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Issue on supply chain of renewable energy

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ABSTRACT

Actually, one of the most relevant debates, among both citizens that government, is related to energy and environmental issue. The development of renewable energy usage is due to several factors such as the political strategic decisions and geographical situation.

Indeed the high development of renewable energies requires challenges from a supply chain point of view. In this paper, a thorough survey of the extant literature on the topic of supply chain (SC) and renewable energy (RE) has been conducted. English papers published on international peer-reviewed journals from 2003 to 2013 have been considered.

Sustainable Supply Chain Management (SSCM) resolves the duality between environmental, economic and social aspects. Sustainable manufacturing practices play an essential role in promoting renewable energy development and commercialization; this will require significant changes to the industry's traditional Supply Chain Management and business model. The aim of the paper is investigate literature insights useful to increase the performance and overcome barriers to the RE supply chain development.

Like many typical supply chains, also supply chain related to RE includes elements such as: physical, information, and financial flows. The present research is useful to individualize characteristics of a RE supply chain. Moreover, the research is useful improve the performance of RE supply chain in some aspects like:

- better control supply chain costs to make renewable energy more affordable;
- manage supply chain to address weakened demand in the near term, and increase flexibility to handle anticipated rapid growth in the next 3–5 years;

In so doing the present research has practical implications that make the results interesting for decision maker about optimal design of a system operating from one renewable energy sources. Moreover, the results are interesting for researchers since are individualized many sectors where it is necessary to proceed with additional research investigations.

1. Introduction

In recent years several strategies has been implemented in different European Union (EU) countries to increase the share of electricity generation from renewable energy sources. The change in the makeup and structure of the power sector is determined by three key drivers: ageing infrastructure, security of supply and climate change. The EU heads of State and Government aims to contrast climate change and increase the EU's energy security while strengthening its competitiveness through 20–20–20 targets [1,2].

A simplified market model is defined by Schellekens et al. [3]: Government policy, Investment & Finance, Market structure and Infrastructure & Planning are enabling areas; R&D, supply chains, Generation Capacity, Grid Capacity and Demand are delivery areas.

In this paper the role of the supply chain is in focus. The field of Supply Chain Management (SCM) spans multiple interdisciplinary areas: business, industrial psychology, economics, operations research and organizational science [4]. So the interest in SCM related technologies continues to garner interest from a variety of research disciplines; in particular operations management, logistics and information systems [5]. Operations, purchasing and supply chain managers have seen the integration of environmental, economic and social issues; accordingly they have increased interest in SSCM [6,7].

The importance of supply chain in the renewable energy sector attracts the attention of both public and private actors. The first are concerned to respect the Protocol of Kyoto and to define the policy of subsidy, like green certificate trading and feed in tariffs. They want to stimulate technical progress so that RE technologies will be able to compete with other technologies. The second to gain the economic opportunities. They want help improve climate but

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Nomenclatures

CO_2	carbon dioxide
CFP	carbon footprint
CLSCM	Closed-Loop Supply Chain Management
d	degradation rate
E_{IN}	embodied energy of the system
E_{OUT}	energy output of the system
$E_{OUT,GLB}$	total energy output of the system during all of the life cycle
EPBT	Energy Payback Time
EROI	Energy Return on Investment
ESCM	Environmental Supply Chain Management
F	interest expenditures
GHG/kW h	Greenhouse Gas per kilowatthour
GHG_{EM}	emission of life cycle photovoltaic electricity production
GHG_S	GHG produced by the local power plant for the power generated by PV
$GHG_{SV,GLB}$	annual GHG produced by the local power plant*
GPBT	Greenhouse Gas Payback Time
GROI	Greenhouse Gas Return on Investment
GSCM	Green Supply Chain Management
I	initial investment
IBSAL	integrated biomass supply analysis and logistics
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LCOE	livelized cost of electricity
M	Maintenance cost
O	operation cost
PB	payback
r	discount rate
RE	renewable energy
S	yearly rated energy output
SC	supply chain
SCM	Supply Chain Management
SCOPE	supply chain optimization and planning for the environment
SSCM	sustainable Supply Chain Management
T	life of the project
t	Year

require, also, that the return on investment is greater than the opportunity cost of capital.

This research builds on the body of theory building in SSCM and the article is organized in the following way: in Section 2 it begins with the definition of review scope and the conceptualization of research topic. That is followed by an analysis of the current literature (Section 3); it has been conducted with a specific focus on the year of publication, the nature and perspective of the articles, the interaction between several countries and type of RE used. In Section 4 the research's results and implications are explored. In Section 5 are presented the results of the literature review on models adopted for supply chain analysis. Finally, limitations and future research opportunities are identified (Section 6).

2. A classification and conceptualization of the topic

RE and SC have a central role in social and economic development at all scales, from families and communities at regional and national levels [2,8–10].

RE is a resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). RE does not include energy resources derived from fossil fuels, waste products from fossil sources or waste products from inorganic sources" [11].

Total investment in RE reached $257 billion in 2011, up from $220 billion in 2010. Recent estimates indicate that about 5 million people worldwide work either directly or indirectly in the RE industries: 22% in the European Union and 50% in bioenergy-sector [12].

Total contribution production from renewable energy sources, for all 27 European Union Member States, amounts to 639 TWh in 2010, with respect to 5 years before, this amount represents an increase of the overall renewable share of 33%. Looking at the overall estimated production from renewable energy sources, the growth rate will be of 41% from 2010 to 2015 and 35% from 2015 to 2020 [13].

The Green economy is a new model of economic development in contrast to the current "black" economic model based on fossil fuels; it includes not only green energy, but also energy conservation for efficient energy use [14]. This economic model include several sectors as construction, transportation, sustainable energy, green manufacturing, reforestation, conservation and preservation activities, waste and water management. The global market may reach $2.74 trillion in 2020, increasing 100 percent over 2006 [15].

Renewable energy sources with other factors can increase health equity, reduce poverty and build societies that live within environmental limits [16,17]. The development challenges are complex, but largely fall into five categories: project economics, technical constraints, supply chain capacity, social effects, namely to amenity and aesthetics, and environmental impacts [2,18].

"The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain. Supply Chain Management is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage" [19].

The firms aim to increase the effectiveness of the whole chain, by applying SCM principles. In fact improvements include: shortening lead times, flexibility, significantly lower total inventory and better customer orientation [20].

The literature was unable to unify around a generally accepted definition of Green Supply Chain Management (GSCM) [2,21]; however GSCM is often used interchangeably with the term Environmental Supply Chain Management (ESCM) [22,23]. A paper conceptualize a structural model of natural resource based GSCM, and its relationship, with an indication of cause and effect, to relevant performance measures and drivers [2].

ESCM considers how SCM can be viewed in the context of the environment; the SSCM properly expands its scope also to social and ethical issues [2,24]. Firms can achieve excellence in global supply chain performance through close connections and relationships with other parts in the chain [25]. Sustainability resolves the conflict between economic prosperity, environmental quality and social equity famously known as three dimensions (Triple Bottom Line, Fig. 1) [26]. In its broadest sense, Triple Bottom Line captures the spectrum of values that organizations must embrace to stay in