Review

Green Energy as a Driver for Green Economy and Organizations’ Sustainability

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Green Energy as a Driver for Green Economy and Organizations’ Sustainability

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Abstract

Since the last decade, the concepts of green innovation and green economy have become more and more attractive to researchers and policymakers. This research brings some light to the association of those themes with the concept of green energy. Therefore, this paper is a critical review of the green innovations directed explicitly to the green energy challenges faced by organizations and the world economies. The research question is as follows: What are the main dimensions of a model to implement a green innovation process focused on green energy in organizations? The methodology used to answer the research question was qualitative, and the main techniques included a systematic literature search and survey. The main findings of the study were the identification of the most relevant dimensions of a green innovation model to be implemented in organizations. The article structure is based on the different concepts about innovation and green innovation, related to the green economy, and the analysis of two situational cases on green energy. Finally, we present the analysis made on the articles identified by the literature survey and the green innovation model. By making this research on green economy and related concepts of green innovation and green energy, this paper seeks to make a valid contribution to their definitions and for operationalizing the green innovation model in organizations.

Keywords: Green economy; Green innovation; Green energy; Organizations; Literature review; Case studies.

1. INTRODUCTION

Managerial and technological innovation enables enterprises to boost their leverage against competitors and to achieve desirable revenue streams, to acquire and retain market share. The internal development initiatives and capabilities of firms have been found to play a crucial role in green innovation (Zailani et al., 2015) (Huang et al., 2016). To strengthen their brand-positioning capabilities, firms are pursuing a green innovation approach to achieve economic and organizational sustainability with a circular economy business model.

This paper begins by stating what is green innovation, what for it can be used, and how organizations can become greener. For this purpose, it includes a systematic literature review of internal and external challenges that enterprises may face while implementing and developing a green innovation culture, their engagement with stakeholders, segmentation as well as social, economic, and ambient externalities.

With the intent to understand theories of innovation, namely the green innovation, two case samples of REN - Redes Energéticas Nacionais, SGPS, S.A. (Euronext: RENE.LS) in Portugal and Carbon Recycling International (CRI) in Iceland are mentioned, to perceive the contrasts and competitive advantages differences between these two significant enterprises: first, in terms of business opportunities that arise from a sustainable use of natural resources, strategically leveraged with credible research and development (R&D) projects and second, the importance that engaging with international business networks have to create valuable intellectual property.
2. THE GREEN INNOVATION PROCESS

2.1. Innovation Theories
The literature on innovation theory shows that innovations occur mostly within the national system of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997). However, another perspective was studied by organizational academics in innovation in organizational microsystems (Van de Ven, 1986; Aldrich and Fiol, 1994; Van de Ven et al., 1999; den Hertog and Huizenga, 2000): the literature shows that the concept of innovation is very complicated, which makes it difficult to have a single definition. The Green Book on Innovation from the European Commission (1996) defines innovation as “the successful production, assimilation and exploration of something new.” Mulgan and Albury (2003) made their contribution to the concept indicating the importance of the innovation implementation results: “new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality.”

Leadbeater (2003) exposes the complexity of the concept, including its interactive and social dimensions: he argues that “the process of innovation is lengthy, interactive and social; many people with different talents, skills and resources have to come together.” The literature assumes various categorizations of innovation. OECD (2002) structures the concept around three areas: (i) the renewal and broadening of the range of services and associated markets; (ii) the creation of production, procurement, and distribution methods; (iii) the introduction of changes to management, work organization, and workers’ qualifications. Baker’s (2002) typology also differentiates three types of innovation: (i) process, (ii) product/service, and (iii) strategy/business. Process innovation (i.e., work organization, new internal procedures, policies, and organizational forms) and the strategic and new business models (i.e., new missions, objectives, and strategies) are called organizational innovation.

OECD’s (2002) organizational innovation includes three broad streams: (i) the restructuring of production and efficiency processes, which include business reengineering, downsizing, flexible work arrangements, outsourcing, greater integration among functional lines, and decentralization; (ii) human resource management practices, which include performance-based pay, flexible job design and employee involvement, improving employees’ skills, and institutional structures affecting the labor-management relations; (iii) product/service quality–related practices emphasizing total quality management and improving coordination with customers/suppliers (Table 1).

2.2. Green Innovation for a Circular Economy
Schiederig, Tietze, and Herstatt (2012) clarified green innovation and sustainable development through a comprehensive literature review of the matter, in its different interpretations by the academia, and the authors identified six critical aspects: (i) innovation object, that is, products, services, or processes; (ii) market orientation, meaning satisfying the needs and to be competitive; (iii) the environmental aspect, in which the optimal level corresponds to inexistent negative externalities; (iv) phase, meaning that the full product life cycle must be considered, namely, the recycling stage; (v) impulse, the degree of compliance in the operations with the green innovation vision of the enterprise; (vi) level to which the company is willing to invest in R&D for new technology and green standards.

| Production and efficiency practices | Human resources management practices | Product/service quality |
|-------------------------------------|--------------------------------------|-------------------------|
| Business reengineering              | Performance-based pay                | Total quality management (TQM) |
| Downsizing                          | Flexible job design and employee involvement | Improving coordination with customers/suppliers |
| Flexible work                       | Developing skills                    | Improving customer satisfaction |
| Outsourcing                         | Labor-management cooperation         |                          |
| Greater integration among functional areas |                                |                          |
| Low degree of centralization        |                                      |                          |

Source: Gu and Gera (2004).
Saunila, Ukko, and Rantala (2018) analyzed what drives green innovation investment and exploitation with regard to sustainability, and their theoretical contribution is as follows: (i) the more a company relies on economic, institutional, and social sustainability, that is, circular economy, the more likely is willing to invest in R&D or implementation of green innovation in their operations; (ii) higher estimates of an increase in the institution and financial sustainability of the organization, more willing it is to exploit green innovation; (iii) the valuation of environmental sustainability was not correlated to the rate of investment in or to exploit green innovation. Therefore, organizations are most willing to invest in green innovation if it contributes to their enterprise value instead to invest in the same technology for a positive environmental contribution. Another aspect that has been found to be significant in attaining green innovation is the element of social recognition, which according to Doran and Ryan (2012) concluded that firms are willing to pay to brand themselves as eco-friendly.

Jacobsen (2006) explained the concept of industrial ecology, which comprehends the tangible benefits of recycling residual wastes from production systems. Aligned to this vision is the core element of the circular economy in which from the usual end point of industrial waste (materials to be disposed and destroyed either with artificial methods or naturally), can be reutilized by enterprises on their production systems, moreover, decreasing the use of virgin raw materials for the economic activity (Andersen, 2007). However, aligning a green innovation approach to a circular economy business model is a challenging mission on a hypercompetitive and globalized economic environment: therefore, the operations and executive decisions of an enterprise must capitalize the investments made on R&D, up to the point that it becomes viable to be commercialized. To understand how a company might incorporate a green innovation culture while pursuing the organizational sustainability, it will be analyzed what is done by REN in Portugal and by CRI in Iceland. Moreover, it analyses the importance of the green innovation enterprises for a circular economy.

The innovation processes are influenced and facilitated by the way an organization is structured, mainly, by the way, the top management perceives its meaning (Sousa and Martins, Innovation Competencies to Potentiate Global Trade, 2018). Considering the top-managerial element defining the operations and compliance with the mission and vision of an enterprise as defined by the shareholders, the following table reflects necessary managerial aspects of green innovation: (i) the top management innovation sponsorship, green corporate culture emphasis, and support in its implementation, (ii) R&D and technology such as intellectual property, (iii) stakeholders (Table 2).

### 2.2.1. The Example of REN in Portugal

REN supplies and delivers natural gas and electricity to Portugal. The company is responsible for the transportation of high-pressure natural gas and the technical management for the Natural Gas System in Portugal, in regards to its reception, storage, and regasification of liquefied national gas and its underground storage. Simultaneously, concerning electricity, it maintains the technical needs of the National Electricity System of

| Table 2. Green Innovation Corporate Aspects. |
|---------------------------------------------|

| Top management innovation sponsorship | Research & Development (R&D) | Stakeholders                   |
|----------------------------------------|------------------------------|--------------------------------|
| Created a separate department/unit specialized in environmental issues related to the organization | Investment in low-carbon technology for the production processes | Engagement with business networks |
| Segmentation for the environmentally conscious consumers | Investment in R&D for pro-environmental products/services | Dialogue with the stakeholders about externalities |
| The enterprise absorbs the extra cost of an environmental product/service | Use recycled or reusable raw materials in the production system | Use of specific environmental policy for selecting partners |
| Efforts are made to use renewable energy sources in the production system | Implementation of research to detect green innovation needs in the market | Use of international consortiums’ research funds |
Portugal. Moreover, while maintaining its core portfolio, REN has total ownership over Enondas, S.A., a company that received a concession given by the Portuguese government to operate a pilot area with the goal to generate green electricity from the sea waves. With the green sustainability as a long-term strategy for the energetic system of Portugal, REN produces wind energy with its turbines spread over the Portuguese territory.

To pursue the strategic innovation business model of REN, the necessity for credible R&D projects with tangible results and by the inevitable need to secure financial assets for such investments, a significant consortium was made between the Portuguese company and the Chinese to build R&D Nester, based in Lisbon, the capital of Portugal, “Centro de Investigação em Energia REN—State Grid, S.A.,” with 50% of its shares owned by REN and the remaining by the State Grid Corporation of China (SGCC) via the China Electric Power Research Institute (CEPRI; Table 3; R&D Nester, 2018). Moreover, the goal was to synergize intellectual capital to promote and implement applied research in an international innovation context for smart and green energy systems.

As a result of strong R&D investments and green innovation corporate aspects (see Table 1), REN renewables production supplied over 60% of the electricity consumption in Portugal for the first quarter of 2018. REN published its net profit for the first quarter of 2018, resulting in €13.1M, an EBITDA of €128.4M, and a year-over-year increase of 3.8%, reflecting the integration of Portgás in its consolidated portfolio: Portgás per se contributed positively to the EBITDA with €10.9M (REN Press Release, 2018). This acquisition among others provides the means for REN to continuing pursuing R&D for a greener technology and business model, which can only be made through (i) top management innovation sponsorship, (ii) technology, research & development (R&D), and (iii) stakeholder engagement.

### Table 3. Projects Codeveloped and Funded by R&D Nester.

| Project codename | Project details | Funding scheme |
|------------------|-----------------|----------------|
| ISSWINDEMO       | “Integrated Supporting Services for the Wind Power Industry Demonstrator.” (European Space Agency, 2016) | European Space Agency (ESA) |
| SUSCITY          | “Urban data-driven models for creative and resourceful urban transitions.” (SusCity, 2016) | (i) Fundação para a Ciência e Tecnologia (FCT)  
                    (ii) Ministry of Education and Science—Portugal  
                    (iii) EDP  
                    (iv) ADENE  
                    (v) R&D Nester  
                    (vi) Novabase  
                    (vii) ITds |
| SMARTNET         | “The SmartNet project arises from the need to find answers and propose new practical solutions to the increasing integration of Renewable Energy Sources in the existing electricity transmission network. The subsequent technological (r)evolution is not only affecting the structure of the electricity markets, but also the interactions between TSOs and DSOs.” (SmartNet, 2018) | Total cost = EU contribution: €12,657,928.00  
                    European Commission—Horizon 2020  
                    22 partners from academia, research organizations, and industry from 9 European countries |
| BigDataOcean     | “Aims to enable maritime big data scenarios for EU-based companies, organizations and scientists, through a multi-segment platform that will combine data of different velocity, variety and volume under an inter-linked, trusted, multilingual engine.” (EU Publications Office, 2017) | European Commission—Horizon 2020  
                    Total cost: €3,566,172.50  
                    EU contribution: €2,998,569.50  
                    Coordinated in: Greece  
                    10 partners |
2.2.2. The Example of CRI in Iceland

CRI aims to recycle CO₂ from other businesses so that it can be transformed into liquefied fuel for vehicles specially designed for this type of energy. CRI named its first plant as George Olah, in honor of this author’s publication entitled “Beyond Oil and Gas: The Methanol Economy.” Presenting this enterprise example rather than exploring technological procedures will showcase the importance of stakeholders for the CRI R&D as well as some of the accomplishments of these consortiums.

According to Sousa and Martins (2018), “the creation of a business environment conducive to innovation necessarily involves the creation of a culturally open environment to receive new initiatives, the formation of new skills for innovation and technological development in companies and the business environment. This is a scenario that has to be built by all actors involved in the economic and social processes of the country.” The aforementioned George Olah plant is located in the proximities of the Blue Lagoon in Iceland, which is a thermal silica-infused water spa, for its emissions of carbon dioxide. Moreover, through the recycled geothermal energy from the same infrastructures that supply for the city of Reykjavik, the capital area, CRI can acquire its raw materials at a low cost compared to other European companies. The executives of this enterprise certainly understand that to contribute for a circular economy as a green innovation company, taking advantage of the low-cost prices that a circular economy can afford, would be the astute approach to partially financially leverage CRI in its continuous operations.

Nonetheless, this strategy per se does not deliver economic viability for their operations, nor sustainability: CRI did not have an IPO, at least yet, and its R&D is of such complexity that it requires financial, productive, and commercial partnerships. The company’s expansion plans included an increase from its current 5 million liters of fuel a year to 10 times larger in China, through CRI Ji Xin, a joint venture that CRI Iceland

| Project codename | Project details | Stakeholders |
|------------------|----------------|-------------|
| MefCO2 (EU Publications Office, 2016) | Synthesis of methanol from captured carbon dioxide using surplus electricity  
From December 1, 2014, to November 30, 2018, ongoing project  
Total cost: €11,041,537.46  
EU contribution: €8,622,292.60  
Coordinated in: Spain | I-Deals Innovation & Technology Venturing Services SL—Spain  
Kemijski Institut—Slovenia  
Mitsubishi Hitachi Power Systems Europe GmbH—Germany  
Cardiff University—United Kingdom  
CRI EHF—Iceland  
Universita Degli Studi Di Genova—Italy  
Hydrogenics Europe NV—Belgium  
Universitaet Duisburg-Essen—Germany |
| CIRCLENERGY (EU Publications Office, 2018) | Production of renewable methanol from captured emissions and renewable energy sources, for its utilization for clean fuel production and green consumer goods  
From December 1, 2017, to March 31, 2018  
Total cost: €71,429  
EU contribution: €50,000  
Coordinated in: Iceland | CRI EHF—Iceland |
| GAMER (EU Publications Office, 2018) | Game changer in high-temperature steam electrolysis with novel tubular cells and stacks geometry for pressurized hydrogen production  
From January 1, 2018, to December 31, 2020  
Total cost: €2,998,951.25  
EU contribution: €2,998,951.25  
Coordinated in: Norway | Stiftelsen Sintef—Norway  
Coorstek Membrane Sciences AS—Norway  
Agencia Estatal Consejo Superior De Investigaciones Cientificas—Spain  
CRI EHF—Iceland  
Universitetet I Oslo—Norway  
MC2 Ingenieria Y Sistemas SL—Spain  
Shell Global Solutions International BV—Netherlands |
incorporated, other than the existent shareholders Geely Holdings and Zixin Industrial Co. Notwithstanding the importance that the foreign capital brought into CRI to maintain its operational costs (the equity acquired by the Chinese investors) there is a contrast in the relationship of CRI with its stakeholders: the European Union partially co-funded R&D projects of CRI without taking part of it as a shareholder (acquiring equity) or receiving any annuities from an European Research. In the end, the intellectual property and revenues, resulted of CRI R&D will belong to the Chinese group, in proportion to its shares. Table 4 lists three of many EU projects in which CRI was an active member. MefCO2 is the project with the most available data about CRI R&D for public access, published in Cordis, the official website of the EU that publishes the mandatory reports for funded projects.

3. SCOPE OF THE REVIEW

A systematic search of online scientific databases using b-on, a scientific information research tool, was conducted in the middle of July 2018. The search was made using several queries, containing the keyword “green innovation.” The first results showed 617,641 articles, and if the keyword “energy” was included, 156 articles were listed. Finally, when the publication date criteria was set between “2015-2018” and “Scientific Reviews” included, 95 articles were listed. Only the articles reporting clear empirical data and a scientific methodology were considered for a more in-depth review (55) (Figure 1).

The summary of the articles organized by the research attribute is shown in Table 5.

The green energy attribute is the one with the most articles (34 or 62%), followed by the attribute green economy (12 or 22% of the articles) and, finally, green innovation (9 or 16% of the articles) as presented in Table 2 and Graph 1:

![Figure 1. Flowchart Outlining the Literature Review.](image)

![Graph 1. Percentage of Articles by Research Attributes.](image)
The analysis of the articles selected can be found in Table 6, which summarizes the research attributes and the major research topics of each selected article for this analysis.

For the analysis, it is essential to state what are (a) green innovation, (b) green economy, and (c) green energy:

(a) **Green Innovation**—Chen et al. (2006) defined green innovation as “hardware or software innovation in technology that is related to green products or process, consists of the innovation in...
| Author(s)/year(s)/title/journal | Attributes researched | Key research topics |
|--------------------------------|-----------------------|---------------------|
| Hodgson E, Ruiz-Molina M, Mararra D, Pogrebnyakova E, Burns C, et al. 2016. Horizon scanning the European bio-based economy: a novel approach to the identification of barriers and key policy interventions from stakeholders in multiple sectors and regions. Biofuels, Bioproducts & Biorefining 10(5): 508-522. | Green Economy | Bioeconomics; Emissions (Air Pollution); Europe; Stakeholders; Sustainable Development; Best-Worst; Best-Worst; Bio-Based; Bioeconomy; Biorefining; Bio-Based; Innovation System; Max-Diff; Max-Diff |
| Muscio A, Reid A, Rivera Leon L. 2015. An empirical test of the regional innovation paradox: can smart specialisation overcome the paradox in Central and Eastern Europe? Journal of Economic Policy Reform 18(2): 153-171. | Green Economy | Economic Development; Empirical Research; Europe; Eastern Europe; European Funding; O18; O31; O38; Public Spending; R11; R58; Strategic Planning; Regional Innovation Systems; Smart Specialization |
| Bergquist A-K, Söderholm K. n.d. Transition to greener pulp: regulation, industry responses and path dependency. Business History 57(6): 862. | Green Economy | Environmental Regulations; Paper Industry & The Environment; Paper Mills & The Environment; Path Dependence (Social Sciences); Pulpwood Industry; Sweden—Politics & Government; Sweden; Technological Innovations; United States; Business Strategies; Chlorine-Free; Dioxin; Environmental Legislation; Pulp and Paper (P&P); Technological Path-Dependency; The Us; Transition |
| Cowley R, Joss S, Dayot Y. n.d. The smart city and its publics: insights from across six UK cities. Urban Research & Practice 11(1): 53. | Green Economy | Bifurcation Theory; Business Enterprises; Government Policy; Great Britain; Smart Cities; Technocracy; Uk; Assemblage Theory; Future Cities; Public; Publicness; Smart Cities |
| Portney KE, Hannibal B, Goldsmith C, McGee P, Liu X, et al. n.d. Awareness of the food–energy–water nexus and public policy support in the United States: public attitudes among the American people. Environment & Behavior 50(4): 375. | Green Economy | Food; Government Policy; Public Opinion; United States; Water Power; Energy–Food Nexus; Public Opinion; Public Policy; Water-Energy Nexus; Water–Food Nexus |
| Carlet F. n.d. Understanding attitudes toward adoption of green infrastructure: a case study of US municipal officials. Environmental Science & Policy 51: 65. | Green Economy | Attitudes Toward Green Infrastructure; Green Infrastructure (Economics); Industrial Organization (Economic Theory); Innovation Adoption; Innovation Diffusion; Local Government; Municipal Officials & Employees; Technological Innovations; Technology Acceptance Model; Technology Acceptance; United States |
| Kaledinova E, Langerak T, Pieters R, Van Der Sterre P, Weijers SJCM. n.d. Learning from experiences in sustainable transport practice: green freight Europe and the implementation of a best cases database. Logforum 11(1): 78. | Green Economy | Cost Control; Economic Competition; Europe; Green Freight Europe; Green-Logistic; Innovations In Business; Sustainable Transportation; Willingness To Pay; Green Freight Europe; Green Logistics; Sustainability; |
| Author(s)/year(s)/title/journal | Attributes researched | Key research topics |
|--------------------------------|----------------------|---------------------|
| Barbose G, Darghouth NR, Weaver S, Feldman D, Margolis R, et al. n.d. Tracking US photovoltaic system prices 1998-2012: a rapidly changing market. Progress in Photovoltaics 23(6): 692. | Green Energy | Photovoltaic Cells—Sales & Prices; Pv; Renewable Energy Sources; Solar Energy; Solar Thermal Energy—Equipment & Supplies; United States; Cost; Historical; Photovoltaic; Price; Solar |
| Verhees B, Raven R, Kern F, Smith A. 2015. The role of policy in shielding, nurturing and enabling offshore wind in The Netherlands (1973-2013). Renewable & Sustainable Energy Reviews 47: 816-829. | Green Energy | Energy Policy; Empowering; Netherlands; Nurturing; Offshore Wind Power Plants; Offshore Wind; Policy; Renewable Energy Sources; Sustainability; Shielding; The Netherlands |
| Hannon MJ, Foxon TJ, Gale WF. 2015. ‘Demand pull’ government policies to support Product-Service System activity: the case of Energy Service Companies (ESCos) in the UK. | Green Energy | Product Service System (PSS); Sustainable business model; Government ‘demand pull’ policy; Energy Service Company (ESCo); Innovation system |
| Raunbak M, Zeyer T, Zhu K, Greiner M. 2017. Principal mismatch patterns across a simplified highly renewable European Electricity Network. Energies (19961073) 10(12): 1-13. | Green Energy | Electric Power Transmission; Europe; Renewable Energy Sources; Solar Energy; Spatio-Temporal Variation; Wind Power; Energy System Design; Large-Scale Integration Of Renewables; Principal Component Analysis; Renewable Energy Networks; Solar Power; Super Grid; Wind Power |
| Sgobbi A, Simões SG, Magagna D, Nijs W. 2016. Assessing the impacts of technology improvements on the deployment of marine energy in Europe with an energy system perspective. Renewable Energy: An International Journal 89: 515-525. | Green Energy | Carbon Sequestration; Eu28; Europe; Energy System Model; Low-Carbon; Marine Energy; Ocean Energy Resources; Ocean Energy; Renewable Energy Sources; Technological Innovations; Times |
| Dvarioniene J, Gurauskiene I, Gecievicius G, Trummer DR, Selada C, et al. 2015. Stakeholders involvement for energy conscious communities: the Energy labs experience in 10 European communities. Renewable Energy: An International Journal 75: 512-518. | Green Energy | Decision Making; Energy Consumption; Europe; Energy Conscious Communities; Energy Labs; Renewable Energy Sources; Stakeholders; Stakeholders’ Involvement; Sustainable Communities |
| Ruby TM. 2015. Innovation-enabling policy and regime transformation towards increased energy efficiency: the case of the circulator pump industry in Europe. Journal of Cleaner Production 103: 574-585. | Green Energy | Energy Conservation; Energy Consumption; Environmental Policy; Europe; Energy Efficiency Policy; Industry Driven; Innovation Processes; Pumping Machinery Industry; Regime Transformation; Technological Innovations; Voluntary Energy Labelling Agreement |
| Littlechild S. 2016. Contrasting developments in UK energy regulation: retail policy and consumer engagement. Economic Affairs 36(2): 118-132. | Green Energy | Customer Relations—Great Britain; Economic Competition; Energy Industries—Great Britain; Energy Policy; Government Regulation; Great Britain; Price Regulation—Great Britain; Consumer Engagement; Energy Regulation; Retail Competition |
| Author(s)/year(s)/title/journal                                                                 | Attributes researched | Key research topics                                                                 |
|-----------------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------|
| Geth F, Brijs T, Kathan J, Driesen J, Belmans R. 2015. An overview of large-scale stationary electricity storage plants in Europe: current status and new developments. Renewable & Sustainable Energy Reviews 52: 1212-1227. | Green Energy          | Electric Power Distribution Grids; Energy Storage; Europe; Pumped Hydro Energy Storage; Renewable Energy Sources; Review Current Status Europe; Stored Energy; Technological Innovations |
| Ifelebuegu AO, Aidelojie KE, Acquah-Andoh E. 2017. Brexit and Article 50 of the Treaty of the European Union: Implications for UK Energy Policy and Security. Energies (19961073) 10(12): 1-15. | Green Energy          | Brexit; British Withdrawal From The European Union; Energy Policy; Energy Security; European Union; Great Britain; Renewable Energy Sources; Shale Gas; Uk; Energy Policy |
| Rexhãuser S, Löschel A. 2015. Invention in energy technologies: comparing energy efficiency and renewable energy inventions at the firm level. Energy Policy 83: 206-217. | Green Energy          | Dynamic Count Data; Energy Conservation; Energy Consumption; Energy Efficiency; Europe; Innovation; Invention; Renewable Energy; Renewable Energy Sources; Technological Innovations |
| Lazarević A. n.d. The process of developing decentralised energy policies in the City of London. Energy & Environment 28(5/6): 639. | Green Energy          | Decentralization In Management; Developing Countries; Decentralized Energy Sources; Economic Development; Energy Policy; Great Britain; London (England); Renewable Energy Source Management; Strategic Planning; Energy Planning; Spatial Planning; Strategic Documents |
| Altenburg T, Sagar A, Schmitz H, Xue L. 2016. Guest editorial: comparing low-carbon innovation paths in Asia and Europe. Science & Public Policy (SPP) 43(4): 451-453. | Green Energy          | Asia; Carbon; Europe; Evolutionary Economics; Globalization; Government Policy; Technological Innovations |
| Newbery DM. 2016. Towards a green energy economy? The EU Energy Union’s transition to a low-carbon zero subsidy electricity system – lessons from the UK’s Electricity Market Reform. Applied Energy 179: 1321-1330. | Green Energy          | Auctions; Clean Energy; Contract Design; Electric Power; Electric Power Systems; Great Britain; Innovation Support; Renewable Energy Sources; Renewable Electricity; Support Mechanisms; Technological Innovations |
| Dyckman CS. 2016. Sustaining the commons: the coercive to cooperative, resilient, and adaptive nature of state comprehensive water planning legislation. Journal of the American Planning Association 82(4): 327-349. | Green Energy          | Sustainable Development; United States; Urban Planning; Water Laws; Water Management; Water Rights; Water Use; Social–Ecological Resilience; State Comprehensive Water Planning Legislation; Sustainable Commons Management |
| Regueiro-Ferreira R, García XD. n.d. Comparing wind development policies in Europe, Asia and America. Energy & Environment 26(3): 319. | Green Energy          | Asia; Energy Industries; Europe; Renewable Energy Sources; United States; Wind Power—Government Policy; Regulatory Framework; Renewable Energy; Wind Energy; Wind Promoters |

Continued
| Author(s)/year(s)/title/journal                                                                 | Attributes researched | Key research topics                                                                 |
|-----------------------------------------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------|
| Cohen R, Bordass B. 2015. Mandating transparency about building energy performance in use. Building Research & Information 43(4): 534-552. | Green Energy          | Electric Power Distribution; Electric Power Production; Electricity; Energy Consumption; Energy Policy; Great Britain; Management; Building Energy Use; Energy Benchmarking; Energy Efficiency; Energy Performance; Energy Policy; Energy Rating; Governance; Operational Rating Regulation |
| Lindman Å, Söderholm P. 2016. Wind energy and green economy in Europe: measuring policy-induced innovation using patent data. Applied Energy 179: 1351-1359. | Green Energy          | Energy Economics; Europe; Government Policy; Green Economy; Innovation; Patent Counts; Public Policy; Research & Development; Technological Innovations; Wind Power; Wind Power |
| Birch K, Calvert K. 2015. Rethinking “drop-in” biofuels: on the political materialities of bioenergy. Science & Technology Studies 28(1): 52-72. | Green Energy          | Biomass Energy; Carbon & The Environment; Energy Policy; European Union; Renewable Energy Sources; United States; Bio-Economy; Bioenergy; Drop-In Biofuels; Political Materialities; Sustainable Transitions |
| Strachan PA, Cowell R, Ellis G, Sherry-Brennan F, Toke D. 2015. Promoting community renewable energy in a corporate energy world. Sustainable Development 23(2): 96-109. | Green Energy          | Carbon & The Environment; Communities; Energy Consumption; Great Britain; Renewable Energy Costs; Scotland; United Kingdom; Community Energy; Devolution; Energy Transition; Renewable Energy; Sustainable Development |
| Pollans MJ. 2015. Regulating farming: balancing food safety and environmental protection in a cooperative governance regime. Wake Forest Law Review 50(2): 399-460. | Green Energy          | Agricultural Laws & Legislation; Agriculture—Methodology; Cost Effectiveness; Environmental Protection—United States; Food Safety Measures Laws; Government Policy; Government Regulation; Harvesting; United States; United States. Food & Drug Administration |
| Renewable energy innovation ‘hub’ opens in UK’s Western Isles. 2015. Renewable Energy Focus 16(3): 10. | Green Energy          | Clean Energy; Great Britain; Partnership (Business); Renewable Energy Sources; Western Isles (Scotland) |
| Cohen S. 2015. What is stopping the renewable energy transformation and what can the US government do? Social Research 82(3): 689-710. | Green Energy          | Electric Power Production; Energy Policy—United States; Government Policy; Government Policy On Renewable Energy Sources; Infrastructure (Economics)—United States; Political Systems; Technological Innovations—United States; United States |
| Curtin J, McNerney C, Johannsdottir L. n.d. How can financial incentives promote local ownership of onshore wind and solar projects? Case study evidence from Germany, Denmark, the UK and Ontario. Local Economy 33(1): 40. | Green Energy          | Capital Investments; Citizens; Denmark; Germany; Great Britain; Labor Incentives; Ontario; Renewable Energy Sources; Citizen; Financial; Incentive; Investment; Local; Renewable |

Continued
| Author(s)/year(s)/title/journal | Attributes researched | Key research topics |
|---------------------------------|-----------------------|---------------------|
| Hammond GP, O’Grady Á. n.d. The potential environmental consequences of shifts in UK energy policy that impact on electricity generation. Proceedings of the Institution of Mechanical Engineers – Part A – Power & Energy (Sage Publications, Ltd.) 231(6): 535. | Green Energy | Biomass Energy; Carbon Sequestration; Electric Power Production; Energy Policy; Electricity Futures; Fossil Fuels; Great Britain; Bioenergy; Carbon Capture And Storage; Fossil Fuels; Life-Cycle Assessment; Policy Shifts; Sustainability |
| Price CW, Zhu M. 2016. Non-discrimination clauses: their effect on british retail energy prices. Energy Journal 37(2): 111-132. | Green Energy | Autoregressive Processes; Deregulation; Economic Competition; Energy; Great Britain; Nondiscrimination Principle (International Law); Non-Discrimination; Petroleum Sales & Prices; Retail Industry; Regulation; Vector Autoregressive Model |
| Drummond P, Ekins P. 2016. Reducing CO₂ emissions from residential energy use. Building Research & Information 44(5/6): 585-603. | Green Energy | Commercial Policy; Carbon Dioxide Reduction; Energy Consumption; European Union Countries; Great Britain; Greenhouse Gases; Buildings; Climate Policy; Energy Efficiency; Energy Policy; Policy Formation; Policy Measures; Regulations |
| Schweber L, Lees T, Torriti J. 2015. Framing evidence: policy design for the zero-carbon home. Building Research & Information 43(4): 420-434. | Green Energy | Built Environment; Carbon & The Environment; Energy Policy; Government Policy; Great Britain; Policy Sciences; Building Regulations; Energy Policy; Evidence-Based Policy; Net-Zero; Policy Design; Policy Formation; Public Policy; Regulatory Impact Assessments; Zero Carbon |
| de Boer J, Zuidema C, van Hoorn A, de Roo G. 2018. The adaptation of Dutch energy policy to emerging area-based energy practices. Energy Policy 117: 142-150. | Green Energy | Adaptation; Energy Initiatives; Energy Policy; Environmental Impact Analysis; Local; Netherlands; Renewable Energy; Renewable Energy Sources; Technological Innovations; The Netherlands |
| Cheng M-H, Yang M, Wang Y. 2016. American’s energy future: an analysis of the proposed energy policy plans in presidential election. Energies (19961073) 9(12): 1-17. | Green Energy | Energy Consumption; Energy Policy; Government Policy; Government Policy On Renewable Energy Sources; Least Squares; Presidential Candidates; Regression Analysis; United States; United States Presidential Election; Energy Future; Party Polarization; President Election; Public Opinion; Renewable Energy |
| Potončnik J, Khosla A. 2016. Examining the environmental impact of demand-side and renewable energy technologies. Journal of Industrial Ecology 20(2): 216-217. | Green Energy | Renewable Energy Sources; Supply & Demand; Technological Innovations; Technological Innovations In Environmental Protect; United States |
| Keijzer EE, Leegwater GA, de Vos-Effting SE, de Wit MS. n.d. Carbon footprint comparison of innovative techniques in the construction and maintenance of road infrastructure in The Netherlands. Environmental Science & Policy 54: 218. | Green Energy | Comparative Studies; Carbon Footprint; Ecological Impact; Greenhouse Gas Mitigation; Green Procurement; Infrastructure; Innovation; Netherlands; Pavements; Road Design & Construction; Road Maintenance & Repair; Technological Innovations |

Continued
| Author(s)/year(s)/title/journal | Attributes researched | Key research topics |
|--------------------------------|----------------------|---------------------|
| Hicks AL, Theis TL, Zellner ML. 2015. Emergent effects of residential lighting choices: prospects for energy savings. Journal of Industrial Ecology 19(2): 285-295. | Green Energy | Consumers; Energy Consumption; Light Sources; United States; Visual Environment; Agent-Based Modeling (Abm); Agent-Based Modeling (Abm); Complex Systems; Life Cycle Assessment (Lca); Light Emitting Diodes; Lighting; Rebound |
| Watson KJ. n.d. Understanding the role of building management in the low-energy performance of passive sustainable design: practices of natural ventilation in a UK office building. Indoor & Built Environment 24(7): 999. | Green Energy | Building Management; Building Management; Energy Conservation In Buildings; Energy Consumption Of Buildings; Great Britain; Natural Ventilation; Natural Ventilation; Office Buildings & The Environment; Passive Sustainable Design; Performance Gap; Sustainable Development; Social Practices |
| Dey S. n.d. Does a robust patent regime discourage innovation? Economics of Innovation & New Technology 25(5): 485. | Green Innovation | L00; L24; License Agreements; O34; Patent Applications; Patent Paradox; Semiconductor Industry; Technological Innovations; United States; Complex Industries; Licensing |
| Schmitz H, Altenburg T. 2016. Innovation paths in Europe and Asia: divergence or convergence? Science & Public Policy (SPP) 43(4): 454-463. | Green Innovation | Asia; Europe; Globalization; Technological Innovations; Technology Convergence; Carbon Lock-In; Convergence; Divergence; Dominant Design; Innovation Path; Low Carbon Innovation |
| Hansen E, Knowles C, Larson K. n.d. A modified lead-user approach for new product development: an illustration from the US of a marketing research tool for the forest industry. International Wood Products Journal 6(3): 131. | Green Innovation | Forest Products Industry; Forests & Forestry; Innovations In Business; Innovation; Lead-Users; Marketing Research; New Product Development; New Product Development; Success In Business; United States |
| Rainville A. 2017. Standards in green public procurement – a framework to enhance innovation. Journal of Cleaner Production 167: 1029-1037. | Green Innovation | Commercialization; Environmental Impact Analysis; Europe; Eco-Innovation; Government Purchasing; Green Public Procurement; Pre-Commercial Procurement; Public Purchasing; Standardization; Standardization; Standards; Technological Innovations |
| Bryson D, Atwal G, Chaudhuri A, Dave K. 2016. Antecedents of intention to use green banking services in India. Strategic Change 25(5): 551-567. | Green Innovation | Anking Industry; Europe; Green Marketing; Social Responsibility of Business; Stakeholders; Sustainable Development |
| Scarpellini S, Valero-Gil J, Portillo-Tarragona P. 2016. The “economic–finance interface” for eco-innovation projects. International Journal of Project Management 34(6): 1012-1025. | Green Innovation | Business Planning; Corporate Finance; Eco-Innovation; Europe; Organizational Aims & Objectives; Project Management; Sustainable Development; Technological Innovations |
| Peyravi B. 2015. South East European Countries: the needs of innovations in the context of enlargement of the European Union. Public Administration (16484541) 3/4(47/48): 112-120. | Green Innovation | Economic Competition; Economic Development; Europe; European Union; Innovation; Job Creation; South East European Countries; Sustainable Development; Transfer; |
technology like energy-saving, waste recycling, green product designs or corporate environmental management. From the various definition of green innovation existing in the previous literature, this paper then concludes it as a new environmental approach, idea, product, process or services that concern on minimizing negative environmental impact and also create differentiation of developed product among competitors. Green innovation is categorized into four types of innovations including (i) product innovation, (ii) process innovation, (iii) managerial innovation, and (iv) marketing innovation."

(b) **Green Economy**—has been defined by UNEP (2011) as one that results in improved “well-being and social equity, while significantly reducing environmental risks and ecological scarcities” and it is “low-carbon, resource efficient and socially inclusive” focus on the “preservation of natural capital, which includes ecosystems and natural resources.”

(c) **Green Energy**—“is clean sources of energy that have a lower environmental impact compared to conventional energy technology. It plays a significant role in the strategic energy planning process for any country” (Bhowmik *et al*., 2017).

### 4. GREEN INNOVATION MODEL PROPOSAL FOR ORGANIZATIONS

Innovation is crucial to organizations particularly in encouraging the creation of new products and services, and in the implementation of new practices and processes. In this context, two elements need to be managed together: people and knowledge. Assuming that people are the source of knowledge, practices such as communication, skills development, and recognition are core to promote innovation in organizations. Consequently, it is essential to implement mechanisms for a systematic involvement of employees, either through meetings, technological platforms allowing discussion forums or specific systems of innovation. Besides those as mentioned earlier, it is necessary to highlight the importance of such mechanisms as personal support for solving problems, identifying solutions, and creating new ideas in the workplace. Knowledge sharing practices have a profound effect on the creation of an innovation culture, and in developing conditions to implement new management practices and organizational changes. The model in Figure 2 proposes a set of dimensions that should be nuclear to any green organization:

The most critical questions (see Table 2) that organizations should answer and reflect when adopting and implementing a model of green innovation should be the following:

1. Do we invest in low-carbon technologies for our production processes?
2. Do we use specific environmental policy for selecting our partners?
3. Do we invest in R&D programs to create environmentally friendly products/services?
4. Do we make efforts to use renewable energy sources for our products/services?
5. Do we have created a separate department/unit specializing in environmental issues for our organization?
6. Do we participate in environmental business networks?
7. Do we engage in dialogue with our stakeholders about the environmental aspect of our organization?
8. Do we implement research to detect green innovation needs in the market?
9. Do we target environmentally conscious consumers?
10. Do we use recycled or reusable materials in our products/services?
11. Do we absorb the extra cost of an environmental product/service?

When answering those questions, the organizations can define a strategy based on the dimensions of green innovation, green energy and green economy.

5. CONCLUSION

The political and economic environment plays a vital role in entrepreneurship development (Sousa et al., 2018) and most of the enterprises that dedicate a significant part of their resources in R&D for green energy, regardless of their contribution for a circular economy as part of the business model, shall be considered entrepreneurs if they pursue the commercialization of that same technology.

This paper included two brief situation analysis of REN and CRI, both enterprises highly engaged with their stakeholders, national and international business networks, and intending to raise capitals and to acquire specialized human capital. Notwithstanding, Portugal does not have as many natural resources regarding green energy as Iceland does; however, REN holds the management of most of electric and gas distribution while CRI is a medium enterprise without a significant commercial and industrial market share. Moreover, CRI has been financially resilient to continue its pursuit of a greener energy within a circular economy business model while REN continues to expand its R&D projects and will comply with its vision for 2018-2021, defining three objectives as: (i) to consolidate the core business and maintain
operational excellence that characterizes REN operations, (ii) maintain a discipline of growth, and (iii) ensure a solid financial performance.

Green energy is the predominant research topic found in the literature review; however, green economy and green innovation present potential from the social science subjects, that is, management and business administration. Finally, it appears to be correct to infer that successful businesses that promote green innovation have common traces of (i) top management innovation sponsorship, (ii) technology, research & development (R&D), and (iii) stakeholder engagement.

6. LIMITATIONS AND FUTURE RESEARCH

New expectations of technological innovation are emerging as this research field is becoming strategically crucial for organizations. In this context, a consistent framework needs to be developed. Directly related to the findings from this research, other aspects could be developed:

• A model for facilitating the creation of an innovation culture in large and small organizations.
• A case study of an implementation of the model and its implications on the organization.
• The creation and applicability of an instrument to diagnose innovation profiles in organizations is also a potential for people involvement and development. The results could be used in the training plans to develop organizational actors’ potential for innovation.

Further research could also be undertaken:

• Studies on innovation processes integration across organizational functions and in several types of organizations.
• Studies that develop and test a theoretical framework that relates innovation and organizational outcomes.
• Studies that analyze the capabilities of employees’ informal networks to achieve efficient integration of innovations into their work practices.

Furthermore, future studies are required to determine the importance of different types of innovation for different organizational activities.

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