Project Initiative on GIS-based Tool for Grid Connection Planning in Thailand Power Network

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SUMMARY
This project initiative presents a new conceptual idea to manage, integrate and visualize all grid connections’ information of Thailand Power Network on Geographical Information System (GIS) platform. New planning tool is used to integrate the current information relevant such as substation load forecast, distribution transformer loading, distributed generation, switching diagram, layout, etc., onto the platform. With this, the system planner can utilize it for any evaluation process of effective grid connection planning.

KEYWORDS
Grid Connection Planning, GIS-based tool, Thailand Power Network

I. Introduction
Long-term grid connection planning is one of the most important works as it deals directly with connecting points between distribution and transmission systems. Electric power generating from power plants can supply to end-customers via distribution system connection.

The grid connection planning is related with the power system analysis, cost estimation, engineering designation. In practice, important information e.g. substation load forecast,
engineering drawing, distributed generation, transformer-loading and aging, are gathered non-systemically, lack of connectivity, not integrate into one framework. The power system planners need the information for the analysis of grid connection planning in order to see whether any grid connecting points are required to reinforce or renovate. Recently, there are technological advancement of GIS that can be used in a wide-range area for power engineering applications. The applications are GIS-based implementation for distribution system load flow (DSLF) analysis [1], GIS-based application for new substation and transmission expansion consideration [2], and the fuzzy GIS-based implementation for analyses of line-route selection [3]. This paper presents the development of GIS-based tool for grid connection planning, along with some useful information at grid connecting points for the data management, integration and visualization purposes.

II. Thailand power network in brief

Electricity supply industry (ESI) in Thailand is currently structured as enhanced single buyer (ESB), under view of energy regulatory commission (ERC) and governmental body. Thailand’s power network consists of generation, transmission and distribution power systems. The generation system is open for competition via the four major generating players. They are, Electricity Generating Authority of Thailand (EGAT), independent power producer (IPP), small power producer (SPP), and very small power producer (VSPP). The transmission system is owned and operated by EGAT with the voltage ratings of 500 kV, 230 kV and 115 kV. Whilst the distribution system is responsible by two distribution utilities that are the Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA). MEA serves the end-users of distribution network within the metro area covering Bangkok, Nonthaburi and Samutprakarn provinces. PEA takes care of the rest end-users of distribution network, covering all provincial area. Details of Thailand’s ESI structure are depicted in Figure 1.
III. GIS-based tool for Grid Connection Planning

This section presents the conceptual idea of how to integrate the GIS onto the existing power system platform. The GIS-based grid connection planning tool is developed under the following key concepts: data management, designation, integration, visualization and Graphic User Interface (GUI). Data management focuses on creation of all useful database with an implementation of digitized geographical maps. The symbols which will be used onto the GIS map, such as transformers, grid connecting points, distributed generators (e.g. solar, wind, biomass, biogas, and mini hydro) are designed in designation part. Then, all useful database along with some planning information and database are integrated within the integration part. The panoramic view of the power system including grid connecting points, transformers, generators, and so on, are mapped as a planning chart within the visualization part. Lastly, in order that the users can be friendly interfaced onto the same GIS-based platform, the GUI is adopted for a better interface between user and GIS program. In order to see the flow of work throughout the GIS-based grid connection planning tool, following sections provide the work flow, key planning information and Graphic User Interface (GUI) for better understanding.

A. Work flow

Key methods that use for grid connection planning in this study can be depicted in Figure 2 and summarized as follows:

- **Step 1: data collection** -- to collect all necessary information as shown in Figure 2.
This step is used for data management application in order to solve non-systematic problem.

- **Step 2: designation** -- to design the new platform in realize with the planning information. Panoramic view of power system is an ultimate goal for effective visualization under geographic and info-graphic environment.

- **Step 3: demonstration** -- to demonstrate the particular area of the whole power system as a pilot project. In this project initiative is adopted the north eastern power system as an initiative. The result can be shown in GUI, info-graphic, etc.

- **Step 4: validation** -- to validate all information into the GIS-based platform.

- **Step 5: implementation** -- to finalize and apply method to overall region.

![Figure 2: Work flow for GIS-based grid connection planning tool](image)

B. Key planning information.

Key database for planning information can be introduced into the following. Within the database, the spatial data are stored while the non-spatial data is managed and linked with the substation name.

1. Substations and transmission lines

All substations and transmission lines are coordinated by use of World Geodetic System (WGS) [4]. Each substation’s latitude and longitude are referred for its exact location onto the digitized map.

2. Grid connecting points
Grid connecting points are defined into two types. They are the connecting point via low voltage (LV) side of distribution transformers and the connecting points via 115 kV outgoing feeder of the substation. The grid connection loading data are very important for grid connection planning to see if the system reinforcement is needed to implement. In EGAT practice, when the grid connection planning study is taken, there are power flow analysis run along with other analyses, i.e. contingency analysis (N-1) and stability analysis.

3. Distribution transformers

Distribution transformers are the major substation equipment related directly with distribution grid connection. This is because the transformer rating can be used to evaluated the ceiling MW-capacity of the connecting points to see how much capacity the load can be served. Within EGAT’s system, distribution transformers are connected into four different types of connection. They are:

1. Normal connection -- only one transfer is connected to serve load at only one connecting point,
2. HV-common connection -- two transformers are banked at HV side of the transformers in order to serve loads with two different connecting points,
3. LV-common connection -- two transformers are banked at LV side of the transformers in order to share load at only one connecting point, and
4. Parallel connection -- two transformers are paralleled to share load at only one connecting points.

Further details of transformer connections at distribution level can be seen in Figure 3.

Figure 3: Types of distribution transformer connection
4. Substation Load Forecast

All substation forecasting loads are taken here for grid connection planning purpose. The data from load-forecast study are adopted in 20-years planning period, focusing only on non-coincident peak load at each substation. The forecasting loads are separated into 22 kV and 115 kV ratings. These information relate to distribution connection loading also.

5. Engineering Documents

Engineering documents are considered as non-spatial data in this study. The documents are stored in URL link with other database. The documents that use here are substation layout, switching diagram, and information of substation equipment.

6. Distributed Generation

Distributed generation are all power plants that are connected at the distribution level at 115 kV, 33kv and 22kv respectively. These power plants, so-called SPPs and VSPPs, have to consider in the connection planning as they can contribute some generation into the power grid which will have direct impact of varying load consumptions at substations.

D. Graphic User Interface (GUI)

With some limitations of ArcGIS that cannot develop as GUI way, this study is used PyQt to create GUI instead. GUI provides the substation information as shown in Figure 4 and 5, in view of dialog box. The information includes transformer loading, load forecast, switching diagram, switching diagram, and substation layout. Also matlibplot is used to interactively plot the transformer loading at LOEI substation as shown in Figure 6.

![Figure 4: GUI generated by PyQt](image1)
![Figure 5: Transformer loading plotted by matplotlib](image2)
IV. Conclusions

The GIS-based grid connection planning tool presents in this paper. It is initiated within the system planning division of EGAT as a first step for the distribution connection planning development. In design, all non-systematic problems are drawn to solve with data management. Visualization concept is also adopted in order to provide the make-sense statistical power system data, e.g. substation load forecast, grid-connection loading, transformer loading, etc. The tool creates the useful grid-connecting point and transformer installation charts as shown in Figure 6. Both charts bring panoramic view in use for grid connection planning. Overall information is integrated in GIS program. In addition, GUI is developed for effective interface between user and GIS program. Next step of the study is currently undergoing within the division, with integration of the distribution system load flow (DSLF) [3] to be introduced for future work.

Figure 6: Grid-connecting points and transformer installation charts
BIBLIOGRAPHY


Biographies

Kongrith Komasatid, received B.Eng degree in electrical engineering from King Mongkut's Institute of Technology Ladkrabang (KMITL). M.Eng degree in industrial engineering from Chulalongkorn university. He is currently working at Electricity Generating Authority of Thailand in distribution connection planning section. He is interested in long-term load forecast and optimization technique for power system planning.

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