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Renewable energy sources project appraisal under uncertainty: the case of wind energy exploitation within a changing energy market environment

Konstantinos Venetsanos[a], Penelope Angelopoulou[a], Theocharis Tsoutsos[b,*]

[a] National Bank of Greece SA (NBG), 86 Aeolou str, GR-10232 Athens, Greece
[b] Centre for Renewable Energy Sources (CRES), 19th km Marathonos Avenue, GR-19009 Pikermi, Greece

Abstract

There are four elements, which contribute to the oncoming increase of electricity demand: climate changes, the expected growth rates of EU Member State economies, changes in the consumption patterns and the introduction of new technologies. The new deregulated Electricity Market is expected to respond to this challenge and the energy supply will be adequate and cost effective within this new environment which offers promising opportunities for power producers both existing and newcomers.

In this paper a framework for the appraisal of power projects under uncertainty within a competitive market environment is identified, focusing on the electricity from Renewable Energy Sources. To this end the wind energy-to-electricity production in Greece will serve as a case study. The subject matter is centred on the following areas:

- the uncertainties within the new deregulated energy market;
- the evaluation methods including an analysis of the introduced uncertainties after deregulation and a new approach to project evaluation using the real options, as well as comparison of the valuation methodologies within the new environment drawing from the case for Greece.

Keywords: Wind energy; Call options; Uncertainty

1. Introduction

The transition from a highly regulated industry to a competitive environment calls for the re-adjustment of appraisal methods for new investments in order to take proper account of the introduced uncertainties.[1]

Uncertainty creates financial opportunities. It is important to determine the degree of exposure of our investment (how external events translate into profits and losses) and then respond by positioning this investment to best take advantage of uncertainty (Amram and Kulatilaka, 1999). Companies should alter their investment strategy and add the value of these inherent uncertainties to their project evaluation.

Traditional discounted cash flow (DCF) approaches can neither properly deal with unexpected market developments nor allow for management's flexibility to adapt and revise later decisions in response to them.

A company's adaptability to changes in market conditions can expand the value of an investment opportunity by improving its upside potential. Additionally, this will limit downside losses relative to the company's initial expectations under "passive" management. The resulting asymmetry caused by managerial adaptability calls for an "expanded net present value" rule reflecting both of the value components below:

- the traditional (classical, static or passive) net present value (NPV) of direct cash flows (CFs),
- the option value of operating and strategic adaptability/flexibility.

This does not make traditional NPV redundant, which should now be seen as a crucial and necessary input to an option-based expanded NPV analysis

*Corresponding author. Tel.: +30-1603-9900; fax: +30-1603-9904.
E-mail address: ttsout@cres.gr (T. Tsoutsos).

[1] "Uncertainty" refers to an unstructured perception of uncertainty, whereas "risk" to the situation in which alternative outcomes have been specified and probabilities have been assigned to them.

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Nomenclature

A	current value of the underlying asset
CAPM	Capital Asset Pricing model
CC	capital cost
CF	cash flows
CO	call options
CRES	Centre for Renewable Energy Sources
D	long-term debt
DCF	discounted cash flow
E	equity
E(cost)	the expected overall cost plant
GDP	gross domestic product
I	segment's cost
L	Lead-time
N	number of increments required
$N(d_x)$	cumulative normal probability density function/the value of the normal distribution at d_1 and d_2
NPV	net present value
p	probability of demand increasing in any given year
PPA	power purchase agreements
PPC	public power corporation
PV	present value
r	discount rate
RET	renewable energy technology
r_f	risk free rate of return
RO	real options
S	subsidies
T	time estimated that the existing excess capacity would vanish if demand grows at a high rate
t	time to expiration
tax	tax rate
T	existing excess capacity will vanish in 2 yr if demand grows at a high rate
V	total value
WACC	weighted average
WE	wind energy-to-electricity
WP	wind park
WT	wind turbine
X	exercise price or investment cost
Σ	volatility of the underlying asset

(Trigeorgis, 1993):

Expanded (strategic) NPV
= Statical (passive) NPV
+ Valuel of options from active management.

Table 1 summarises the most important uncertainties related to energy production—utilisation and the attributes, which interact with them (Kaslow and Pindyck, 1994).

Table 1
Uncertainties related to the energy production

Uncertainty	Relevant resource attributes
Fossil fuels price	Operating costs
Environmental regulations	External costs
Demand	Location flexibility Modularity and Lead-time Capability Availability
Supply	Location flexibility Modularity and Lead-time Capability Availability
Initial CC and technological issues	Initial capital requirements Modularity and Lead-time Location flexibility
Market structure	Overall costs

2. Uncertainties

2.1. Fossil fuel price uncertainty

This uncertainty can be seen as a side effect of renewable energy technologies (RETs) and it is rather closely related to environmental issues.

Electricity production using fossil fuel based technologies incurs high variable costs and is vulnerable to oil-price shocks. The result is extended operating costs volatility, which is directly reflected on electricity prices.

RETs with high fixed but low variable costs can provide price stability and a good hedge against the risk of fuel price volatility. To some extent we may regard them as a physical risk management tool. This last feature is also related to the other attributes of the wind energy-to-electricity (WE) production process.

2.2. Environmental regulations uncertainty

It is closely related to the fossil fuel uncertainty and the environmental restrictions placed upon "polluting electricity production methods" (e.g. stringent emission standards). This issue increases the uncertainty of conventional production methods, due to the incorporation of environmental costs into electricity prices, whereas environmentally friendly production methods (e.g. WE production) do not face such an uncertainty (i.e. such external costs are expected to be negligible or not to be applied at all).