

**THE ENVIRONMENTAL IMPACT EVALUATION
OF A WIND FARM IN VIETNAM**

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Certificate of Authorship/Originality

I certify that the work in this thesis has not been previously been submitted for a degree, nor has it been submitted as part of the requirements for a degree, except as fully acknowledged within the text.

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Table of content

List of tables	v
List of figures	viii
Abbreviations	x
Abstract	xii
Chapter 1	1
1.1 Introduction.....	1
1.1.1 The current global wind energy situation	1
1.1.2 Wind energy scenario in Vietnam	4
1.2 Research objectives	7
1.2.1 Scope of research.....	8
1.2.2 Research framework.....	9
Chapter 2	10
2.1 Review of existing wind farm projects in Vietnam.....	10
2.2 Review of the major impacts on wind farm analysis	13
Chapter 3	19
3.1 Introduction.....	19
3.2 Life cycle theory.....	19
3.3 Life cycle assessment	20
3.3.1 Life Cycle Assessment structure	20
Chapter 4	36
4.1 Case study description.....	36
4.2 Goal and scope definition	37
4.2.1 Goal	37
4.2.2 Scope definition.....	38
4.3 Inventory analysis of case study.....	42
4.3.1 Methodology.....	42
4.3.2 Stage 1- manufacture of wind turbines, transformers, and electrical cable	47
4.3.3 Stage 2 – Transportation and installation.....	64
4.3.4 Stage 3 and 4 – power generation and maintenance	68
4.3.5 Stage 5 – decommissioning	70
4.3.6 Inventory Analysis Calculation	71

Chapter 5	87
5.1 Supporting software	87
5.2 Environmental Impact Assessment	87
5.3 Midpoint of Environmental Impact Categories	89
5.3.1 Acidification	89
5.3.2 Climate Change	90
5.3.3 Photo oxidant formation.....	92
5.4 Characterization.....	93
Chapter 6	97
6.1 Life Cycle Impact of total wind farm assessment	97
6.2 LCIA of different components contribute to impact categories	100
6.3 Energy payback time	103
6.4 Uncertainty Analysis	107
6.5 Conclusions and future work	110
6.5.1 Conclusion	110
6.5.2 Future research.....	111
References.....	112
Appendix	
Appendix A	122
Appendix B	123
Appendix C	124
Appendix D	125
Appendix E	126
Appendix F	158
Appendix G	161
Appendix H	164
Appendix I	166
Appendix of references.....	168

List of tables

Table 1.1: Wind energy potential of Southeast Asia.	4
Table 1.2: Comparison of average wind speed estimated by EVN.....	5
Table 2.1: Wind farm development in Vietnam.....	11
Table 3.1: List of the key features of various LCA methodologies.	22
Table 3.2: Two sample lists for chosen impact categories	30
Table 3.3: Calculating impacts of some greenhouse gases with Global warming potential (GWP100) or characterization factors (time period 100a).....	32
Table 4.1: Capacity weighted average 2006 capacity factors by region and commercial operation date	43
Table 4.2: Wind turbine main characteristics.....	45
Table 4.3: The component weights from the manufacture.	51
Table 4.4: Material use for the main components of 800 kW onshore wind turbine.....	54
Table 4.5: The calculation of mass of different material in FL MD – 77 1.5 MW.....	56
Table 4.6: Material distribution in wind turbine.	57
Table 4.7: List the main material required in manufacture phase of the transformer 45 MVA calculated from Environmental Product Declaration Power Transformers 40/50 MVA, 2003.....	59
Table 4.8: List main materials required in manufacture phase of transformer 1.8 MVA.	59
Table 4.9: Technical data for the 22kV used in the study.	61
Table 4.10: Cabling materials of 22 kV per metre.....	62
Table 4.11: Technical data of 110 kV cables used in the transmission system with the performance of one conductor with wire amour.	63
Table 4.12: Life cycle inventory of 110 kV cable.	64
Table 4.13: Distance travelled of rotor and nacelle.	66
Table 4.14: Distance travelled of tower and foundation.....	66
Table 4.15: Construction data used for erection of turbines bases.	67
Table 4.16: The distance of transportation of transformers and cables.	67
Table 4.17: The total hours for installation of transformers and cable.....	68
Table 4.18: The total energy input for operation process.....	68

Table 4.19: Total inspection and maintenance of wind farm.	68
Table 4.20: Material type and disposal method considered.	70
Table 4.21: Emission per kg material produced and energy embodied	72
Table 4.22: A part of inventory list after calculation (table of glass fibre presented only, the full inventory lists shown in Appendix E. 2.1).	80
Table 4.23: Final energy consumption for vehicle travel. The energy values are based on the lower heating values of diesel fuels (42.8 MJ/kg diesel).	81
Table 4.24: Transportation embodied energy and emission inventory data.	82
Table 4.25: Resulting data for rotor and nacelle transportation.	83
Table 4.26: Results of rotor and nacelle transportations.	83
Table 4.27: The value environmental intervention of vector.	85
Table 4.28: A part of inventory list after calculation during transportation stages (light vehicle only presented, the full inventory lists shown in Appendix E).	85
Table 5.1: Environmental impacts temporally estimated by Life Cycle Assessment.	88
Table 5.2: Acidification Potential (AP) of some gas emissions.	90
Table 5.3: Some greenhouse gases with Global Warming Potential (GWP100) or characterization factors.	91
Table 5.4: Photo-Oxidant Potential of some gases emission.	93
Table 5.5: Selected inventory parameters (column for rotor and nacelle includes glass fibre only while transportation is the full calculation of rotor and nacelle distances). ...	95
Table 5.6: Acidification potential (AP) for the manufacture of the Rotor and Nacelle in SO ₂ equivalent/fU.	95
Table 5.7: Acidification potential (AP) for transportation of the Rotor and Nacelle in SO ₂ equivalent/fU.	96
Table 6.1: The results of total emission categorized according to impact assessment. ...	97
Table 6.2: The total Life Cycle Inventory results of various parts in wind turbine	100
Table 6.3: Environmental impacts of each component by functional unit.	101
Table 6.4: Total primary energy consumption in mega-joules (MJ) for production of particular materials per kg (Schleisner 2000).	103
Table 6.5: The total energy consumption during all manufacturing stage of wind turbine.	104

Table 6.6: The comparison of different energy consumption stages with the total energy consumption and the annual power generated.	105
Table 6.7: The matrix of uncertainty of inventory.	108
Table 6.8: Uncertainty for unit process of all wind farm configurations.	109

List of figures

Figure 1.1: Global cumulative installed wind capacity in Megawatt from 1996-2013.....	2
Figure 1.2: Global annual installed wind capacity 1996 -2013.....	2
Figure 1.3: Top 10 cumulative and new installed capacities 1996 -2013.	3
Figure 1.4: Research framework.	9
Figure 3.1: Various phases and applications of an LCA (based on ISO 14040, 1997). .	21
Figure 3.2: System boundary of generic process.	24
Figure 3.3: Life cycle inventories account for material use, energy, wastes, emissions, and by products over all of the stages of a product's life cycle.	27
Figure 3.4: Principle of classification and characterization in the phase of Life Cycle Impact Assessment.....	31
Figure 3.5: Main components of stage 4 Interpretation and other stages regulated by ISO 14044.....	35
Figure 4.1: The illustration of the wind farm in 3-D map in Binh Thuan province.	36
Figure 4.2: The layout of wind farm in Binh Thuan province	37
Figure 4.3: The basic system boundary for the life cycle assessment of a wind turbine.	39
Figure 4.4: Average capacity factors in US region.	43
Figure 4.5: The inventory of the wind farm for the case study in Vietnam.	46
Figure 4.6: Wind turbine main components (source: wind turbine development: location of manufacturing activity- 2004 (Sterzinger & Svrcek 2004)).	48
Figure 4.7: Life cycle inventory of wind turbine based the unit processes.	50
Figure 4.8: The life cycle inventory of one standard transformer.....	58
Figure 4.9: Life cycle inventory of basic cable in manufacture stage.	60
Figure 4.10: Illustration of the high voltage three core XLPE insulated power cable....	64
Figure 4.11: The unit process for the manufacture of glass fibre reinforced plastics used in rotor.....	74
Figure 4.12: The scaling approach for mass of glass fibre in one turbine, corresponding to fU (1kWh).	76
Figure 4.13: The method for calculation of emissions released, corresponding to functional unit.....	78

Figure 6.1: Environmental impacts of wind farm generation.	99
Figure 6.2: Environmental impact distributed on wind farm by unit process.	102
Figure 6.3: The comparison between the energy input of various stages and total energy consumption of wind farm.	106
Figure 6.4: Comparison of Global Warming Potential impacts from configurations' under 95% confidence range uncertainties.	109
Figure 6.5: Comparison of Acidification Potential impacts from configurations' under 95% confidence range uncertainties.	110
Figure 6.6: Comparison of photo-oxidant chemical Potential impacts from configurations' under 95% confidence range uncertainties.	110

Abbreviations

LCA	Life Cycle Assessment
RECTERE	The Research Centre for Thermal Equipment and Renewable Energy
US EPA	United States Environmental Protection Agency
\$	United States dollars
AC	Alternating Current
AP	Acidification potential
CF	Capacity factor of wind farm
CH ₄	Methane
CO	Carbon oxide
CO ₂	Carbon dioxides
DFAG	Doubly Fed Asynchronous Generator
DFIG	Doubly Fed Induction Generator
EIO-LCA	An economic input-output analysis based LCA
EIO-LCA	An economic input-output analysis based Life Cycle Analysis
EU	European Union
EVN	Electricity Group of Vietnam
FL MD – 77	Fuhrlander 1.5 MW wind turbine, rotor diameter 77m
fU	Functional Unit
GHGs	Greenhouse gases
GWP	Global warming potential
GWP _{100a}	Global Warming Potential 100 years applied in this thesis
HVAC	High Voltage Alternating Current
IE	Institute of Energy, Vietnam
IEA	International Energy Agency
IEC -IIA	International Electro-technical Commission of wind Turbine under turbulence intensity distribution class IIA
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standard Organization
Kg C ₂ H ₄ -eq	Kg of ethane equivalent
Kg CO ₂ -eq	Kg of carbon dioxides equivalent
Kg SO ₂ -eq	Kg of sulphur dioxides equivalent
kV	Kilo voltage
kW	Kilowatt
kWh	Kilowatt-hour
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Category
m	Meter
m/s	Meter per second

MGh	Megawatt-hour
MJ	Mega-Joules
MoIT	Ministry of industry and Trade
MVA	Megavoltage – Ampere
MW	Mega Watt
N ₂ O	Nitrous oxide
NMVOC	Non-Methane Volatile Organic Compounds
NO _x	Nitrogen Oxides
NP	Eutrophication potential
OECD	Organization for Economic Co-operation and Development
PLCA	Process analysis based Life Cycle Assessment
POCP	Photon Oxidant Chemical Potential
Project site	Binh Thuan Vietnam
REVN	Renewable Energy company in Vietnam
SO ₂	Sulphur dioxides
t.km	Ton × kilometre
TCVN 5844:1994	Vietnamese Standard No 5844, year 1994
TR-XLPE	Tree-retardant cross-linked Polyethylene
USA	United States of America
VNRE	Vietnam Renewable Energy Joint Stock company
WB	The World Bank
XLPE	Cross linked Polyethylene, insulation polyethylene

Abstract

This research conducts an in-depth analysis of the environmental impact assessment of a wind farm in Vietnam, with a view to identifying the various environmental stressors and then assess them under suitable impact categories. Although wind power releases no emissions during operation, there is an environmental impact related to the wind turbine during the entire life cycle from manufacturing to dismantling. In this study, a Life Cycle Assessment is carried out to quantify the environmental impact of twenty existing 1.5 MW wind turbines. The assessment analyses emissions in different unit processes and compares the means of different emissions during the lifetime of a wind farm. Furthermore, at the end of the thesis, the energy payback time is determined based on the cumulative energy requirements for a 20-year life period.

For the quantitative analysis of the material and energy balances over the life cycle, all unit processes based on life cycle assessment are determined, and many matrix series are designed and calculated. Moreover, the environmental impact categories are set to match the conditions in Vietnam and the aims of the research.

This study also shows that while the comprehensive life cycle inventory of a wind farm is heavily dependent on the unit processes, the impact can be divided into three categories: raw material data input, energy consumed in each unit process, and the emission outputs such as CO₂, SO₂, CH₄, etc.. The three impact categories allow the classification of the emissions and give results for all life cycle assessment.

Finally the findings shows that the largest emission contribution is mainly derived from the manufacturing phase, which varies from 60 % to 80 % of the total life cycle stages. The totalCO₂ equivalent emissions in the climate change category is around 14 g for every kWh of electricity generated from the wind plant and the primary energy return is 5 months.

This research is a good example that proves that a wind plant is one of the best options for mitigating climate change and for providing electricity in rural areas that are not connected to the grid. It can be stated that wind energy is among one of the cleanest sources of energy available today.