

# *The Significance of Control and Auditing in the Windpower Plant Relevant Engineering Projects and Controlling Purposed Positional and Geometric Measurement Services.*

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**Abstract**—Wind energy and wind power plants that are included among the renewable energy resources, have an important place in our days. The consumption of wind energy that has no adverse effects in terms of the human health and environmental protection, and performing fast technologic progress, presents apparent advantages in comparison with the fossil fuels. Conducting controls and auditing becoming very important issue, in such a useful power plants, in design, field application, production of digital field models, conducting topographic measurements stages (realized levelling and GPS measurements in geodetic network) of the projects. In the application of engineering projects for the design and construction of the power plants that utilizes the wind power and generating electricity, a lot of problems and non-conformities could be faced that might be emerged due to insufficiencies in the project data and/or the realized design works that are made depending on the available data. In order to present these problems and take precautionary actions, the intended technical controls and auditing in each stages of the geographic based projects are necessary as well as the requirement for verification of the applicability of the project and for compliance with the implemented geograpy. In this context, in performing the relevant duties, technical control and auditing, in other words to verify the difference between existing one and intended one and realized one and the one has to be made carries great importance. The activities made in this context, are the kind of multidisciplinary studies and have to be made by the mapping, energy systema, industrial, ..etc engineers that are expert and qualified in their discipline. Again in this context risk analysis, administration activities and organizational studies have to be controlled in the project. In this study, it is attempted to give some valuable information on the wind power plants that realizes generating electricity by utilizing wind energy, and their status in Turkey and in the world, as well as the importance of the topographic measurements for controlling and auditing purposes during the construction and operation stages of these power plants.

**Keywords:** Geographic Based Engineering Projects, Engineering Control Measurements, Wind Energy, Control and Audit, Surveying and Topographic Measurements

## 1. INTRODUCTION

Energy is the key of many processes. After the 1970s energy crisis, energy usage becomes more important and efficient use of energy attracted attention. Nevertheless, many scientific studies and efforts have also done for effective use of resources. Accordingly, scientists pay special attention to renewable energy sources. Among these renewable sources, wind energy increases its share in the energy mix. Wind energy offers many advantages, and this leads wind energy as a growing source in the world. It is free, clean and a domestic source. Power generation from wind does not cause any emissions. Furthermore, wind energy can be applied as a remarkable choice for responding energy demand in remote areas, and the land found to set up a wind turbine can be thought for some other uses. Although fossil fuels constitute a significant share in the world primary energy demand, the share of renewable-energy is considerably increasing day by day based on the new strategies. Thereby, global CO<sub>2</sub> emissions may be avoided by the more use of renewable energy technologies. Here, Figure 1 shows the global cumulative wind capacity of the world by the end of 2015. Figure 2 and Figure 3 demonstrate Turkey's energy mix and total cumulative installed capacity by the end of 2015, respectively [2]. Figure 4 illustrates the Turkey's cumulative installed wind capacity (MW) by the end of 2015 [2]. According to the figures, wind energy share grows faster compared to other renewable-energy sources.

Figure 1 Global cumulative wind capacity of the world by the end of 2015 [1]

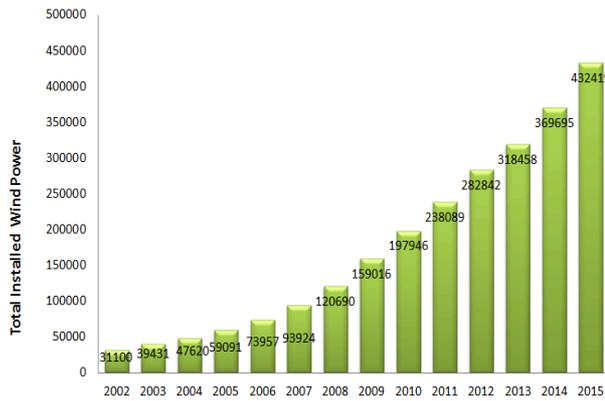


Figure 4 Turkey's cumulative installed wind capacity (MW) by the end of 2015 [2]

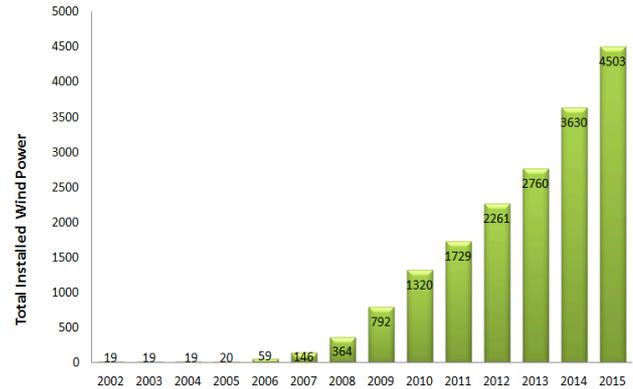


Figure 2 Distribution of Turkey's installed capacity by the end of 2015[2]

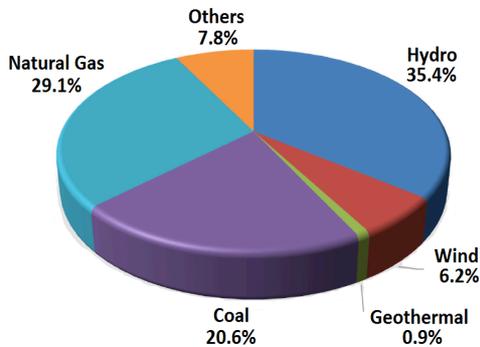
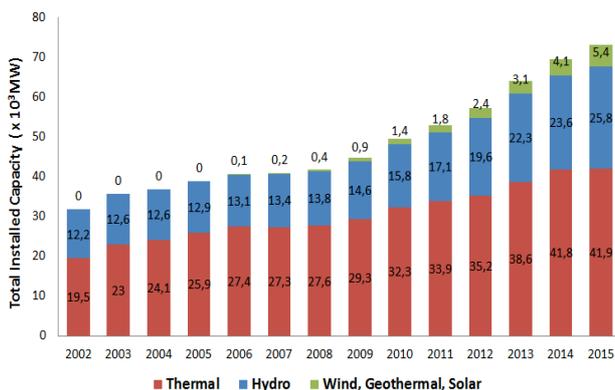


Figure 3 Turkey's cumulative installed total capacity (MW) by the end of 2015 [2]



According to researches in Turkey, the share of renewable-energy resources in primary energy supply and electricity generation shall be increased. For this reason, utilizations of domestic resources such as wind, hydro, solar, geothermal, biomass, other renewables and introduction of them into the economy are strategically remarkable for providing the resource variety. In accordance with the world, Turkey's policies seek to increase the share of renewable resources and particularly increasing the use of wind energy.

Scientists are doing research for improving the performance of the wind energy systems and thereby the shares of wind energy as a renewable source in the energy mix.

The performance of a wind turbine can be affected by many parameters. Among these, topographic features of the land play an important role and directly affect the net power output.

The prediction of the wind-energy distribution over territories is a necessity for the appropriate selection of an adequate site for a wind power plant.

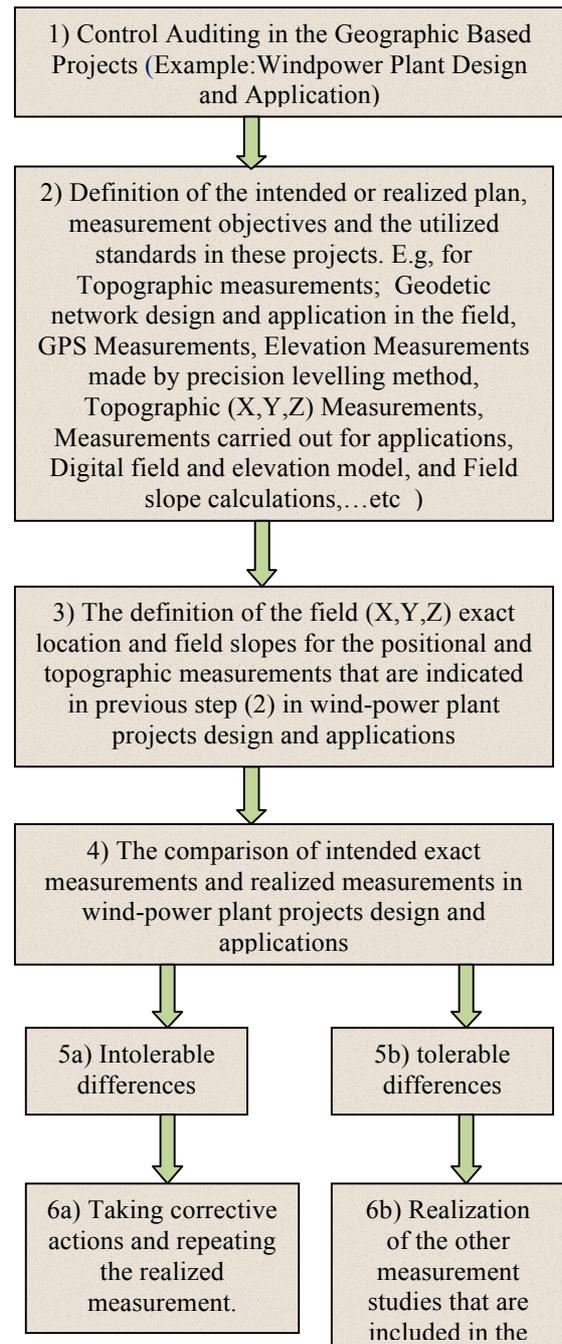
Thereby, topographical wind effects have a great impact on wind energy distribution. [3] Studied two-dimensional numerical simulations of flow over three common types of topographic features. Ayotte [4] performed the computational modeling for wind energy assessment. In another study, numerical investigation of the influence of topography on simulated down burst wind fields by Mason et al. [5]. Sen [6] presented an assessment providing useful information concerning the regional mutual relationships between the topographic and wind characteristics around the site. In this paper, focuses are given for the significance of the topographic measurements controls throughout the control and auditing stages of the wind power plant assembly projects.

## 2. CONTROL AND AUDITING IN THE ENGINEERING PROJECTS

In general terms, control and auditing is a management activity of comparison thematic that is needed almost in all fields of human activities and management. The comparison in this sense is the activity that is to compare the quality and quantity of an existing job of comparison thematic with the one of intended transaction. [7]. On the other hand, the control and auditing in the management activities comprises the activities of responsibility of the managers, comparison of the realized activities with the intended ones, defining discrepancies among them and the suggested solutions to eliminate these discrepancies. The activities in this context, are of multy disciplinary studies and have to be made by the expert persons in the fields of Mapping Engineering, Energy Systems, and Industrial Engineering etc... Again in this context, risk analysis, management activities and organizational studies in the project have to be controlled as well. The measurements in the context of controlling and auditing that are made in the very important geographic based engineering projects such as windpower centrals have vital importance during the realization stages of these projects from design and development to production. Specially, in healthy modelling of the concerned field, obtaining the digital elevation model, and making slope calculations of the field, this control measurement presents ultimate importance. With the aid of these topographic measurements, the location of the topographic field that indicates the windpower plant project field settlement and application position could be defined by healthy correlation and modelling with wind power in the project area. In addition, by making healthy simulations and animations of the windpower plant project in virtual field model made in computer media, near as-built modelling of the project could be made prior to final application of the project on the field. Hence, this will provide a lot of cost and economic benefits. It is understood that topographic and control measurements made on the field, have critical importance on the geographic based engineering projects.

Considering the control subject it presents some differences in terms of the control method and application, However, basic operation of the main process is the same with regard to the main issues. As shown in Figure 5, It is attempted to depict the topographic and measurement control stages in the selected windpower plant projects, schematically. On the other hand, in our days public enterprises embrace the the mission of 'main contractor' not the 'constructor' in the world, hence in accordance with this approach, the projects of engineering applications are usually realized by tendering method, hence 'control measurements' work presents critical importance in the 'main contractor'-'investor' public enterprises [7]. As a result of this, the control activity has equal importance wit the project management in the view of the 'main contractor'-'investor' public enterprises. [7].

Figure 5 Topographic and Measurement Control Stages in the Geographic based projects (For example Wind Power Plant Projects.)



Considerable numbers of engineers are employed in the control duties, project control organizations or units are being formed for project control, and quality control laboratories are being constructed in the organizations that geographic based engineering applications are realized [7]. The following basic features have to be provided in the control of geographic based engineering projects that requires topographic control such as wind-power plants. [7].

- The control in wind-power plant projects must be made in accordance with the current legal requirements, standards, and the existing plans and programs.
- In these kind of projects facilitations have to be provided for detecting the non-conformities as early as possible and relevant precautions have to be implemented on time for the non-conformities (applications, GPS measurements with regard to horizontal and vertical positions, Precision measurements, details record measurements, and other measurements to define the location of the wind-power plant projects in relation to wind flow direction in the digital field model) that are originated from measurements.
- The control has to be made in a sense of flexibility to comply with the changing conditions.
- The control has to be made by objective, neutral, qualified and trained in topographic measurements, expert and professional persons according to suitable and applicable objective criteria.
- Joint studies have to be realized with the relevant disciplined experts in the control transactions in wind-power plant projects. (e.g Energy systems engineering, industrial engineering, Geodesy (Surveying) engineering, geology engineering, geophysics engineering,..etc).
- The application of control transactions must not require excessive resource; other activities must not be restrained during their implementations.
- Corrective or preventive actions have to be initiated in case of non-conformities, on the other hand in case of positive results rewarding actions have to be provided.
- The control has to be easily applicable and transparent.
- It has to be kept in mind that best control in an implementation is the following internal control routes that is provided for this process.
- The applied control mechanism, has to be in compliance with the existing work, audited organization structure and the process.

### 3. CONTROL AND AUDITING ISSUES IN THE APPLICATION OF WINDPOWER PLANT PROJECTS.

Important part of the documents and data that are relevant with the engineering projects such as wind-power plant design and application, are related with the geometric (positional and formal) features; namely position, form, and dimensions of the project on the earth and underground. On the other hand, it is a known fact that the design of these kind of field bound projects, are formulated according to data that is obtained from limited numbers of (topographic, geologic, geotechnic, geomorphologic,..etc) measurements and observations related

to application field. It is also obvious that, theoretically each part of the field has different natural features, and the design activity made according to these features and limited amount of data, may not be in compliance with the natural and ever changing cultural structure of the field. (For example, in wind-power plant projects, lack of correlation and modelling of field and elevation structure with wind flows). Therefore, in realization of these kinds of geographic based projects, permanent control of the compliance or non-compliance of the project with the field natural and cultural features becomes very important in addition to the control of project conformity. Even it is an important issue or obligation to improve this compliance during each stage of the implementation. In geographic based engineering projects, the realization of project as per the position, dimension and form that are defined in the project, the compliance with the field topography, ownership, on-earth and underground field usage properties, and improvement issues are the subjects that are considered in the topographic and engineering measurement studies. [7]. In our age, technical arrangements for geographic based engineering applications such as wind-power plant projects, the compliance of the projects with the above defined issues, and maintaining the conformity of position, dimensions and geometry and relevant measurement and control items as per defined in the project and conformity standards are of prime concern. Conformity and technical integrity of these projects are the common result of whole activities contained in the project, and possible realization of one of the project items in a non-conforming way, could not mean the successful outcome of the project even though other aspects of the project carried out properly by all means. Therefore, in these projects, a geographic based engineering structure, that is in non-compliance with the topography and land usage of the applied field, and not realized as per the planned position, geometry and measurements, having insufficient information about stability problems, evidently regarded as unsuccessful. In Table 1, control and auditing issues are included that are relevant to this kind of field based engineering projects. The critical issues that are included in the subject can be defined as follows;

- Position, dimension and geometry control related to projects
- The control for cadastral and expropriation maps and the relevant field measurements
- Controls and auditing related to geodetic network structure and position measurements of other earth control points
- The controls relevant to verification of compliance of the applications with the projects that is related to wind power plants.
- General controls for topographic measurements that are realized on the horizontal and vertical axis. (GPS measurements, Levelling measurements, Tacheometry measurements)

Table 1- Control and auditing issues relevant to field based engineering projects.(For example wind power plant projects)

Seq. No.	The topographic and other control issues relevant to wind power plant projects.
1	Position, dimension and geometry control related to projects
2	The control for cadastral and expropriation maps and the relevant field measurements
3	Controls and auditing related to geodetic network structure and position measurements of other ground control points
4	The controls relevant to verification of compliance of the applications with the projects that is related to wind power plants.
5	General controls for topographic measurements that are realized on the horizontal and vertical axis. (GPS measurements, Levelling measurements, tacheometry measurements.)
6	In energy supply plant projects, land usage conformity control relevant to project (digital field and elevation model, and slope calculations, on the produced digital field and slope model, to define the project location in the best possible position in the area with the assumption to correlate with the wind flows,...etc)
7	landslide control that is made toward the project application area (by periodical measurement and observations)
8	Geological and geotechnical conformity control
9	The control of physical and chemical features and exactness of the used material, workmanship, hardware and function.
10	job types and amounts control
11	Management and organization control with duration and time, however conducting risk analysis (the control of sub-processes and whole realization time and calendar)
12	Conformity and applicability control of specifications, project plans, programs and standards,...etc criteria that are relevant to project.
13	Quality assurance controls, and failure and non-conformities controls and assessments in the context of the ISO 9000 and other standards,..etc.
14	Calibration control of the measurement devices that are used in the project.
15	Project organization control.
16	Occupational Health and safety Controls.

- In energy supply plant projects, land usage conformity control relevant to project (digital field and elevation model calculations and field slope calculations, on the produced digital field and slope model, to define the project location in the best possible position in the area with the assumption to correlate with the wind flows,...etc), and stability and landslide control that is made toward the project application area (by periodical measurement and observations)

are all relevant with the topographic measurement controls [7].

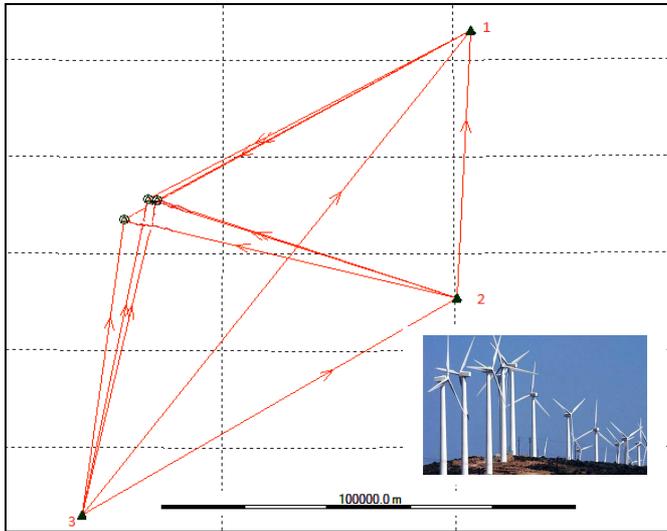
#### 4 TOPOGRAPHIC MEASUREMENT STAGES IN APPLICATION OF WIND POWER PLANT PROJECTS

Topographic measurements and activities has considerable importance in the geographic based engineering projects such as wind-power plants during the implementation and post implementation control stages. In the progress of the project as per the design frame,(Project application) and in completion stage, the realization of these kind of engineering measurement implementations with ultimate care and using the most advanced technological devices and methods is inevitable. Furthermore, relevant to project scope; due care must be given to find the best possible project application location in the area with the assumption to correlate with the wind flows along side with the envisaged digital field model, and slope calculations. In this kind of field based projects, in addition to the conformity of all components, primarily in order to realize the topographic measurements, a suitable and well optimized geodetic network must be established in the project region.

With the aid of this established network, proper progress of the project as per design frame could be realized provided that most advanced technological devices are used and most sensitive measurements are made. In the studies toward the establishment of geodetic network with triangulation and polygon points, it is necessary to take care that these points would be set on the solid grounds, furthermore proper special marking and witness mark studies have to be made. The designation of (X,Y) coordinates on the horizontal axis has to be made by utilizing the GPS instruments and static measurement technique, on the other hand the coordinate of (Z) that is indicated on the vertical axis has to be defined by precision levelling studies on the concerned area in a sensitive manner. While doing this operation, latest technology digital levelling instruments and levelling rod instruments has to be used. Main ground control points of geodetic networks that are called as triangulation points have to be consist of reinforced concrete columns of 30-35 cm diameter and 1.30mt to 1.40 mt high so called bent bar. The data that are obtained as a result of measurements have to be calculated and offset carefully in

the work office. In the Figure 6, a sample geodetic network study is given for the ground control points that will be established in the study area.

Figure 6, A sample geodetic network studies that is made in the wind energy projects related to ground control points.



In Figure 7, a sample view is given relevant to bent bar structure that is intended to be used in the measurement control studies.

Figure 7 An example of a bent bar that is constructed for control measurements.



Some images that will exemplify the measurements are given; In Figure 8, for GPS measurements and in Figure 9. for Digital Levelling measurements that are made in the geographic based engineering projects.

Figure 8 An example of GPS Measurements that are Made in the Geographic Based Engineering Projects. (X and Y coordinates in the topographic measurements)



Figure 9, An example of Precision Levelling measurements (Z axis) that are Made with Digital Levelling Instrument in the Geographic Based Engineering Projects.



Depending on the established sensitive geodetic network, each kind of topographic application, GPS and Tacheometry measurements, levelling measurements, expropriation, cadastre measurements, field slope calculations, digital elevation models and quantity surveying studies for wind energy plants will also be made sensitively, and hence the expected mistake ratio in the project will be brought to a minimum.

## 5. CONCLUSION

Control and auditing will be necessary in each place that geographic based engineering projects are performed depending on a plan, program, project and a contract. Likewise, these kind of activities that are considered to be made with a lot of administrative, financial, technical, and temporal limitations, and their comparison with the realized activities and defining the discrepancies between them is a technical and administrative obligation. The studies that are made in that context, are the kind of multidisciplinary studies and they have to be made by Geodesy (Surveying), Energy systems, Industrial ,...etc engineers. Likewise, in that context, risk analysis, administration activities and organizational studies have to be controlled in the project. The control and auditing activities that are made in that kind of projects, will also be necessary with regard to gaining experience for the execution of similar future projects. In that context, the following issues have to be taken into consideration while executing geographic based engineering projects such as wind energy plants.

- The controls in the topographic measurements that are made for controlling purpose in the wind energy plants projects, have to be made in accordance with the methods and bases to be defined in the relevant legal, administrative and technical arrangements.
- In the controls, the methods, tools and instruments that are to be used in realization of the measurements and processes, have to be selected carefully, topographic controls have to be made by expert and qualified persons.
- Due care has to be given that the controls must not exert excessive load and not require extra resource for the implementers.
- The intended controls should have a systematic and an objective and the control results have to be reported by the controllers in that kind of projects.
- In these reports, the results that are reached by control, could be assessed and commented by statistical methods when required; the causes of the non-conformities and findings that might be arisen as the result of controls, have to be investigated and solution proposals to be suggested.
- Unless the technical integrity of the whole project proved in a project, the decision must not be given about the exactness of the sub-projects and sub-processes.
- The executor of the project and the controller of the project must not be the same person, unit or organization in the geographic based large

engineering projects such as wind energy plants. Therefore, big and important international projects that are realized with tendering method, the control duty has to be made by the independent organizations from the main contractor.

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