ENERGY COOPERATION BETWEEN THE EU, THE LITTORAL STATES OF THE BLACK & CASPIAN SEAS AND THEIR NEIGHBOURING COUNTRIES

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ACTIVITY COMPLETION REPORT

The formulation of the RE secondary legislative base and related procedures for facilitation of the future wind project development and investments

CWP.11.GE (AHEF.97.GE)

INOGATE Technical Secretariat and Integrated Programme in support of the Baku Initiative and the Eastern Partnership energy objectives

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Prepared by	Kim S. Jensen Shorena Kalandarishvili	October 31, 2015
Checked by	W.F. Lutz, O. Antonenko	August 6, 2016, August 12, 2016
Approved by	P. Larsen	August 15, 2016

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Abbreviations

AEP	Annual Energy Production
AHEF	Ad hoc Expert Facility
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ESCO	Electricity System Commercial Operator
EU	European Union
GEDF	JSC Georgian Energy Development Fund
GNERC	National Energy and Water Supply Regulatory Commission
GSE	Georgian State Electrosystem
IEC	International Electrotechnical Commission
ITS	INOGATE Technical Secretariat
MoE	Ministry of Energy (of Georgia)
MoU	Memorandum of Understanding
RNA	Rotor-Nacelle Assembly
WPP	Wind Power Plant

1 PART 1 – EUROPEAN COMMISSION

1.1 Background

Assignment Title:	The formulation of the RE secondary legislative base and related procedures for facilitation of the future wind project development and investments, CWP.11.GE (AHEF.97.GE)
Country and Dates:	May 2015 – April 2016
Beneficiary Organisation(s):	The Georgian Energy Development Fund (GEDF)
Beneficiary Organisation's key contact persons – name and e-mail address	Mr. Galaktion Buadze, Financial Director, g.buadze@gedf.com.ge
Deliverables Produced	Final report and presentations
Expert Team Members	K.S. Jensen, S. Kalandarishvili, W.F. Lutz

1.2 Essence of the Activity

The Technical Assistance (TA) assignment on the formulation of the Renewable Energy (RE) secondary legislative base and related procedures for facilitation of the future wind project development and investments was implemented during the period May 2015 – April 2016. The TA was requested by the Georgian Energy Development Fund (GEDF) and implemented according to the INOGATE Country Work Plan for Georgia.

The overall objective of the assistance was to improve investment climate for the implementation of wind power projects in Georgia. The specific objectives were to help the beneficiary to develop the secondary legislative base and related procedures for facilitation of the future wind project development and investments.

The assignment also facilitated the wide application of RESMAP tool developed by ITS within the previous technical assistance project for the GEDF. The tool can be effectively applied for the development of the wind observation data which is a part of the pre-feasibility study for a potential wind power project according to Georgian legislation. The further advantage of the tool is that it provides potential investors with important information on the economically viable wind resource in terms that investors will readily understand.

Despite the fact that there is no common approach or policy concerning the development of wind power in the EU, in most EU Member States (MS) the establishment of wind farms involves an Environmental Impact Assessment (EIA) in compliance with Directive 2011/92/EU and in some MS – mandatory adherence to the international standards regarding wind turbines (IEC61400).

The ITS achieved the overall and specific objectives of the TA assignment that were related to the development of recommendations for the improvement of the investment climate and enhancing the capacity of the beneficiary on the legislative changes needed to facilitate the wind project development and investments.

1.3 Key Findings

1. The electricity supply in Georgia is dominated by hydro power. Despite the fact that the diversification of energy sources is one of the objectives of the Georgian Energy Policy, there is no urgent need or political desire to divert the focus from hydro power to wind energy, and subsequently no measures or plans in place to actively support or promote wind power in Georgia.
2. The requirements and procedures stipulated by the Georgian legislations for the development of RE projects are mainly focussed on hydro power. The current legislative framework also does not stipulate any methods, tools or standards to be applied in the investigations, analysis, design or construction of the wind power plants in Georgia.
3. The absence of specific requirements for wind power may lead to a high-value site being occupied for an extended period of time by developers that do not approach the development process in a professional and responsible manner. If not addressed, there is a risk that the available resources are not utilised in a way which serves the interests of the Georgian government and society.

1.4 Ownership and Benefits of the Activity

The main benefits of the activity for the Beneficiaries are:

1. The Georgian experts and decision makers improved their understanding on the applicability of the requirements of Environmental Impact Assessment (EIA) according to the Directive 2011/92/EU and international standards IEC 61400 while developing wind power projects.
2. The developed recommendations can be used by the GEDF to align the wind plants development process (investigations, surveys, studies, wind-measurement campaign etc.) with IEC 61400-22:2010 Standard "Conformity testing and certification". Annex 2 of this report can be also published on the web-site of the Ministry of Energy as a guideline for the potential wind project developers.

The Beneficiaries took ownership in the following way:

1. The Beneficiary and local stakeholders provided ITS with all requested information and necessary support during the preparation and implementation stages.
2. The beneficiary expressed interest in the introduction of IEC 61400 Standards into the Georgian legislation framework.

1.5 Recommendations

1. To Introduce the certification of the wind power project according to the IEC 61400-22:2010 Standard "Conformity testing and certification" as a part of the project development process in Georgia.
2. To adopt DNV-GL as an official guidance on interpretation and detailing of the IEC standard (DNVGL-SE-0073 Project certification of wind farms according to IEC 61400-22) for the evaluation of wind projects by the Ministry of Energy of Georgia.

3. To set criteria, thresholds or other conditions relevant to determine when, if and to which extent an Environmental Impact Assessment is required for wind power plant in Georgia. Align the EIA according to the requirements of the Directive 2011/92/EU.
4. To adopt Annex 2 of this report as a guideline on the development of the prefeasibility study according to Order № 40 for potential wind project developers.
5. Introduce additional requirements for the early stages development of wind project according to the recommendations outlined in Section 2.10 of this report.

1.6 Challenges Faced

The ITS experts did not face any challenges during the preparation and the implementation of the TA assignment, except the different interpretation of the requirements of Order № 40 between the representatives of the Ministry of Energy of Georgia and the beneficiary, the GEDF. The adoption of Annex 2 of this report as a guideline on the development of the prefeasibility study according to Order №v 40 for the potential wind project developers should resolve the identified challenged on different interpretation.

Table 1. Impact Matrix

Impact Area	Developments	2012 (%)*	Apr 2016 (%)*
Policy	*Diversification of energy sources through support for the development of wind projects*	0%	10%
Regulation	*Support for the implementation of IEC 61400 standards*	0%	5%
Technology	*Support of the development and utilisation of the modern wind power technologies*	5%	15%
Environment	*Introduction of the Environmental Impact Assessment according to the Directive 2011/92/EU as a part of wind project development process*	0%	15%
Economics	*Additional investments in wind projects*	0%	10%
Social	*Direct and indirect creation of jobs as a result of the development of wind projects*	5%	15%

* The impact is estimated based on the experts' opinion under the current circumstances and can be changed over time

2 PART 2 - BENEFICIARIES

2.1 Executive Summary

This report presents the results of the assignment "The formulation of the RE secondary legislative base and related procedures for facilitation of the future wind project development and investments, CWP.11.GE (AHEF.97.GE)" implemented by the EU funded INOGATE Technical Secretariat (ITS) project. The assignment was requested by the Georgian Energy Development Fund (GEDF) and was implemented during the period May 2015 - April 2016.

The main objective of this assignment was to improve investment climate for the implementation of wind power projects in Georgia and to contribute to the achievement of the following objectives of the Georgian Energy Policy:

- Diversification of energy sources;
- Decreasing the reliance on imported fuel and conventional thermal generation of power;
- Attraction of foreign investments;
- Expansion of international cooperation, especially towards the European Union.

The results of this assignment show that the requirements and process stipulated by the Georgian legislations for the development of Renewable Energy (RE) projects are mainly focussed on hydro power. The current legislative framework does not stipulate any methods, tools or standards to be applied in the investigations, analysis, design or construction of the wind power plants in Georgia. The absence of specific requirements may lead to a high-value site being occupied for an extended period of time by developers that do not approach the development process in a professional and responsible manner. If not addressed, there is a risk that the available resources are not utilised in a way which serves the interests of the Georgian government and society.

This assignment addresses the identified shortcomings of the Georgian legislative framework through the development of recommendations on the introduction of Environmental Impact Assessment (EIA) according to the Directive 2011/92/EU and IEC 61400 standards in the process of evaluation, design and construction of wind power plants in Georgia. This practice is universally accepted within the wind energy industry and the adherence to IEC 61400 standards is a legal requirement is some EU Member States.

This part of the report consists of the following sections and the pertaining annexes:

Sections 2.2 provides introduction for the development of viable wind projects and highlights the absence of common EU approach or policy concerning wind power in the EU. Each Member State has its own policies, legislation and regulations governing the development of wind power.

Sections 2.3 - 2.5 comprise the analysis of electricity supply, energy policy, key regulations and procedures in Georgia. The Georgian energy market can be characterised as rather liberal, with few regulatory limitations or requirements for the production and sale of electricity. The analysis results in Section 2.6 that summaries the issues and concerns related to the implementation of wind projects in Georgia.

Section 2.7 outlines the key objective for the regulatory set up, including the Environmental Impact Assessment (EIA) – in compliance with Directive 2011/92/EU, in order to ensure safe and reliable production of power during the whole operational life as well as financial and economic viability of all new wind plants to be constructed in Georgia.

Section 2.8 introduces the requirements of the International Electrotechnical Commission (IEC) 61400 Standards that all of the credible wind turbine suppliers are complied with. The division of wind turbine classes according to IEC61400-1 standard and list of IEC 61400 standards applicable for the scope of this assignment are presented in Annex 1.

Section 2.9 provides key recommendations for the early stage development of wind projects in Georgia and justifies the application of IEC 61400-22:2010 Standard "Conformity testing and certification" as one of the requirements for the pre-MoU pre-feasibility study. Annex 2 also provides recommendations on how to address each point of the pre-feasibility study according to Order №40.

Section 2.10 provides the recommendations for the introduction of additional requirements for the wind project developers at the Pre-MoU stage to improve the procedures according to the best EU practice.

2.2 Introduction

A wind power plant is a significant industrial facility, and developing a wind farm is a complex undertaking, involving many fields of expertise. Subsequently, defining the national rules and regulations and defining how a government can or should be involved, and manage the development of this industry is also a complex task.

From a regulatory point of view there is no common EU approach or policy concerning wind power in the EU. Each member state has its own policies, legislation and regulations governing how and to which extent wind power are included in its energy supply, according to the member state's political priorities, access to energy resources etc.

The development of a wind power plant – and the regulation relevant for this – may involve considerations concerning:

- Energy policy;
- Available energy resources;
- Wind resource;
- Environmental policy and legislation;
- Electricity networks;
- Building regulations;
- Structural design codes;
- Property law;
- Road transport regulations;
- Work safety regulations;
- Electricity demand vs. supply.

It is not realistic to cover all issues which may be relevant in the context of this task. The priority has been given to dealing with wind power-specific issues, and less on general issues, e.g. environmental, planning, financial and legal matters, which typically would concern any industrial or investment project.

2.3 Electricity supply in Georgia

The electricity supply in Georgia is dominated by hydro power followed by thermal (coal/gas fired) generation, with approximately an 80/20 split.

The potential for further development of hydro power is understood to be abundant, with only approximately 20% of the available potential being utilised. The cost of establishing new hydro power plants is expected to increase, as the sites which are easiest to develop or most productive are being utilised, leaving sites with increasingly difficult conditions to be developed.

Nevertheless, hydro power cannot currently meet the demand during the winter months when reservoir levels and flow rates in the rivers are low (see Figures 1 and 2). The deficit is made up partly by increasing thermal generation and by import of electricity from neighbouring countries (Russia, Armenia, Azerbaijan and Turkey).

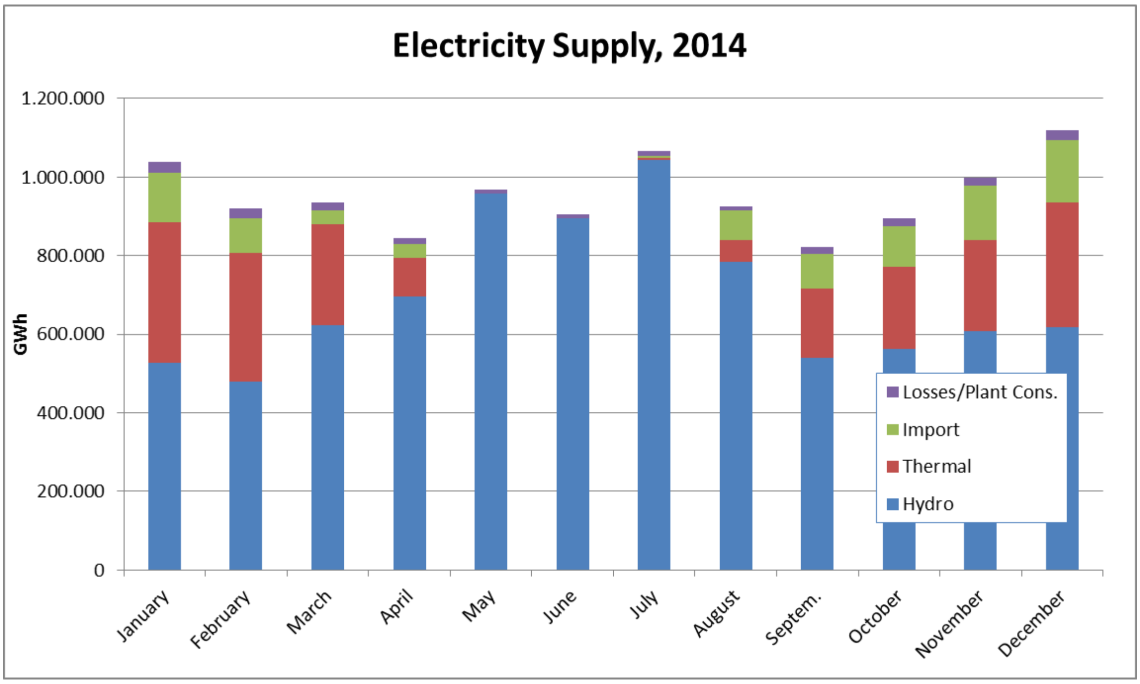

Figure 1: Electricity supply sources in Georgia (monthly), 2014 (ESCO Energy Balance)

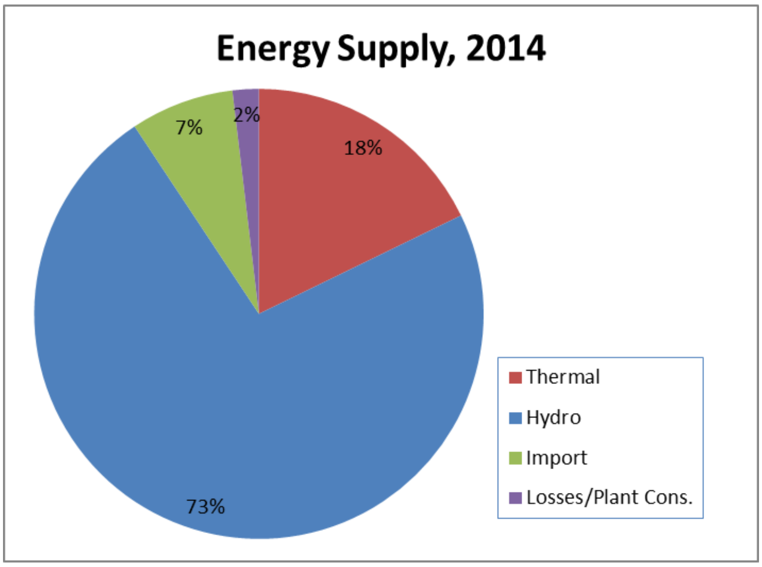

Figure 2: Electricity supply sources (annual), 2014 (ESCO Energy Balance)

Wind energy appears to be well suited as a supplement to the hydro power. Figure 3 shows the indexed wind speed for the central parts of Georgia. The wind speed is up to approximately 20% higher during the winter months than during the summer. The spread in terms of potential electricity production will be significantly larger (as will be explained in Annex 2 of this report).

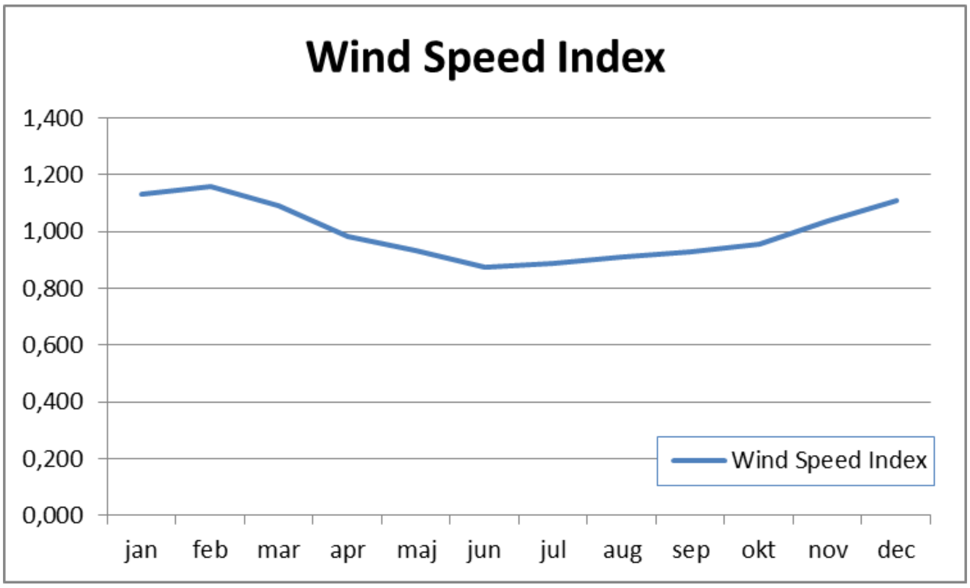

Figure 3: Wind Speed index, Central Georgia (From IRENA Global Atlas)

2.4 Energy policy

The Georgian core national energy policy directions include:

- Diversification of supply sources, optimal utilisation of local resources and reserves;
- Utilisation of Georgia's renewable energy resources;

- Gradual approximation of Georgia's legislative and regulatory framework with the EU's Energy acquis;
- Energy market development and improvement of energy trading mechanism;
- Georgia – regional platform for generation and trade of clean energy;
- Develop and implement an integrated approach to energy efficiency in Georgia;
- Taking into consideration environmental components in the implementation of the energy projects;
- Improving service quality and protection of consumer interests.

The first two policy direction points indicate a desire to reduce the reliance on imports – fuel (oil, gas, coal) and electricity. The abundance of the hydro power potential and the experience with the development, construction and operation of hydro power plants means that the energy policy, regulation, administrative practices – and the technical capabilities the energy administration – is largely focused on hydro power.

There is no urgent need or political desire to divert the focus from hydro power to wind energy, and subsequently no measures or plans in place to actively support or promote wind power in Georgia.

The energy market is rather liberal, with few regulatory limitations or requirements for the production and sale of electricity. This is a deliberate policy and understood to be instated to – as far as possible – let the market forces rule the electricity market.

Independent power producers, mostly operating smaller hydro power plants, are numerous. The primary incentive for establishing small hydro power plant is the prospect of either exporting power to Turkey, which typically has higher electricity prices than Georgia or to sell it to a distribution company or an industrial end-user.

2.5 Key regulations and procedures

There are two processes which can lead to an entity qualifying to develop and operate a power plant in Georgia:

- For a project/site which is identified by the Ministry of Energy, the "Decree # 214"[1] applies;
- For a project/site selected by the applicant, the "Order 40"[2] applies.

The key difference is that according to Decree # 214, it is required that a pre-construction guarantee must be provided by the applicant during the process - to motivate the applicant to complete the construction according to the envisaged time schedule.

[1] Government Decree No 214 of August 21, 2013 "on Approval of the rule of expressing interest in technical and economic study of the construction, ownership and operation of the power plants in Georgia" (unofficial translation).

[2] Order No 40 of the Minister of Energy of Georgia of 10 April 2014 "on Approval of the terms and conditions for submission and review of the proposals about construction technical and economic feasibility study, construction, ownership and operation of those hydro power plants to the Ministry of Energy of Georgia, which are not included in the Potential Power Plants in Georgia".

The hydro power projects/sites which are listed by the Ministry of Energy (MoE) have been identified by a study conducted by USAID, by which more than 90 sites/projects were pinpointed – with potential capacities up to more than 700MW. For these projects, the basic site scouting and feasibility evaluation has been done and the information is publicly available.

At this point in time, only potential hydro power projects are listed by the Ministry of Energy, and subsequently, the Order 40- process applies to all and any wind power projects in Georgia.

Irrespective of the approach (Order 40 or Decree 214) the Ministry of Energy is the primary point of contact for the applicant – and a Memorandum of Understanding (MoU) between the applicant and the Ministry must be concluded.

As part of the application for the Memorandum of Understanding the applicant must submit a ***Pre-feasibility study***, comprising:

m) Sites and main parameters of the object;
n) Topographical Map of the territory of potential construction object (scale: 25000);
o) Brief geological data and geological map of the site of the object (on the basis of the materials protected in the fund);
p) Seismic data and seismic map of the site of the object;
q) Wind observation data;
r) Energy model (about approximate generation);
s) Initial Environment Impact Assessment;
t) Presumable scheme of connection to network and the possibility of network to receive generated electro energy;
u) Information about infrastructure (Existing and under construction roads should be marked on topographic maps indicating the approximate distance);
v) Approximate estimate;
w) Economic report (economic analysis of the project, which includes the duration of the investment and the credit rate);
x) Financial Analysis (financial model) according to Article 2 of Order# 40.

Provided that the MoE considers that the submitted information is satisfactory, a MoU between the MoE and the applicant can be concluded. The Memorandum of Understanding grants the applicant the exclusive rights to develop a wind power project at the site – within a specified time frame.

Further, the MoU will specify:

- A time schedule for the completion of the feasibility study;
- Progress reporting schedule (typically quarterly);
- A stipulation that 20% of the production is to be sold to the JSC "Electricity System Commercial Operator" (ESCO), during the winter months where there is a deficit (the typical price paid is approx. 4 – 5.5 €c.).

If the applicant's feasibility study indicates that the project is feasible, the MoE will assist by facilitating the necessary permits, rights and access to the relevant land area. It is the stated policy of the Georgian Ministry of Energy to be as open and flexible as possible to encourage potential developers, investors etc. to get involved.

2.6 Issues and concerns with the current process

It is evident that the requirements and process stipulated by the Order 40 are focussed on hydro power projects. The Order 40 does comprise a separate section addressing wind projects; however, this is largely a copy of the section dealing with hydro power projects.

As neither section comprises any detailed requirements regarding the methods, tools or standards to be applied in the investigations, analysis, design or construction of the power plants, it is not clear from this document how and which criteria are used in the MoE's evaluation of and application.

The absence of specific requirements may lead to a high-value site being occupied for an extended period of time by a developer who for whatever reason does no approach the development process in a professional and responsible manner. The consequence of a sub-standard development process may be that, either that the project is not implemented or, if implemented, result in a wind farm which does not utilise the wind energy resource in an optimal way or in the extreme case, be structurally or mechanically unsafe.

It is the impression that the current Georgian practices relevant for the development and construction of a wind power plant does not adequately account for the issues which are in fact relevant for such a facility. If not addressed, there is a risk that the available resource is not utilised in a way which serves the interests of the government and Georgian public.

2.7 Objective of the regulatory set-up

As mentioned, a wind power plant will involve a wide range of technical, environmental and financial issues – and not all of them can be addressed in this study. However, there are certain issues which are of key importance for the development and implementation of wind power plants in a responsible way.

In order to recommend and provide advise on how a wind power project should be developed as seen from a governmental and regulatory point of view, it is necessary to define which reasonable expectations and requirements can be made of the end-product of the development process; the complete and operational wind power plant.

It must be assumed that if wind power plants are to be established in Georgia, they are to be:

- **state-of-the-art facilities**;
- which are **safe and reliable**;
- which, with reasonable maintenance and monitoring can and will **produce power** during their operational life**;**
- which can pass a **Due Diligence** evaluation by financial institutions, and
- which **can be financed and insured** according to current practices.

For a wind power plant this basically means that the complete facility must be - if not actually certified then at least - certifiable according to the IEC 61400 – 22-standard (See Section 2.8 and Annex 1 for more details). In practice, there is no better way of ensuring certifiability than actually going through the certification process, and therefore it is a clear recommendation that a wind power project should be required to be certified.

To a large extent, this includes most technical issues: structural, mechanical, electrical, transport, installation, commissioning as well as, but not always necessarily, the requirements to the technical development process.

If we follow the current Georgian process, in which the MoE grants a developer the rights to develop a WPP at a given site during a period of time, this means that at the end of the development process, the MoE should require that the developer submits a Certificate of Conformity or Statement of Compliance, issued by a qualified certification agency, concerning the investigations, surveys, measurements and studies on which the detailed engineering and design is to be based.

Further, prior to issuing a construction permit, the MoE (or whichever authority is responsible) should require that a Certificate of Conformity is submitted concerning the detailed engineering and design work undertaken prior to the actual construction of the wind power plant.

Finally, it should be required that prior to powering up the wind power plant, a Certificate of Conformity on the manufacturing, transport, construction and installation, commissioning work is submitted.

Requiring that a wind power project is certifiable or certified is a part of the requirement in several European countries. However, the certification process only covers the technical matters related to the development, construction, etc.

A certified wind project does not necessarily utilise the site, area and wind resource in an optimal way or provide the best possible return on the investment. Nevertheless, by requiring that a developer must provide a certified project, which meets current international technical standards, the project – even prior to the actual construction – represents a considerable investment in time and money, which the developer is keen to recover. It can be assumed that the need to recover the investment will encourage and motivate the developer to design his project in a way that it is not only technically sound but also financially optimal.

Further, the scope of the IEC 61400 - 22 does not include environmental and social impact. In European legislation (specifically Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment)[3] it is up to the member states to determine if and how a wind power plant is subject to an Environmental Impact Assessment.[4]

In most EU member states the establishment of a wind farm or in some cases even an individual wind turbine will often involve an Environmental Impact Assessment (EIA) – in compliance with Directive 2011/92/EU.

A wind turbine/wind farm is a so-called Annex II-project, for which the Member State shall "determine whether the project shall be made subject to an assessment". Subsequently an EIA is not obligatory for wind power projects according to the Directive, but the Member State shall determine if or not an EIA is required by either a case-by-case examination or by evaluating it against thresholds or criteria – which the Member State must define.

[3] Commonly referred to as the Environmental Impact Assessment (EIA) Directive.

[4] Article 4(2) and Annex II of Directive 2011/92/EU.

In any case, the developer of a wind project must apply for a planning permission, and the application must comprise sufficient information to allow the relevant authorities to evaluate whether or not an environmental impact assessment is required.

Part of the EIA considerations are an obligation to inform those affected or representing interests affected by the project of the plans and to give them an opportunity to comment or – which is quite common – to object to the project or aspects of it. This typically involves neighbours, nature preservation societies, industrial interest such as tourism, farming etc.

Even if an environmental and social impact assessment does not directly contribute to the technical or financial performance of a wind power project, such assessment are typically a precondition for obtaining financing from the international financial institutions such as EBRD, IFC, EIB, World Bank etc. and from several commercial banks as well. The mentioned international finance institutions have published guidelines and procedures to be followed.

Environmental Impact is a high priority issue in European and international policies and regulations, not least with regard to energy. The EIA directive is part of EU's Energy acquis, towards which a "gradual approximation" is part of Georgia's stated energy policy objectives[5].

It is therefore recommended that a set of criteria, thresholds or other conditions (ref. Directive 2011/92/EU) relevant to determine when, if and to which extent an Environmental Impact Assessment is required for a wind power plant.

To sum up, the recommendations included in this study are made under the assumption that wind power plants established in Georgia are to be:

- State-of-the-Art- facilities, project certified according to IEC 61400 – 22;
- Very likely subject to an Environmental Impact Assessment according to Directive 2011/92/EU and/or environmental guidelines of the financial institutions involved.

2.8 Standards within the wind energy industry

Wind power is a global industry, and turbine manufacturers, mainly from Europe, Asia and North America are operating on a global scale. The vast majority of the manufacturers provide "utility scale" (as opposed to smaller "house-hold scale") wind turbines, design and install wind power plants in accordance with a well-established set of norms and standards.

2.8.1 Wind turbine design

The key standard is the International Electrotechnical Commission; IEC 61400 - 1 "Wind Turbines – Design Requirements". In IEC61400-1 the design requirements and design input data are specified. The specifications refer to other international standards for engineering and design such as ISO 2394 (General principles on reliability for structures) – and are as such linked to an extensive complex of international engineering standards and national codes.

[5] According to Georgia's application for the full membership in the Energy Community submitted to the Energy Community Secretariat in 2012

IEC61400-1 divides wind turbines into classes dependent on the range of wind speed and turbulence it is designed to withstand. In addition to the design requirements, the IEC 61400-complex includes standard for a wide range of wind power engineering. Annex 1 illustrates the division of wind turbine classes and provides the list of applicable IEC 61400 complex standards.

The IEC 61400 standards are in practice universally accepted within the wind energy industry, and all serious and credible turbine suppliers complies with the IEC standards. In order to ensure that a wind project is developed, engineered and built responsibly, safely and according to the current state-of-the art, the IEC 61400 standards must be adhered to – and this is indeed a legal requirement in several European countries.

2.8.2 Wind Power Project Certification

IEC 61400-22:2010 on “Conformity testing and certification” should be of special interest.

The project certification process involves that the project developer - as early as possible in the process - selects a certification agency, which will monitor and review the process and associated documentation, and for some processes, make independent analyses and engineering calculations.

The process requires that the important process in the technical project development, data collection, manufacturing, construction, commissioning programme is planned, designed, carried out, verified and documented to ensure that the resulting wind farm conforms to the required standard.

On the European and international market, there are numerous agencies accredited to perform such certification, such as: DNV-GL, TÜV, Bureau Veritas, ABS, SGS, etc. The standard concerns the certification of a wind power project, including:

- site conditions evaluation;
- design basis evaluation;
- integrated load analysis;
- site-specific wind turbine/RNA design evaluation;
- support structure design evaluation;
- other installations design evaluation;
- wind turbine/ Rotor-Nacelle Assembly (RNA) manufacturing surveillance;
- support structure manufacturing surveillance;
- other installations manufacturing surveillance;
- project characteristics measurements;
- transportation and installation surveillance;
- commissioning surveillance;
- final evaluation; and
- operation and maintenance surveillance.

A precondition for the project certification is that the turbine used is type certified (for on-shore turbines, this would be according to IEC 61400-1) and the project certification is done to ensure that the turbine, foundation etc. is certified – i.e. is designed to operate at the conditions (wind conditions, soil conditions, grid code etc.) found at the site.

The certification agencies are to interpret the IEC standard in accordance with the local regulations (such as building codes, grid code etc.) and the client's requirements.

DNV-GL (one of the accreditation agencies) has published its general interpretation and detailing of the IEC standard (DNVGL-SE-0073 Project certification of wind farms according to IEC 61400-22) which is widely recognized within the wind power industry, being more specific, detailed and process–oriented.

Thus, it recommended to incorporate the IEC 61400 – 22 certification standard as a requirement to wind power projects - and to consider to accept the guidance given by DNV-GL, as this has several advantages:

- **It is the de-facto current standard and practice within the wind power industry** (all competent suppliers, contractors and service providers know and understand the practices and procedures. They will know what is required from them in terms of delivery standards, testing and documentation);

- **It is known and understood by international wind power developers** (the IEC standards are well known by the international wind power developers, as virtually all wind power projects in Europe and worldwide are designed according to this);

- **It is well known and accepted by the financial institutions** (makes the uncertainties and risks manageable and understandable by investors, banks, buyers, lenders, insurers etc.

- **It is implemented as a legal requirement in several European countries** (by implementing IEC 61400 – 22 in the regulatory requirements which a wind farms have to comply with, alignment with European practices is achieved).

- **It provides a "plug-and-play" standard** against which the progress of a development process, which can be monitored and enforced by the responsible national authorities.

2.8.3 Shortcomings

In the context of the Georgian regulations with regard to the development of wind power plants, the IEC 61400-complex is not perfect and does not provide an answer to all questions.

There is no standard or norms for pre-feasibility studies, and there is currently no specific norm or standard for wind resource assessment. IEC 61400 – 1 specifies wind data required for the turbine design – from a structural integrity (and type certification) point of view, but not how to collect and process wind data in order to estimate the production which can be achieved by the turbine or by a wind farm.

However, in our understanding, IEC is currently working on this, and IEC 61400-15 on "Assessment of Wind Resource, Energy Yield and Site Suitability input conditions for wind power plants" is currently being prepared.[6]

6

Until then, there are several guidelines and best practice processes published by various sources such as (in no particular order):

- Evaluation of Site Specific Wind Conditions, Measnet, 2009
- Wind Resource Assessment Handbook , AWS Truepower for New York State Energy Research and Development Authority, 2010
- Guidelines for Wind Resource Assessment: Best Practices for Countries Initiating Wind Development, Asian Development Bank, 2014

It must be mentioned that in order to be considered valid, a bankable wind resource assessment requires a minimum of one full year of on-site wind measurements, supplemented by long term measurements from nearby permanent meteorological stations.

2.9 Recommendations for early stage development

For the developer, the primary purpose of the development process is to collect and process information necessary to make an informed decision as to whether or not the project is viable, technically, financially, legally etc. In the earlier stages, the development activities are focussed on investigating the viability of the project, and then to collect data required for the planning and design, and as the process progresses, the focus typically shifts to activities solving the problems and challenges which such a process inevitably meets.

The project developer must be assumed to have a fundamental interest in collecting and processing information which increases the understanding of all issues which impact the viability of the project – and at later stages, to be able to plan, design, build and operate the project.

From the point of view of the government and authorities which are responsible for the licencing and permitting process, it must be assumed that the purpose of their involvement is to ensure that the fundamental interests of the public are taken into account. The public interests must be assumed to be reflected in the policies, laws and regulations which the authorities institute and enforce.

In the case of wind energy in Georgia the situation appears to be that – as no wind energy project has been fully developed or built – there is very little concrete experience with the development of wind power projects on the part of the potential Georgian developers or on the part of the authorities.

This implies that there is a risk that those who might be interested in developing a wind energy project do not necessarily have the knowledge required to conduct the development process in an appropriate way. On the part of the authorities this means that they, even though they know and fully understand the policies, laws and regulation they work to enforce, may not necessarily possess the know-how to enforce these in the context of a wind energy project.

It is evident that the implementation of wind energy does not have a high priority in the context of Georgian energy policy, as there are other sources that are possibly easier and perhaps less costly to

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http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_LANG_ID,FSP_PROJECT:1282,23,25,IEC%2061400-15%20Ed.%201.0

utilise. However, there seem to be very favourable wind conditions and suitable areas available, both factors which should make it attractive to develop wind energy – if not now then perhaps later when/if the "low hanging fruits" within hydro power have been exploited.

The current practice, of granting a developer exclusive rights to develop a site for a period of time, is fair to the developer who is to invest resources in the developing the site or project. However, it should also be ensured that the exclusive rights are granted only to applicants who have the capability of developing the site in a responsible way. If not the site is blocked for at least the time in which the exclusive development rights are in force.

To facilitate this it is recommended that:

- The requirements to the pre-MoU pre-feasibility study is further qualified.
- The applicant is required to describe the development process (investigations, surveys, studies, wind-measurement campaign etc.) to be included in the MoU-obligations, and that these are aligned with IEC 61400 – 22.
- The criteria applied in the evaluation of the application/feasibility study are defined.

2.9.1 Pre-feasibility study

The life-cycle of a wind power project is typically divided into the following stages:

- **Site scouting or prospecting**, during which areas and sites with a potential are identified;
- **Pre-feasibility stage**, during which the potential site is subject to an preliminary evaluation, primarily as a desk-top study, with limited site-specific data;
- **Feasibility stage**, in which site surveys, investigation, wind measurements, preliminary engineering studies are made;
- **Design and planning stage**, during which the contracting, design, planning, permitting is undertaken;
- C**onstruction, installation and commissioning stage,** during which the facility is built, connection to the electricity network is made and powered up;
- **Operational stage** in which the wind power plant operates and produces power;
- **Decommissioning stage** at which the WPP has reached the end of its technical life and is dismantled.

Up to and including the design and planning stage, the project is under development, as the stages involve investigations and studies which may result in the project being found to be not feasible.

Before taking a project from one stage to the next, the developer must evaluate the information collected during the preceding stage, and decide if the project is still viable, technically and financially. Subsequently, the developer's willingness to commit resources to a project is relatively low in the early stages, as the uncertainties are very high - but as more information is collected and processed, the project characteristics and associated risks are progressively better understood, and – provided that the indication still points to a viable project – the willingness to invest in the development also increases.

Figure 4 shows that there is, to a large extent, reasonable alignment between the Order 40-process and the typical WPP development process.

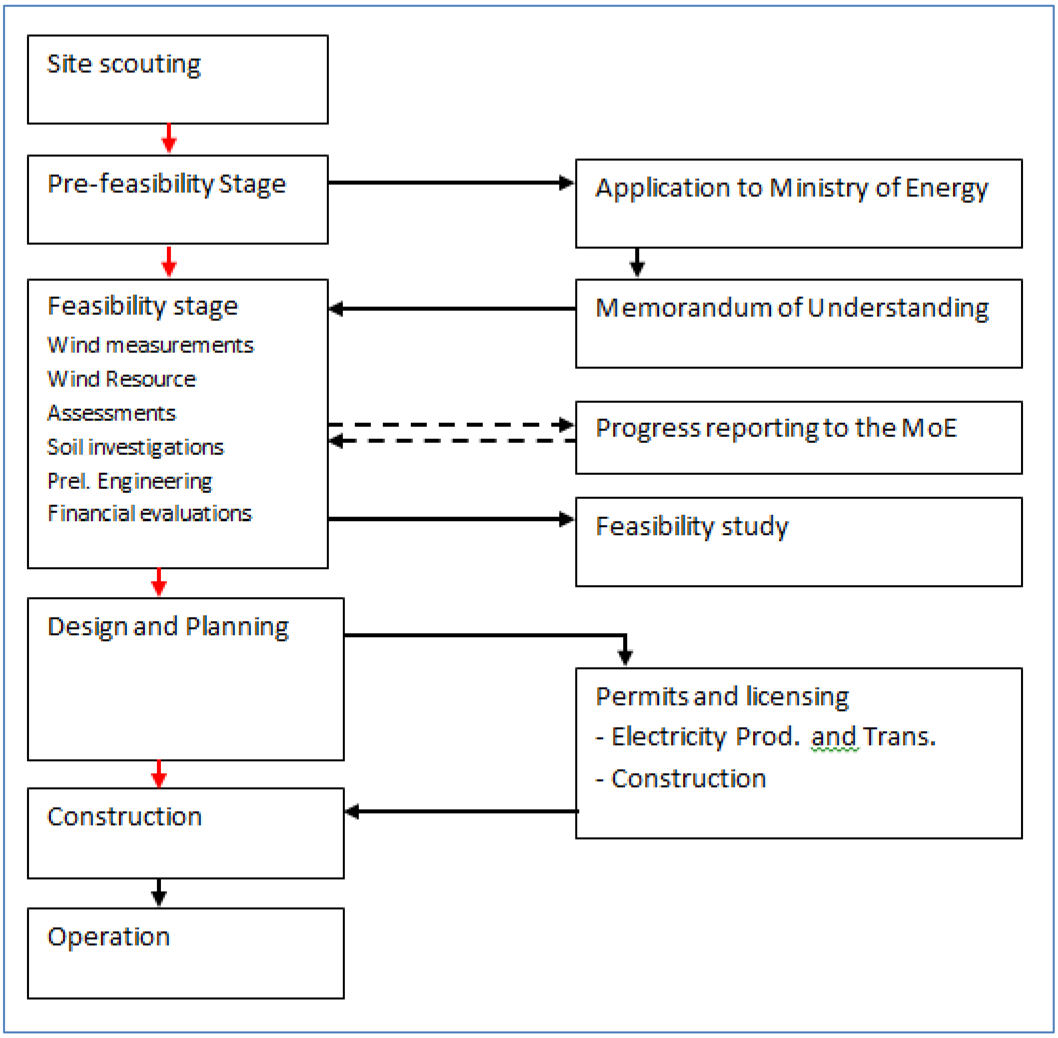

Figure 4. Development stages according to Order#40 process

However, the ways and means according to which the MoE evaluates the application and eventually the feasibility study are not very clear. In previous sections it has been suggested that the MoE requires that a certification process is followed – but that will only be relevant from the Feasibility stage and onwards.

It is important that all concerned – the developer and the MoE and other parties involved, understands that, with the information, tools and methods available at the prefeasibility stage, it is not realistic to make anything but very basic estimations on the feasibility of a project, profitability of the investment as the uncertainties are significant. The wind data and the perspective production figures may have an uncertainty of +/- 30%. On the construction side, it is difficult to price such a project with an accuracy of less than +/- 50% without fairly comprehensive engineering studies to back it up.

The developer should determine his own criteria for deciding if a potential project is worth pursuing, and this would typically involve a basic estimation of:

- Development and construction costs;
- Operation and maintenance costs;
- Estimated power production;
- Expected selling price.

Based on this a basic calculation of payback-time, NPV, IRR and other financial key figures can be made. It is possible – and frequently seen – to make a significantly more detailed financial modelling exercise in a pre-feasibility study. But the basic input parameters which are available at this stage are typically highly uncertain and rarely warrants more than the most basic rules-of-thumb estimations.

2.9.2 Suggested Methodology

There is no generally accepted standard for the preparation of a pre-feasibility study for a wind energy project. Following the above process, the purpose of a pre-feasibility study is to evaluate the site/project in order to determine if or not it show sufficient promise to justify further, more time consuming and costly studies.

As part of the application for the rights to develop a wind power project, the applicant is required to provide a prefeasibility study. A pre-feasibility study is typically understood to be largely a desk study with no or only limited on-site data collection or investigations required.

On the face of it the overall requirements to the pre-feasibility study, as requested by Order No 40, are largely reasonable – but only stated in headline form, with very limited guidance, specific requirements or qualifications of the information to be provided. Annex 2 provides interpretation of the information required by the MoE as well as suggestions as to how the each point could be qualified further – based on commonly used methods and tools.

2.10 Recommended procedures

2.10.1 Pre-MoU application

In general, the public interest in the wind power project, and the issues which the MoE has valid reasons for the applicant to submit at the early stage – is assumed to be as listed below:

- Location and extent of the site (not least as the site is likely to be on public lands);
- Size and number of turbines, capacity;
- Access route to and capacity of grid connection point;
- Existing roads, required access roads;
- Benefits to the public, such as:
  - Power production potential, and due to the supply/demand situation in Georgia, the monthly distribution of the annual production;
  - Social benefits, such as jobs, economic activity in the area;
- Preliminary Environmental Impact Assessment/Screening.

Further, the above must be assumed to be reasonable issues which an applicant can be expected to investigate and consider prior submitting an application, and not overly critical “business sensitive information".

2.10.2 Additional requirements

In addition to the above, it is recommended that the information below is required to be submitted prior to exclusive development rights are granted:

- Time schedule for the development process
- Initial Specification of Development programme, including:
    - Wind measurement campaign (see suggested guidelines in Section 2.8.3);
    - Topographical survey/study (covering site and surroundings);
    - Geophysical Survey (covering site and connection route);
    - Geotechnical investigations/laboratory tests (covering site and connection route);
    - Project Design Basis ;
    - Grid connection study;
    - Transportation Study;
    - Conceptual engineering studies;
    - Technical Project Description (see the description of IEC 61400-22 and DNVGL-SE-0073 in Section 2.8.2 for further details);
    - Statements of Compliances to be submitted;
- Capability statement of (preliminary) organisation; staff, engineering consultants and contractors, certification agency.

The above list includes only deliverables which the responsible authority (MoE) is expected to have a valid interest in, for the purpose of licencing and permitting and in order to monitor progress of the development process.

The MoE should be prepared to accept it if the applicant plans to start out with preliminary surveys/investigations, e.g. a preliminary, short term wind measurement campaign or a few geotechnical tests etc. prior to committing to a full-blown measurement campaign or more extensive geotechnical investigations. The process should allow the applicant to cancel the MoU, if the developer during the development process comes to realize that the project is not viable.

Further, it cannot be expected that the applicant has a fully developed resource organisation in place at this early stage, but key technical capabilities for the initial phase should be in place. The MoE should however, require that the applicant states which resources/capabilities are secured, and which will be procured/secured at a specified later stage.

The purpose of the specifications and time schedule required at this stage is not necessarily to force the applicant to commit to a rigid development programme and schedule extending over several years. The intention is to ensure that the applicant understands what is required to develop a wind farm and that he either has or knows how to get the relevant resources and capabilities involved in the project.

Further, it is recommended that the Ministry of Energy ensures that the technical capabilities relevant for the evaluation of applications, and for the review of progress reports, specifications etc. are in fact available, either internally or by employing qualified external resources.

When the project approaches the design stage, the MoE should consider requiring that the developer submits Statements of Compliance from the certification agency involved. This will secure that the resources and capabilities to follow and review the process are available. The alternative is to simply require that the project design is certified and that the Statement of Compliance is submitted prior to a construction permit being granted. The latter may require less input on the part of the MoE, but with a higher risk of the project running off-track without the active monitoring.

2.10.3 Other issues

In general it is understood that the processes, regulations etc. are aimed at WPP (and hydro power projects) which are to be built on public land, and that a MoU will not only give the applicant the rights to develop the project, but also transfer the ownership of the land area to the applicant.

Wind power plants do require a sizable area and the rights to use the area for this purpose is of course an important incentive. However, the profitability of the wind power project may be severely affected, if a second wind power project is developed on an adjacent or near-by location. The impact of a wind power plant on the wind can be felt a considerable distance away, as can the impact of other structures. Figure 5 illustrates an example of such situation in Denmark.

Figure 5: Wind turbine near Copenhagen – next to a high-rise hotel built several years after the turbine was installed. The hotel is actually considerably taller that the turbine.

There is no obvious response to the issue, but a developer would most likely be frustrated if something was later developed, which affected the operation and profitability of his project. Therefore the good planning should mitigate such situation in Georgia.

Annex 1. The division of wind turbine classes and wind power engineering issues according to IEC61400 standards

Wind turbine class		I	II	III	S
V_{ref}	(m/s)	50	42,5	37,5	Values specified by the designer
A	I_{ref} (-)	0,16			
B	I_{ref} (-)	0,14			
C	I_{ref} (-)	0,12			

V_{ref} is the reference wind speed average over 10 min,
A designates the category for higher turbulence characteristics,
B designates the category for medium turbulence characteristics,
C designates the category for lower turbulence characteristics and
I_{ref} is the expected value of the turbulence intensity[2] at 15 m/s.

In IEC61400-1 the wind data on which the design is to be based is specified in detail:

- the extreme 10-min average wind speed at hub height with a recurrence period of 50 years;
- wind speed probability density function $p(V_{hub})$ in the range of V_{in} to V_{out};
- ambient turbulence standard deviation σˆ (estimated as the mean value of the standard
- deviation of the longitudinal component13) and the standard deviation ˆσ σ of σˆ at V_{hub}

between Vin and V_{out} and V_{hub} equal to V_{ref};

- flow inclination;
- wind shear;
- air density.

The IEC 61400 specifies a number of Design Load Cases (DLC) comprising a number of events and combinations of operating conditions which must be analysed to ensure that the turbine can withstand the operating conditions. The above data is key input in these Load Cases.

Of course, a wind turbine is rarely designed for a specific project. In most cases, a standard production turbine is selected, based on the conditions at the site. However, in order to evaluate the site conditions, the above wind data is required. It is therefore very important that the wind measurement campaign is carried out in a way that it is ensured that the data collected is representative of the actual conditions.

In addition to the design requirements, the IEC 61400-complex includes standard for a wide range of wind power engineering issues such as:

- IEC 61400-1: 2005 Part 1: Design requirements
- IEC 61400-2:2013 Part 2: Small wind turbines
- IEC 61400-3:2009 Part 3: Design requirements for offshore wind turbines
- IEC 61400-4:2012 Part 4: Design requirements for wind turbine gearboxes
- IEC 61400-11:2012 Part 11: Acoustic noise measurement techniques
- IEC 61400-12-1:2005 Part 12-1: Power performance measurements of electricity producing wind

turbines

- IEC 61400-12-2:2013 Part 12-2: Power performance of electricity-producing wind turbines based on nacelle anemometry
- IEC TS 61400-13:2001 Wind turbine generator systems - Part 13: Measurement of mechanical loads
- IEC TS 61400-14:2005 Part 14: Declaration of apparent sound power level and tonality values
- IEC 61400-21:2008 Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
- IEC 61400-22:2010 Part 22: Conformity testing and certification
- IEC 61400-23:2014 Part 23: Full-scale structural testing of rotor blades
- IEC 61400-24:2010 Part 24: Lightning protection
- IEC 61400-25-1:2006 Part 25-1: Communications for monitoring and control of wind power plants - Overall description of principles and models
- IEC 61400-25-2:2015 Part 25-2: Communications for monitoring and control of wind power plants - Information models
- IEC 61400-25-3:2015 Part 25-3: Communications for monitoring and control of wind power plants - Information exchange models
- IEC 61400-25-4:2008 Part 25-4: Communications for monitoring and control of wind power plants - Mapping to communication profile
- IEC 61400-25-5:2006 Part 25-5: Communications for monitoring and control of wind power plants - Conformance testing
- IEC 61400-25-6:2010 Part 25-6: Communications for monitoring and control of wind power plants - Logical node classes and data classes for condition monitoring
- IEC TS 61400-26-1:2011 Part 26-1: Time-based availability for wind turbine generating systems
- IEC TS 61400-26-2:2014 Part 26-2: Production-based availability for wind turbines
- IEC 61400-27-1:2015 Part 27-1: Electrical simulation models - Wind turbines

Annex 2. Recommendations on the qualification of requirements for the pre-feasibility study according to Order No 40

m) Sites and main parameters of the object

Information must be provided on the location and extent of the site as geographical coordinates. If the site in question is limited by geographical features such as rivers, lakes, ridges, ravines, roads etc. the site borders can be described as "extends to the western bank of XYZ", otherwise, the extent must be specified as geographical coordinates and the reference system and datum must be included.

n) Topographical Map of the territory of potential construction object (scale: 25000)

The requirement for a topographical map makes good sense. In a mountainous area, the topography is a key factor for the layout of the wind farm. By taking advantage of the site topography, ridges and slopes, a significant advantage in terms of power production can be achieved. It is also important to have understanding of the topography as steep slopes and inclines may make it difficult to actually build the wind farm.

Topographical data can be obtained from various sources including online databases. It is typically also accessible through the tools mentioned in the wind data section below (Figure 6).

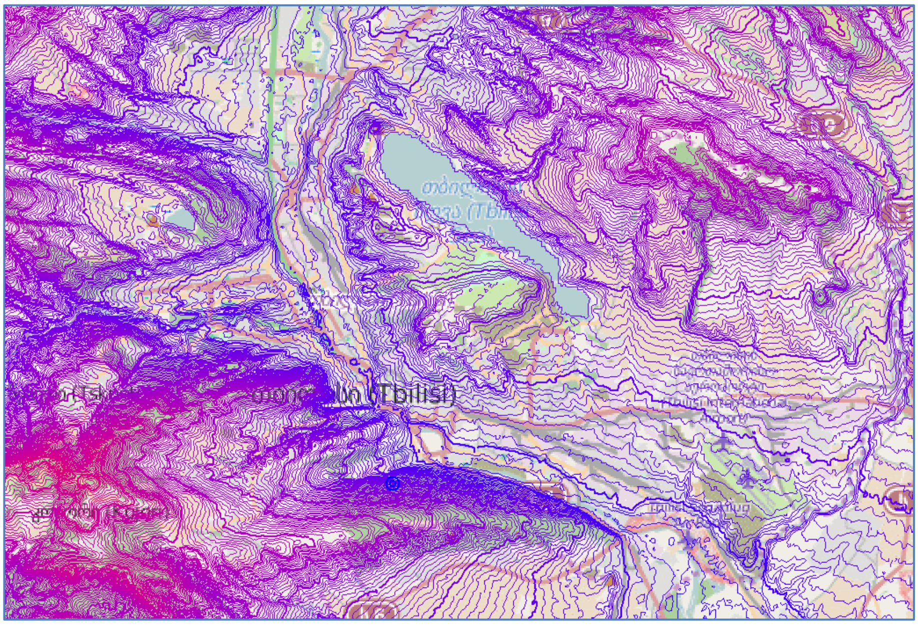

Figure 6: Topographical contour lines overlying Open Street map of Tbilisi (Contour lines from Radar Topography Mission (SRTM), accessed using WindPro software)

o) Brief geological data and geological map of the site of the object (on the basis of the materials protected in the fund)

Geological information is relevant for the development of a wind power plant primarily in terms of having an understanding of the upper soil or rock strata and their geotechnical properties in order to engineer and design the foundations for the turbines – and the access roads needed to construct the wind farm and to service it during operation.

Understanding of the geotechnical properties of the soil/rock will be required for the design of the turbine and mast foundation. In a pre-feasibility study it would be advisable to require some form of site assessment and possibly investigations of the ground conditions by a geotechnical engineering specialist.

p) Seismic data and seismic map of the site of the object

It is our understanding that much of Georgia is subject to significant seismic activity. The relevant design standard (IEC 61400 - 1) describes how to account for seismic loading when designing (or compliance checking) a wind turbine structure.

In a pre-feasibility study it is most likely not reasonable to expect that design or compliance checks of turbine structures is undertaken.

From the point of view of the public interest it may be worth noting that the consequences of the catastrophic failure of one or more wind turbines due to an earthquake is relatively modest, especially when compared to the potential consequences of a catastrophic failure of a dam/hydro power installation.

q) Wind observation data

Information on the wind conditions is **the key** requirement for the development of a wind power plant.

The wind condition at the site will determine the production which can be achieved, the type of turbines which can be used, where and how many turbines can be placed within the site boundaries.

For the purposes of a pre-feasibility study – where a preliminary desk-top-type study of the wind conditions must be assumed to suffice, there are several option to obtain wind data:

- Existing, permanent meteorological stations. However, data available from such station are often not very useful for wind power planning;
- Web-based commercial tools as offered by AWS Truepower and 3Tier/Vaisala;
- The RESMAP tool[7] developed within ITS project for the GEDF. The advantages of the tool is that it provides not only wind data, but important information on the economically viable wind resource in terms that investors will readily understand (Figure 7)
- The freely available and recently released Global Wind Atlas by the International Renewable Energy Agency (IRENA) (Figure 8);
- Data accessible through wind resource analysis software such as WindPro, Windfarmer and possibly others (Figure 9).

These data providers rely primarily on historical, recalculated datasets. The spatial resolution between data points may be rather coarse, however, sufficient for site prospecting or scouting.

[7] http://gedf.maps.arcgis.com/apps/MapJournal/index.html?appid=c5cd39fef9184bee8590596cc093520a

Wind data is typically given as wind speed (m/s) and direction (either in degrees or N, NE, E, SE, S, SW, W, NW) at a given elevation (e.g. 50m, 100m or 200m) over the terrain, and may be given as a time series on an daily, 6 hours, hourly or even smaller intervals.

All the tools are to some extent able to produce a map showing where the wind speeds are higher or lower, which typically depends on the landscape features (hills, mountains, valleys, vegetation, buildings/towns/cities).

AT the same time, the RESMAP tool also provides additional information for potential investors:

- Explain to stakeholders (investors, policy makers, equipment suppliers) the location, amount (MW and GWh/year) and Net Present Value of the economically viable wind and solar resource available in their country, at different combinations of capital cost, investment discount rate and power purchase tariff, thereby determining the value at stake.
- Map existing reference projects.
- Map wind and solar resource (to 10km square scale).
- Improve data collection/management.
- Present results on an online tool, suitable for sharing with stakeholders.

For example, the blue dots on Figure 7 shows the location of a pilot 20MW wind farm that is under construction at Gori. At the same time, the RESMAP gives the opportunity to identify a much larger area to the west which has considerably greater potential. This screenshot below shows how this area is highlighted.

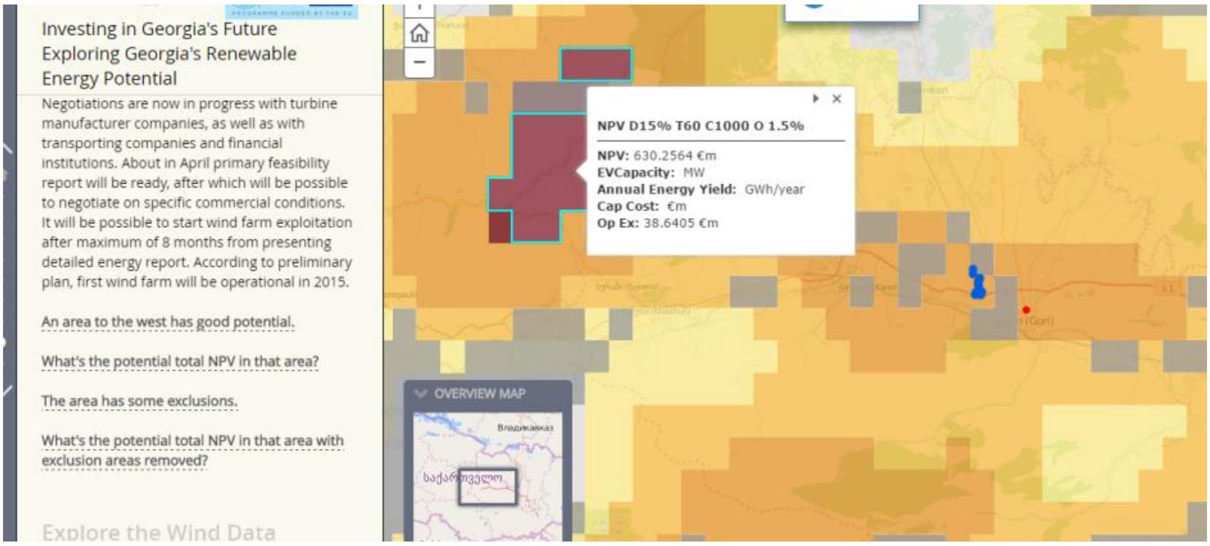

Figure 7: Screenshot from RESMAP tool developed by ITS

The maps typically show the average annual wind speed (m/s) at a given elevation above ground. Knowing where a relatively high annual wind speed can be achieved gives a good indication on the optimum location of a wind farm (from a wind resource perspective) but it is an insufficient basis for estimating the energy production potential.

Figure 8: Screenshot from IRENA Global Wind Atlas

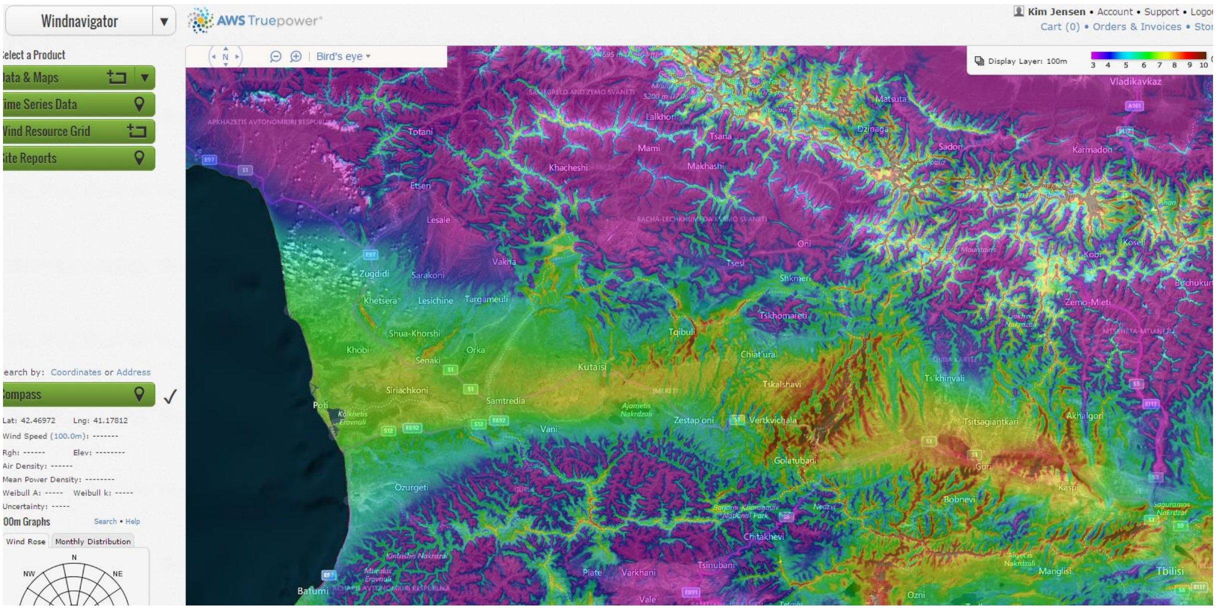

Figure 9: Screenshot from AWS Truepower's WindNavigator

As the energy content of the wind increases by the cube of the wind speed increase (e.g. the energy content of air moving at 8 m/s is 2^3 or 8 times higher that air moving at 4 m/s) it is extremely useful to know the probability distribution of the wind speed.

The above tools and data sets also provide this information, either directly or a raw data to be processed.

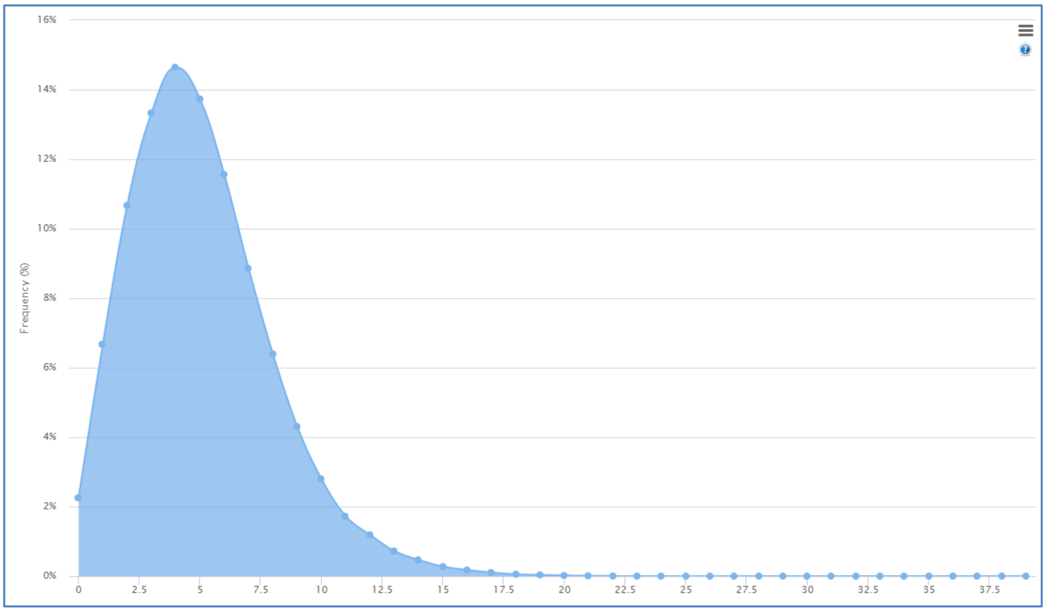

Figure 10: wind speed probability distribution (from IRENA Global Atlas)

Further, it is also important to understand the directional distribution, and again, the tools provide this information, either directly or as a time series to be processed.

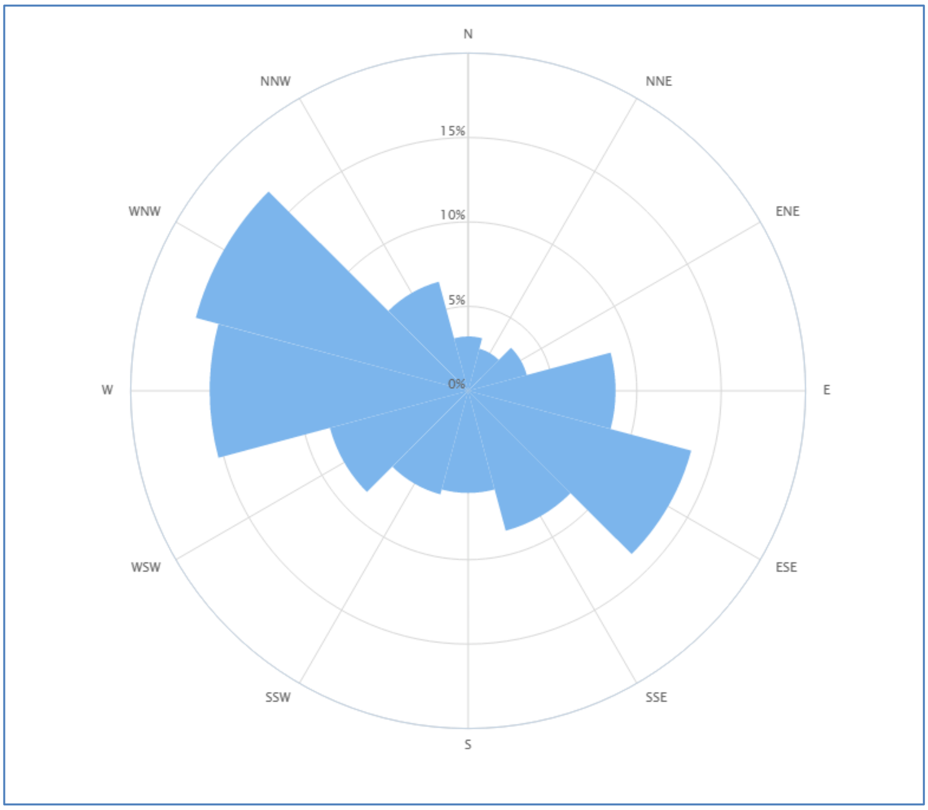

Figure 11: Wind Rose (from IRENA Global Atlas)

The directional information is important to assess the possibilities for populating the area with wind turbines. Turbines must eventually be placed so that they are able to utilize the available resource to the maximum extent. This is both with respect to the site and landscape, but perhaps more importantly, with respect to the other turbines in the wind farm or in the vicinity.

A wind turbine will not only use most of the available energy in the wind which passes through the rotor – but also disturb the (largely) linear flow of air and create a wake of turbulent air – which, when it hits a turbine downstream, will cause vibrations which may increase the fatiguing of turbine components over time (Figure 11).

Figure 12: Turbine wake (turbulence) at Horns Rev offshore wind farm

Due to this, it is important to position the turbines within a wind farm in a pattern in which the distance between the turbines in the direction of the prevailing wind is as large as possible. Further there is a limit as to how close together turbines can be placed.

The extent to which it is relevant to consider these issue in detail in a feasibility study may be discussed – but one should be concerned if a study states an inter-turbine distance of less than 3-4 rotor diameters (at 90^{o} to the prevailing wind direction and 6-8 in line with the prevailing wind direction). This will impact the number of turbines and by that the electricity production which can be achieved.

r) Energy model (about approximate generation)

The gross production which a turbine can achieve at a site can be calculated once the wind speed probability and the power curve of the wind turbine are known. The power curve shows the relationship between the wind speed and the electricity output of the turbine.

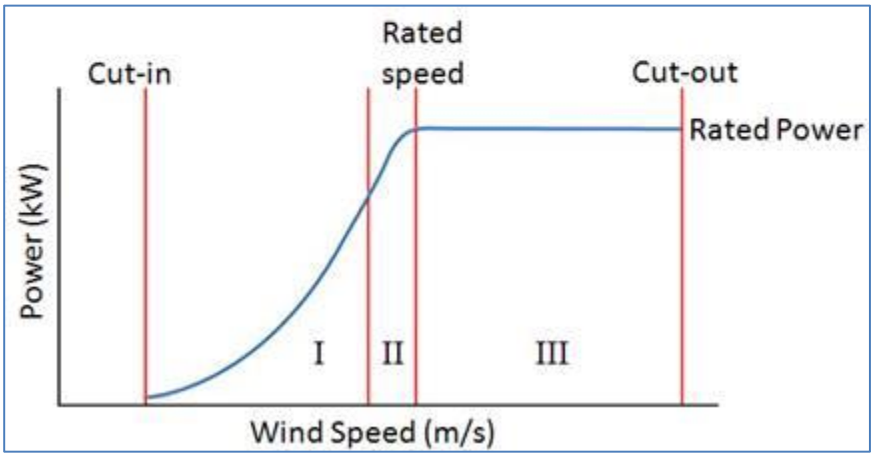

Figure 13: Power curve and terminology

The cut-in wind speed is the wind speed at which the turbine starts producing power (typically at 2 – 5 m/s), the rated speed is the wind speed at which the maximum (rated) power output is achieved (typically at 11-14 m/s) and the cut-out speed is the wind speed at which the turbine is stopped (typically at 25 m/s) to avoid damage.

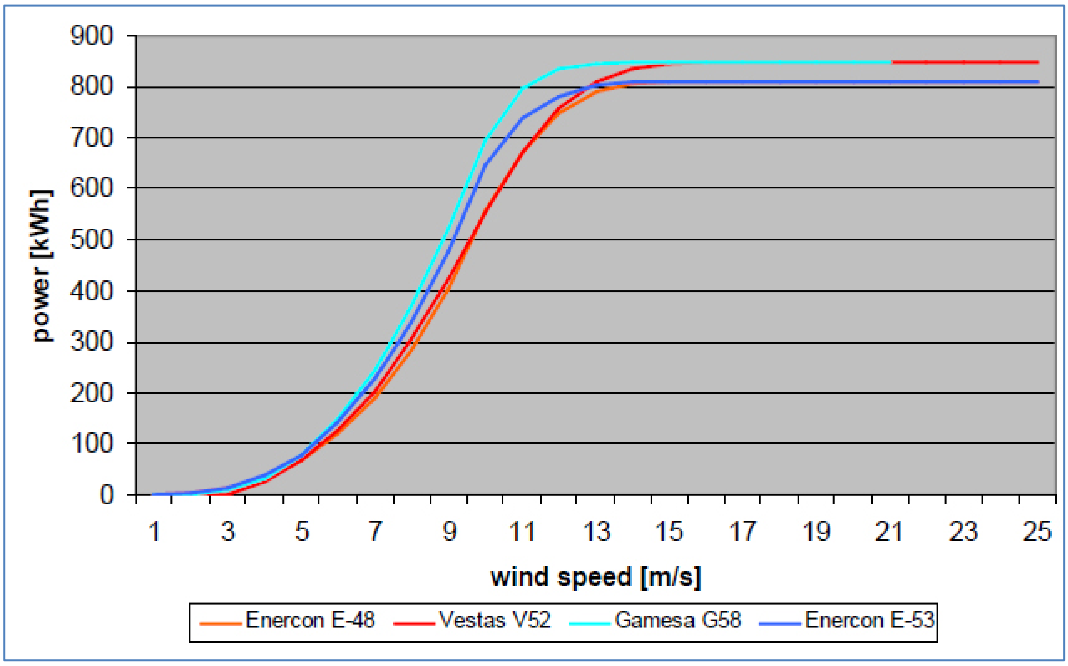

Figure 14: Power curve comparison

Apart from their rated power, turbines characteristics vary according to their design. The most obvious design difference is the rotor diameter, which determines the swept area – and the swept area is the key factor determining the power which can be extracted from the wind. A turbine with a large rotor diameter tends to be better at utilising lower wind speeds, but it may also have lower cut-out speed, limiting its production at higher wind speeds.

Turbine production characteristics are also influenced by the rotor blade aerofoil profile, by the power electronics and control system applied – and these factors all contribute to the shape of power curve.

In simple terms, the gross annual production is the wind speed probability distribution multiplied by the turbine power curve. Most of the tools previously mentioned are able to perform this calculation directly, but a basic free-of-charge tool is available is the RET Screen software tool.

However, the gross production is a theoretical value – assuming that the turbine works at its optimum 24 hours a day, 365 days or 8760 hours per year. In order to arrive at a realistic production figure, a number of loss-factors must be included.

As mentioned, a wind farm consisting of a number of wind turbines will experience a measure of wake losses – no matter how the turbines are placed. A loss of 5 – 15% is not unrealistic.

Further, even the best turbine will experience down-time and outages due to service work, stoppages etc. A down time of 3 - 6% is not unrealistic. Further, as a turbine gets older, components wear and some work increasingly less efficient. One issue is blade fouling and degradation due to dust, bird strikes, insects, which cause the blade and turbine to work less efficiently etc. (Figure 14). This can be mitigated by regular cleaning of the blades and repair of the blade surface.

Figure 15: Rotor blade fouling due to insects.

Further, the cable and MV/HV equipment required to connect the wind farm to the grid will also cause losses.

In the context of this study, it is not realistic to give a detailed explanation of how to get from the theoretical gross production of a single turbine to a realistic Annual Energy Production (AEP) of a wind farm. However, it is important to emphasise that a wind farm with ten turbines does not produce 10 times as much net power as the theoretical gross production of one single turbine at the location in question.

s) Initial Environment Impact Assessment

Even a small modern wind farm is a significant civil engineering and infrastructure project. A small modern wind turbine with a capacity of 1.8 MW has a hub height of approximately 90m and a rotor diameter of 80 – 100m. The components of the machine, nacelle, rotor blades, tower etc. will typically weigh several hundreds of tons. In addition to this, a concrete foundation using more than 1000 tons of steel reinforced concrete will be required for each turbine. The turbine rotor blades may reach 150 m or more above ground level and rotate at 10 – 20 rpms in operation.

The construction and operation of a wind farm with using perhaps 10 or 20 such turbines will have a significant impact on its surroundings.

At the pre-feasibility stage, an environmental impact screening should be carried out. Important issues which should be investigated include:

- Is the site close to inhabited areas, where people could be affected by noise, flicker, and general visual impact? (Several countries enforce distance requirements, noise thresholds etc.)
- Is the site located in an area which is sensitive such as:
    - Air traffic, airports;
    - Road/rail traffic;
    - Power transmission lines;
    - Oil/gas pipelines;
    - Radar lines-of-sight;
    - Defence facilities;
    - Other economic activities (industry, tourism, farming etc.)
- Does the site include or is it close to areas/objects of historic or cultural significance?
- Does the site include, or is the site close to protected or sensitive areas (due to wildlife/flora)?

t) Presumable scheme of connection to network and the possibility of network to receive generated electro energy

The distance and route to the potential grid connection point is of course important, as is the grid's capacity to handle the power produced. It is vital that the grid operator can/will provide reliable information, as – without a functioning grid connection – the wind power project has no purpose. The distance between the WPP and the grid connection has a direct impact on the electrical loss, and will also impact at which voltage level the connection should have.

u) Information about infrastructure (Existing and under construction roads should be marked on topographic maps indicating the approximate distance)

A wind farm requires fairly good road access, especially during construction, when large quantities of concrete and steel for foundations is required, heavy construction equipment and large and heavy turbine components have to be transported to the site. During the operation phase, access roads are required and used by the service crew – and most likely also for the transport of large/heavy spare parts.

If transport bottle-necks, such as mountain passes, bridges (with limited load bearing capacity) or tunnels between the site and the port at which the turbine components etc. are known to exist, it should be investigated if this impacts the wind project,

The construction of access roads, lay-down areas, storage areas, crane pads etc. may be a significant civil engineering project on its own – and this should be taken into account in the environmental screening process.

v) Approximate estimate

w) Economic report (economic analysis of the project, which includes the duration of the investment and the credit rate)

x) Financial Analysis (financial model)

As previously discussed, the information collected at the pre-feasibility study is only suited for very basic financial calculations. It should be noted that the financial performance of the project if primarily a concern of the developer/potential investor, and only of secondary interest for the Government.