power plants. The users can compare the power production data by checking the details of different nodes easily. Meanwhile, detailed information and neighbors of this node will be shown as text. Upon clicking the Search Plants button, the users can query for specific power plants by their names. After clicking the Country Information button, the users are presented with a form displaying the total power generation of each country included in the data. By selecting check boxes corresponding to specific countries, users can filter the displayed power plants based on the country.

4. Conclusions and Future Work

In this poster abstract, we have briefly introduced our prototype tool for visually representing the network of power plants in European countries that help the user to explore the power systems infrastructure in Europe. Through this tool, we can identify the complexity and the scope of the problem related to modeling and analyzing such power systems, and for that, we intend to apply a more powerful and involved conceptual framework such as multilayer networks [MRA*21] to further explore the domain problem from a visual analytic perspective.

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