Techno-economic assessment of new energy technologies: case study

A thesis submitted in fulfilment of the requirements for the Master's degree in Business Administration and Total Quality Management

by

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2017

Acknowledgements

This thesis would not have been possible without the efforts of my supervisor, Professor Dimitrios Georgakellos. His unwavering enthusiasm, support and genuine concern were utterly conducive to the realisation of this study. I am also greatly indebted to Eleni Didaskalou, Assistant Professor at the University of Piraeus, for her contribution to my searches.

Abstract

This thesis examines the implementation of new energy technologies in organisations and assesses techno-economically a solar photovoltaics technology. The study is partitioned into three main parts.

The first part comprises the literature review, with primary focus given on innovation and energy efficiency and the tangential relevance that these elements have on securing a sustainable future. The words “new” and “energy technologies” represent the latent notions of “innovative technologies“, “energy-efficient technologies”, “clean technologies” and “energy management practices” within this thesis’ purview. In order to cover the economic dimension of those notions, heed was given to the nexus between innovation and economic growth as well as the nexus between energy efficiency and economic growth. At the end of the first part, a reference is also made to some of the world’s new energy technologies.

The second part constitutes a research on the relationship between an organisation’s approach towards innovation and the incorporation of energy management practices within its functions. The flimsy attention given to this topic in Greece, acted as a jumping-off point for this research. Besides, any nuggets of information would be a contribution to the existent literature, while it would potentially kindle other researcher’s interest and serve as an inception work for anyone willing to delve deeper

into the subject. The survey was conducted with the use of questionnaires and included 278 organisations with offices and registered activity within the region of Attica (but not strictly confined to this specific region). The method of sampling technique adopted was stratified sampling – probability method - in order to produce as due results as possible.

The third part, following the interest of this thesis on the investigation of new energy technologies, presents a techno-economic analysis of a relevant technology. The project explores the siting of solar photovoltaics on areas, which are potentially contaminated (brownfield lands) and is based on a real feasibility study carried out by the National Renewable Energy Laboratory (NREL) of the USA. Specifically, the project refers to a commercial-scale PV system with 348kW installed capacity, privately purchased and with a power purchase agreement (PPA) in place. The land, though is assumed state-owned. In the third part, useful information about conducting a techno-economic analysis are cited as well, among them the strengths and weaknesses of each investment appraisal technique.

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1.1 Innovation

1.1.1 Defining innovation

Innovation, although as old as mankind itself, has been studied as a separate field of research within the 20th century. Defining innovation has been occupying researchers' interest for decades, as it is believed that the definition given to innovation breeds some critical organisational implications (e.g. what should be produced internally and what should be outsourced) (Popa et al., 2010).

The first economist who attempted to analyse the process/model of innovation in a structured way, Joseph Schumpeter (1930), provided various definitions of innovation: from the introduction of a new product and the discovery of a new market to the development of new sources of supply and a new process of innovation in an industry (Popa et al., 2010). In the same paper one also finds other authors' definitions of innovation. Hence, there are more general definitions like Simmonds' (1986) that innovation is a basic creative process, Damanpour's (1991) that innovation is the development of new ideas by a firm, Davenport's (1991) that innovation is the development of a task in a radically new way or Henderson and Lentz's (1995) that innovation is the implementation of innovative ideas. An interesting approach towards innovation is taken by Rogers (2010), who extensively investigated the diffusion of innovations, defined innovation as "an idea, practice or object that is perceived as new by an individual or other unit of adoption". To that perspective, he argued that it matters little whether or not this idea is "objectively" new; newness is indifferent of time lapse and "perceived newness" is important, which can be expressed with respect to knowledge, persuasion or decision to adopt. Innovation has also been defined within oragnisational boundaries, since the way an organisation defines innovation is inextricably linked to its strategic orientation (Popa et al., 2010). The authors refer to existing literature that gives evidence of the fact that organisational strategy, which involves marketing orientation, orientation towards learning and towards technology, is related to the degree and nature of organisational innovation, which in turn is tightly connected to the initial definition of innovation. As a result, the way an organisation defines innovation at first is definitive. This criticality has been manifested in Peter Drucker's work already since 1954. Drucker (2008), postulates that innovation is the mainstay of an organisation, which "has two – and only these two – basic functions: marketing and innovation". Other authors, like Howard and Sheth (1969) stated that any element brought to the buyer, whether or not new to the organisation is considered as innovation, Mohr (1969) referred to innovation as the degree to which specific new changes are implemented in an organisation, while Simmonds (1986) reported that innovation is a set of new ideas consisting of new products and services, new use of existing products, new markets for existing products or new marketing methods (Popa et al., 2010). Boer (2001) supports that innovation is the creation of a new product-market-technology-organisation-combination (PMTO-combination) and compares three types of innovation, namely, product, process and organisational innovation. A more recent definition of innovation includes F. Gault's (2015). The author tried to create a generalised definition applicable to all sectors of the economy. He came up with the following definition: "an innovation is the implementation of a new or significantly changed product (a good or service) or process (production or delivery, organisation, or marketing processes). He also argued the necessity for innovation to be measured and, to that extent, it must be defined for statistical purposes, without excluding the requirement that a product be brought to the market.

1.1.2 Innovation models

However, the focus has mainly been not strictly on the definition of innovation itself, but on how innovation works and many theories have been introduced in order to explain the latter. The first models were developed in the first half of the 20th century and were mainly represented by Joseph Schumpeter. These were the older linear models with the identification of three stages of the process: invention, innovation and diffusion (Greenacre et al., 2012). Schumpeter (1934) was the first to underpin the distinction between invention and innovation in capitalism, because, in his opinion "as long as they are not carried into practice, inventions are economically irrelevant". He also claimed that the disturbance factor of economical equilibrium is the power of innovation, something considered as endogenous to the economic system (Croitoru, 2008). During the 1950s and 1960s the theories of technology push versus demand pull were introduced (Nemet, 2007), while during the 1970s and 1990s some conceptual approaches were addressed, notably these of induced innovation, evolutionary and path-dependent models (Ruttan, 2000) as well as additional concepts that lean towards a systems approach (Greenacre et al., 2012). In the years up to 2000 and throughout the 21st century, that approach was enhanced to the level of a fully systemic dynamic, non-linear process that involves a range of interacting actors. Hence, nowadays, it is unanimously accepted that innovation is a systemic phenomenon by its nature (Fagerberg, 2003), since it is the result of the unceasing interaction between numerous actors.

1.1.3 Technological innovation

The systemic notion of innovation can be used to define technological innovation as well. Technological innovation is part of the total innovation discipline (Vaughan, 2013) and consists of three elements: invention, realisation and implementation. Invention is the generation of a new idea based on technology capability or knowledge. Realisation is the development of this new idea into a reality or product, while implementation bears the meaning of diffusion and marketing of this new idea. Other definitions of technological innovation found in literature all make some reference to at least one of the aforementioned three elements. Therefore, with reference to the invention attribute one finds the definition of Edosomwan (1989) "the creation of new idea for a product, process or service…new combination of pre-existing knowledge". Freeman (1982), by stating that "industrial innovation includes the technical design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or first commercial use of a new (or improved) process or equipment", incorporated the aspect of realisation. Implementation in innovation was pinpointed by Utterback and Abernathy under the statement "…a new technology or combination of technologies introduced commercially to meet a user or market need". Vaughan (2013) proposes an integrated working definition of technological innovation as follows:

- To conceive and produce a new solution (from a scientific and technological knowledge) to a real or perceived need (Invention).

- To develop this solution into a viable and producible entity (Realisation).
- To successfully introduce and supply this entity to the real or perceived need (Implementation).

Another popular type of innovation in the 21st century, with a relation to the present thesis, is that of eco-innovation. Eco-innovation was defined by OECD (2009) as "the creation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which - with or without intent - lead to environmental improvements compared to relevant alternatives".

1.1.4 Innovation, spillovers and economic growth

Innovation in modern societies is considered to be the linchpin of long-term, sustainable economic growth. Subsequently, evidence is provided from the existent literature that aims to highlight the contribution of both innovation and its technological/knowledge spillovers to economic growth.

Among many others, Griliches (1980) investigated the relationship between various measures of company productivity and investments in R&D innovation and gave evidence of a consistent positive relationship. This conclusion was reinforced by IMF's research findings, which denoted the strong positive relationship between innovation (patent stock) and per capita GDP in both OECD and non-OECD countries (Ulku, 2004). Zooming in to the firm level, evidence accords with the results mentioned. Cainelli et al. (2004) proved a positive impact on growth and productivity in service firms and, specifically, the higher the level of innovation expenditure in ICTs, the better is the economic performance of firms in terms of productivity. Innovation, when studied by G. Cameron in 1996, was also found to make a significant contribution to economic growth, while two more conclusions were documented:

- Cameron showed that significant spillovers were created between countries, firms and industries. Technological or R&D spillovers are positive externalities (Arrow, 1962) and are generated when "(1) firms can acquire information created by others without paying for that information in a market transaction, and (2) the creators (or current owners) of the information have no effective recourse, under prevailing laws, if other firms utilise information so acquired" (Grossman and Helpman). Dumont and Meeusen's (2000) definition is closer to 'layman's terms': "Technological or R&D spillovers are most often defined as externalities, with agents unable to fully appropriate all benefits from their own R&D activities".

- He also proved that spillovers have a tendency to be localised, something many authors agree on. Numerous similar references to the geographical dimension of knowledge spillovers can be found in Audretsch and Feldman's (2004) paper as well.

In the past decades, a body of empirical work on knowledge spillovers indicated an undisputable linkage with innovation and economic growth. Romer (1986) showed that, under certain conditions, a given firm is more productive the higher the average knowledge stock of other firms, thus endogenous growth is formulated due to knowledge externalities (Klenow, 2004). Van Stel's (2004) empirical evidence, using data covering the entire Netherlands, supported the theory of Jacobs (1969), who assumed a positive effect of local competition and spillovers that emerge from diverse enterprises. Capello after studying the influence of regional growth spillovers on competitiveness in 27 member countries, concluded that there is a tendency of a diffused development in the Western part of Europe, whilst the phenomenon is even more intense in the Eastern part of Europe.

Aside from the economic performance enhancement, spillovers can also instigate other companies' product activity. Cappelli et al. (2013) found that spillovers from rivals tend to cause more imitation (products new to the firm), while inputs from customers and research institutions tend to enhance original innovation (products new to the market) within the firm. However, although incoming spillovers have a positive effect on a firm's performance, outgoing ones significantly dwindle profits; the more unconstrained knowledge flows are among competitors the less the profitability (Czarnitzki and Kraft, 2011). The contribution of spillovers to the economy is unequivocal according to Madsen (2007). The author used data from 13 OECD countries over the past 120 years and showed that import technology spillovers have been responsible for approximately 200% increase in total factor productivity (TFP) –

TFP is the portion of output not explained by the amount of inputs used in production (Comin, 2010). Thus, without the contribution of spillovers the average person in the OECD countries would have had 1/3 of the present income.

Today, scientific communities and industries both share the same view. Innovation is imperative. In 2005, the internationally recognised expert in the field of innovation management Robert G. Cooper succinctly described the grim future that awaits organisations failing to innovate in this quote “it is war: innovate or die”. Unfortunately, Greece is lagging behind other countries in the European Union in terms of innovation. According to Suriñach et al. (2009) innovation and its adoption in Greece are weak and the same applies to R&D, human capital and cooperation. The level of economic freedom is lower than the EU average, whilst the protection methods of innovation are not widely deployed either. Market size also plays an important role for effective R&D sectors. Acemoglu and Linn (2003) emphasised on that, while Ulku (2004) at a similar tone showed that only larger markets are able to enrich their innovation by investing in R&D.

However, Ulku’s research also showed that the OECD countries that lack effective R&D sectors seem to harness technology spillovers from other OECD countries in order to improve their innovation. These imports should not be considered as causes for debt creation, but as income growth stimulus (Madsen, 2005). Additionally, Madsen’s results proved that the largest beneficiaries from technological spillovers were predominantly the OECD countries with the lowest TFP, something that gives proof of convergence. In the same line of argument of R&D spillovers transmitted via trade imports, Bournakis (2011) concluded that countries like Greece with low TFP experience faster rates of growth than high-TFP countries and, interestingly enough, the higher is the TFP gap the faster the rate of TFP growth over the examined period of time. One can detect in his findings that Greek manufacturing industries in 1980 were 10% productive compared to their German counterparts, whilst in 2003 the same industries had almost closed this gap, meaning that countries like Greece with low TFP experience faster rates of growth than high-TFP countries.

Greece can reap the benefits of both its own innovation efforts and simultaneously exploit the positive externalities that result from adopting or imitating other countries’ incoming spillovers (technological or R&D):

- Fostering domestic innovation would boost TFP and overall economic growth at the industry and firm level as well. The means by which the promotion of innovation could best be facilitated would be of special interest to the policy maker. It should, however, be borne in mind that the subsidisation of firms' R&D should not be underestimated, since social returns are larger than private ones (Czarnitzki and Kraft, 2011)
- The adoption or imitation of innovation would have a more indirect effect upon the economic indicators i.e. productivity, because spillovers appear to stimulate growth by affecting the absorptive capacity of an industry. Even if, currently, an industry cannot itself develop and produce new technological products, it would become familiarised by using novel technologies developed abroad (Bournakis, 2011)

1.2 Energy efficiency

1.2.1 Importance of energy efficiency

At the perspective of the present thesis, innovation is aligned with energy efficiency and together posit a conduit for delivering sustainability. A sustainable energy system is defined as a triangle (often referred to as Energy Trilemma), which does not compromise any of its three elements: security of supply, economics and environment (Wyman, 2013). Renewed attention is being given to energy efficiency as a fundamental guarantor of sustainability. Its environmental contribution is indisputable – it accounts for approximately 40% of the GHG emissions abatement potential (Enkvist et al., 2010), while its economic contribution is also definitive (examined in the next chapter). With regards to security of supply, energy efficiency helps countries decouple from the domestic dependence to fossil fuels, which induces severe geopolitical costs (Weiss and Bonvillian, 2009). The importance of having alternatives in terms of energy supply should not be underestimated. Energy supply is intertwined with economic development (Ozturk, 2010). Ozturk takes as axiomatic that energy consumption (and thereby energy supply) is an essential input for economic activities, but he is more interested in the causality relationship of the two, namely electricity consumption and economic growth. He concludes that this direction runs from the former to the latter, suggesting that a potential risk of energy supply would have adverse impacts on economic growth. In line with Ozturk (2010), Killian's (2007) survey showed that precautionary oil demand shocks caused by fears about future oil supply shortfalls, lead to "immediate and large effects on the US economy". Similar implications could be drawn from Stern's (2004) study, too. As a consequence, all three factors of the Energy Trilemma that demand to be in balance make energy efficient technologies justifiable and necessary.

More efficient use of energy throughout a product's lifecycle and at every link of the supply/demand chain would stop environmental deterioration, without compromising economic development (REEEP). On the contrary, it would save all actors of energy use various costs, as mentioned in the report: first of all, the energy end-user would enjoy reduced operating costs, and the private sector would also enhance its profitability from cost-savings; then for the nations worldwide it would mean decreased energy imports and, therefore, increased energy supply security within the countries, while indirectly the reduced prices of traditional energy sources would allow less prosperous countries develop energy-dependent activities; society as a whole would benefit, because tapping into novel or existing technologies that promote energy efficiency would mitigate energy consumption and thus environmental footprint. In any case, more efficient use of energy and energy supply from a growing proportion of carbon-free sources is necessary, given that resources (mainly fossil fuels) are finite and will at some point be depleted.

1.2.2 Energy efficiency and economic growth

Energy efficiency measures are not cost-free, although they can range remarkably depending on the technology involved. However, while they involve costs, they can also reduce the cost of energy purchase and pay off financially. The Energy Efficiency and Economic Growth (Vivid Economics, 2013) report that was prepared for the Climate Institute intended to investigate exactly this relationship between energy efficiency and economic growth by incorporating advanced statistical methods. They studied a group of 28 OECD countries (meaning that the findings are not representative of a single country) over the last three decades and the outcomes of the research proved a positive correlation between energy efficiency and economic growth. However, the researchers emphasise on the “notorious difficulty” of estimating energy efficiency itself and so the relation between the two elements subject to study was indirectly derived from. Specifically, they extracted their results by observing the effects of energy efficiency on energy productivity and then, in turn, on output (implying economic growth). That was an accurate assumption, since energy productivity enhancement boosts economic growth, even without imposing a tax on carbon emissions (Sorrell, 2010; Sorrell et al., 2011). Referring to the national level, researchers K. Greven et al. addressed the contribution of energy efficiency to economic development in Germany providing a summary of their results in McKinsey’s compendium (Kiely, 2010). Indeed, they revealed that energy efficiency can act as a competitive advantage for a specific country. Businesses in energy-intensive sectors would be the main beneficiaries of this competitive advantage against their competitors. According to IEA estimates IEA’s (2014) EU’s GDP would see a 1.1% increase, would energy productivity double by 2030. Similarly, the Econometrics report in 2015 assessed the employment and social impact of energy efficiency including a thorough literature review. Its findings suggest that energy efficiency investments have a positive impact on GDP and employment with a range of other benefits on society in general. The case that employment can be stimulated is related to the fact that energy efficiency measures are predominantly characterised by labour intensity. Surveying the macroeconomic effects (economic output and job creation) of energy efficiency investments, Howland et al. (2009) gave evidence that the combined economic benefits exceed the overall spending for these investments. Still from a macroeconomic point of view, when energy efficiency promotes cost savings and energy demand reduction it affects the entire economy, since this spare disposable income/profit can be spent (in the case of individuals), reinvested (in the case of productive sectors) or it can be indirectly expanded as a result of lower output prices (IEA, 2014).

What would happen, however, if energy consumption reached very low levels due to the impacts of energy efficiency? Is energy such a crucial factor of economic development that growth cannot be realised without even (or around even) increases in per capita energy consumption? If ‘yes’, then the prospects about either energy efficiency or economic growth would not be optimistic. Nevertheless, the findings of a research conducted in 2007 were encouraging. The authors (Gales et al., 2007) investigated energy consumption over 200 years in Sweden, Holland, Italy and Spain and their research included both traditional and modern energy carriers. Interestingly enough, while our economies have developed significantly, our societies' economic growth seems to be decoupled from energy consumption intensity (Figure 1), partly because of energy efficiency and technical advance (Gales et al., 2007; Vivid Economics, 2013). In other words, there has been a long-term reduction of per capita energy consumption, whilst at the same time more GDP has been created per unit of energy. Thus, literature is constantly enriched with solid and conclusive data, challenging even the more sceptics with arguments towards energy efficient technologies.

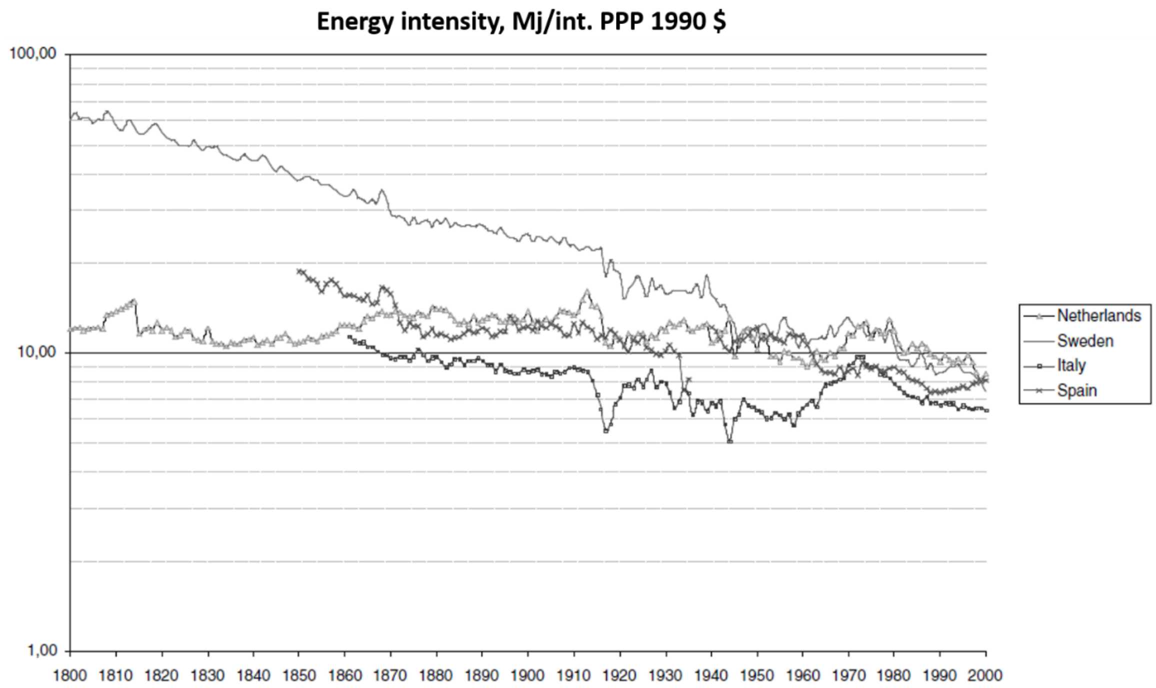


Figure 1. Energy intensity over time. Adapted from Gales et al., 2007.

1.2.3 The "energy paradox"

Despite the grounded reasons for governments to adopt energy efficient technologies in order to tackle GHG emissions, reduce domestic dependence on foreign energy supply and stimulate their economies, there are a number of publications that identify a contradiction. These technologies appear to be adopted by consumers and businesses in a less than justifiable extent, even on a financially favourable for them basis (Gerarden et al., 2015). This is often referred to as the “energy paradox” (the case of not adopting some energy-efficient technologies that would pay off for adopters) or in its broader manifestation it is referred to as the “energy-efficiency gap” (the case of not adopting some energy-efficient technologies that would be socially optimal). This phenomenon has been examined by numerous researchers, among them (York et al., 1978; Schleich and Gruber, 2008; Jaffe and Stavins 1994; de Groot et al., 2001). Thollander (2010), who explain that certain barriers exist that hamper investments towards energy efficient technologies, which are economically efficient at the same time. These barriers could vary widely in terms of context and categorisation, depending on the researcher. For example, Gerarden et al. (2015) have built on existing literature in order to classify barriers to energy efficiency and divided them into three categories, namely: market failures (e.g. liquidity constraints or information spillovers), behavioural anomalies (e.g. systematically biased beliefs) and model and measurement errors (e.g. the use of incorrect discount rates). When investigating the energy-efficiency gap in three countries simultaneously (Ireland, United Kingdom and Germany), O’Malley et al., 2003 concluded that in most organisations there were many cost-effective potential investments that were left out. Access to capital and hidden costs were identified as the main barriers, with the former meaning a reluctance to borrow due to stringent payback criteria and the latter meaning time requirements by energy management staff. In a more recent similar study, those hidden costs were again found to form the foundation of the “energy-efficiency gap” explanation (Sorrell, 2011). Notwithstanding, the overall neglect of potentially profitable energy efficient opportunities does not lie exclusively on barriers with high relative importance, yet their aggregated effect should be considered instead. Another important distinction that needs to be made among barriers according to Jaffe et al. (2004) is the one between market failure and non-market failure. They also note that the time lag between energy efficiency initial costs and expected benefits of future cost-savings is why “discount rates” are often examined in the “energy paradox” literature. Figure 2 represents an interesting graphical visualisation of their work, where different “actors’” optimums are illustrated.

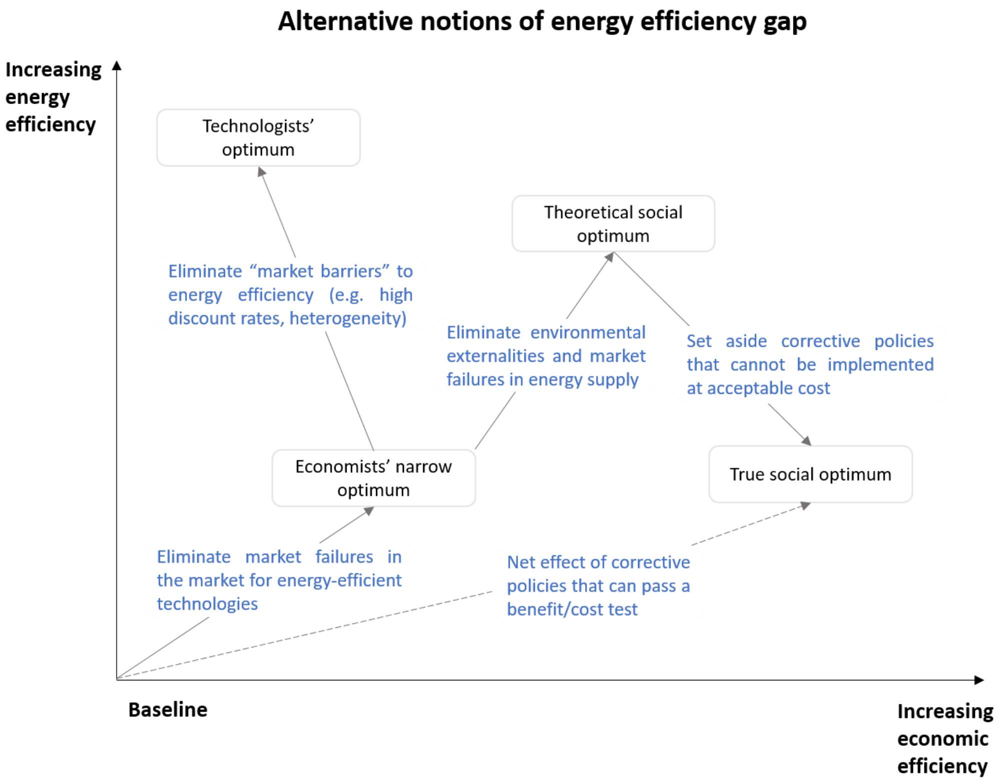


Figure 2. Alternative notions of energy efficiency gap. Adapted from Jaffe et al., 2004.

In the business sector, however, sometimes investments in energy efficiency do not even exist as a category, let alone be appraised (Cooremans, 2011). This is primarily attributed to the organisation's strategic character of an investment. Cooremans surveyed 35 companies and concluded in the following: "in order to successfully champion energy-efficiency investments, all energy-efficiency actors need to highlight, when possible, the impact of energy-efficiency investments on firms' competitive advantage in performing their core business". Nevertheless, even if barriers do exist, the "energy paradox" or in its broader concept "energy-efficiency gap" should be resolved on the basis that the prospective financial returns of energy efficiency investments give a concrete incentive to market actors (Peretz, 2009).

1.3 New energy technologies

1.3.1 Do we need new technologies?

From a technological point of view, societies could make inroads in energy efficiency both from existing and novel/innovative technologies. Blok et al. (2015) state that just by adopting existing technologies more aggressively, all regions around the world would benefit, as energy productivity performance would be increased dramatically. In their results it can be found that only 1% energy savings in the industry sector, 2% in transport and 4% in the building sector would be required in order to double energy productivity, which would in turn reduce the global fossil fuel costs by more than 2€ trillion and could create more than 6 million jobs by 2020. During that period, Europe could expand economically by 35% with this improvement being realised within a healthier purview.

With regards to a fossil-free long-term future, characteristics of energy technologies suitability become more challenging, questioning whether present technologies would be able to carry out such an onerous task. Even if one takes as given that market and non-market forces would operate effectively (e.g. with a proper policy mix or with private actors who make only informed choices for the social benefit) then still they would not be able to sufficiently accommodate a fossil-free energy reality. Generally, although fossil fuel alternatives can be realised, only few are techno-economically ready to be scaled up to the level where a noteworthy demand change towards fossil fuels could be made (Weiss and Bonvillian, 2009). For example, photovoltaics are expensive, carbon capture and sequestration (CCS) requires prototyping and validation, batteries have shortcomings in terms of cost and fuel cells still need years of experimentation. New energy technologies should be introduced to the market according to the authors. These would include wind and solar energy for the competitive production of electricity with a 'smart' grid that would be much more efficient and could be able to accommodate renewable resources. Upgraded geothermal energy and CCS technologies as well as nuclear energy technologies with addressed issues of storage, safety, diversion and proliferation would also have potential to prosper. Moreover, plug-in hybrid-electric vehicles comparable to conventional ones in terms of performance and range but with wider mileage, significantly more efficient buildings, lighting technologies with twofold efficiency compared to fluorescent lights and manufacturing technologies with a broad energy spectrum that could lower costs and improve quality, are all considered prospective for fruition. The figure below illustrates the maximum 2030 global GHG abatement potential if each of the technical GHG abatement measures was pursued aggressively (reaching almost 40%). A negative abatement cost indicates net economic benefits to society from reducing GHG emissions.

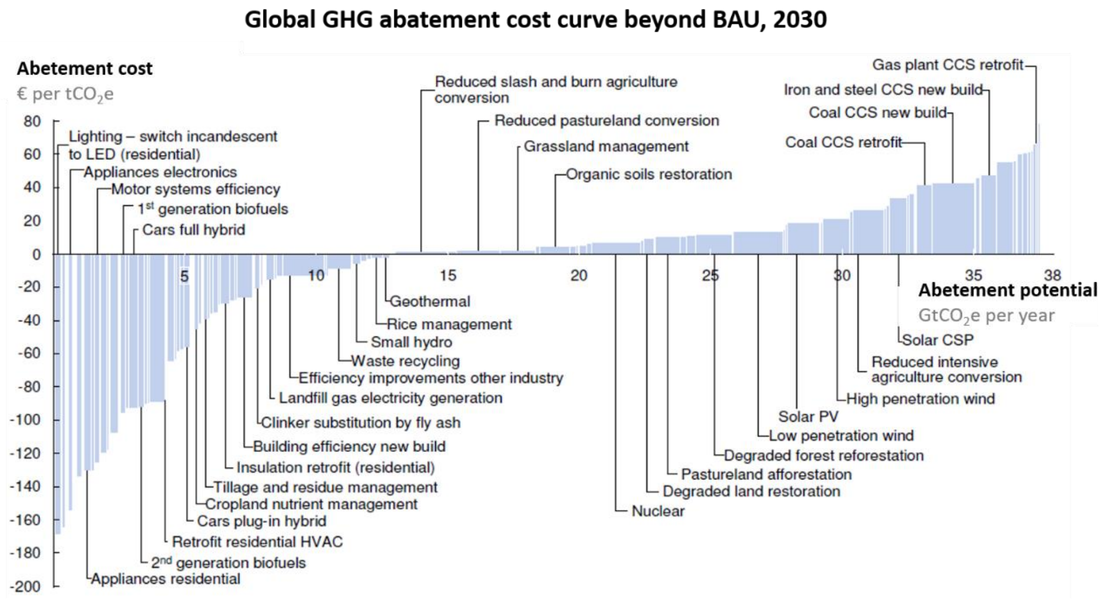


Figure 3. Global GHG Abatement Cost Curve v2.1. Adapted from Enkvist et al., 2010.

Subsequently, several trends in energy efficiency technologies are discussed with reference to the respective situation in Greece too.

1.3.2 Bioenergy

Bioenergy is derived from biofuels, which are liquids or gaseous fuels (bio-ethanol, pure plant oil, bio-diesel, bio-methane, bio-hydrogen etc.) produced from biomass (herbaceous and woody plants, animal fats, agricultural and forest waste, or municipal solid and industrial waste etc.) within an active carbon cycle. They can be utilised for transportation, electricity, heating/cooling to name a few (Rutz and Janssen, 2007), without endangering biodiversity, soil and water resources (EEA, 2006). In 2013, they accounted for 7.7% of total energy consumption in the EU (TNI, 2016), with renewable energy sources having a share of 16.7% of the total energy consumption in the EU (Eurostat (a), 2017). Still the use of today's technologies in the production of biofuels can reduce remarkably carbon emissions. Biofuels comprise a complex supply chain beginning from the cultivation of raw materials (agricultural sector) then they require a conversion plant in order to be converted into the final product (industrial sector) and, finally, they demand proper distribution network for the final product to be delivered (Papapostolou et al., 2011). As a result new technologies that would notably expand the range of biomass feedstock, enhance conversion efficiencies and decreasing production costs would be the most promising ones. For example, the further development of cellulosic materials such as wood, leaves and plant stalks is expected to increase biofuel production dramatically (WWI, 2006). If this cellulosic feedstock (instead of traditional sugar cane) is harnessed for bio-ethanol production, then this type of bio-ethanol would the best possible energy balance; other innovations include "zero discharge" plants for minimum water consumption during the production of bioethanol, the commercialisation of the technology that enables the production of oil-rich microalgae near power plants (for the final production of pure plant oil and biodiesel, also known as "lipid biofuels") and, generally, innovations concentrated on the production of biomass and biofuels conversion (Rutz and Janssen, 2007). The biofuel that could make the difference in transportation is bio-methane, which could subsidise natural gas as mentioned in the same handbook. Biomethane is a gaseous biofuel and can be produced from almost all types of biomass, even wet biomass and is the most efficient and environmentally friendly burning fuel. Biogas and its upgrade to bio-methane is tested successfully in the transportation system in Sweden (Jönsson and Persson, 2003). In addition, the gasification of biomass for the production of hydrogen has intensively developed the last decades, because if gasification to hydrogen is combined with carbon sequestration, biomass technology would have the potential to even return CO_2 from the atmosphere back into the earth (Mandil, 2004).

1.3.2.1 Bioenergy in Greece

Renewable energy in Greece accounted for 22% of primary energy consumption in 2015 (Eurostat (a), 2017) with 44.6% coming from biomass (Eurostat (b), 2017). The efficiency of the biofuels sector is determined by the operational planning of their whole supply chain, this is why Papapostolou et al., (2011) developed a mathematical model for the optimisation of this design. However, biomass was fourth in contribution size amongst renewable energy for electricity production and this figure is not expected to increase substantially by 2020 (Panoutsou and Castillo, 2011). Mainly solid fuels (wood predominantly) are used in the residential sector for space heating and biomass is expected to remain the largest contributing source. In the industrial sector, bioenergy applications are used for space heating and production of process heat, harnessing wood and primary agricultural products (Papadopoulou et al., 2015). Heat pumps are expected to become the third largest technology, after wind and solar power. Technologies like the exploitation of biomass resources in co-firing fashion in existing large-scale lignite-fired power stations are also targeted by the Greek government in order to tackle the non-interconnected parts of the electricity system (the islands with the mainland). Overall, the field of bioenergy technologies in Greece is considered an untapped one, with a promising potential (Castillo and Panoutsou, 2011; Christou et al., 2006).

1.3.3 Geothermal energy

Geothermal energy, in plain text, consists of the thermal energy that is stored within the Earth's crust (Tester et al., 2006), although not among the most popular renewable sources for producing electricity or heat (Eurostat (c), 2017), mainly due to cost impediments. This energy is either stored in rock or "trapped" as a vapour or liquid, such water or brines and can be utilised for the generation of electricity, heating and cooling. The required geothermal resource temperature for electricity generation is over 100^{0}C, while for heating the requirements are lower. Thus, geothermal applications range accordingly, from space heating, spa/swimming pool heating and snow melting to greenhouse and soil heating, aquaculture pond heating and industrial process heating. Technologies involving space cooling via geothermal heat can be facilitated through heat-driven adsorption chillers, substituting electrically-driven compression chillers. Even moderate temperatures (below 50^{o}C) found less deeply can be exploited by using Ground Source Heat Pumps (GSHP) usually for heating, cooling and, occasionally, domestic hot water supply (Beerepoot, 2011).

These technologies are very popular among countries with colder climates and address a different market than the one targeted by deep geothermal heat technologies, which are mostly used for power generation. Making use of the ground's temperature of around 10^{o}C to 15^{o}C in moderate climates, they can either be placed horizontally in a few meters deep (horizontal heat exchange systems) or can be placed vertically in up to 150m deep (vertical heat exchange boreholes). A horizontal GSHP system, via a compressor, allows the transformation of lower temperature heat, run through a closed-pipe-loop into the ground, to a higher temperature heat. In order for this technology to be environmentally and economically viable, the amount of external energy input used to operate the GSHP is of paramount importance (GHP, 2011). The energy savings in buildings with regards to electrical energy consumption per unit of heating or cooling, which can be drawn from such technologies can often be more than 75% (Tester et al., 2006).

Technologies dealing with the increase of borehole's diameter by under-reaming are pivotal both for present and future drilling technologies, because the highest geothermal costs are the ones associated with deep geothermal heat technologies. In particular, the cost of the well field can comprise over 60% of the total capital investment, albeit emerging technologies still being developed are expected to minimise these costs, especially for wells that reach more than 4000m in depth (Tester et al., 2006). Progress in technologies in the field of downhole measurement feedback is also essential, because real-time data collection, transmission and interpretation is believed to be the principal need for flat time reduction. One technology that was developed in the last decade and appears to be promising for expanded use of real-time downhole data is a drill pipe with built-in instrumentation cable (Allen et al., 2009). However, innovative geothermal drilling technologies are thought to originate from the field of oil and gas, since the size of its market is considerably larger than that of geothermal energy (Finger and Blankenship, 2010).

1.3.3.1 Geothermal energy in Greece

Geothermal energy in Greece is only utilised for direct uses, for the most part in the agricultural sector (greenhouses and soil heating), in aquaculture, and healing and recreation sectors (spa facilities) (Papachristou et al., 2016). Fish farming applications of geothermal energy are rapidly expanding (Nguyen, 2015), while direct geothermal uses in general made a noteworthy increase in terms of installed capacity during 2007-2012. The cornerstone of geothermal energy's growth is attributed to the installed heat pump systems (circa 3000 units) (Andritsos et al., 2013). Only 10 of such systems were in operation by 2002 (Mendrinos et al., 2002).

So far though, no geothermal electricity was being produced by geothermal energy, in spite of a two-year pilot installation in Milos during the 1980s. Since a high enthalpy potential has been proven for Milos and Nisyros islands and a medium enthalpy potential has been indicated by solid estimations in Chios, Lesvos and Samothrace, electricity production via geothermal energy remains a desideratum (Andritsos et al., 2013; Chatziargyriou et al., 2016; Papachristou et al., 2016). Moreover, base-load electricity generated by geothermal energy can be provided in low cost (Chatziargyriou et al., 2016). The most important recent geothermal investment took place in 2014 and is pertain to a new hydroponic geothermal greenhouse unit in Neo Erasmio, Xanthi. Two other low enthalpy fields are earmarked for exploitation, namely in Eratino-Chrysoupolis and Aristino (Papachristou et al., 2016).

1.3.4 Wind energy

In 2016, wind power accounted for 51% of total new power capacity installations in Europe (WindEurope, 2017) and 12.7% of primary energy production (Eurostat (b), 2017). Technological development is chiefly driven by cost reduction with other technologies still advancing with regards to grid compatibility, acoustic emissions, visual appearance and compatibility to site conditions (European Wind Energy Association, 2010). In line with cost end energy efficiency requirements are advanced rotor technologies with larger swept area and reach, which enable a higher energy capture, while higher voltage power electronics are expected to lower the cost of power conversion. Areas like blade pitch control, towers, blade bearing, pitch systems, hub design, drive systems, and also materials and infrastructure, all encapsulate promising technologies under development (e.g. telescoping or self-erecting towers) (IEA, 2013; Thresher et al., 2008; Kabouris and Kanellos, 2009). Even noise reduction technologies are considered critical, especially when land availability is limited. The existing technology infrastructure should be fully deployed avoiding material waste and unnecessary additional costs, while R&D efforts are laser-focusing on scaling technologies like "dynamic line ratings", which could enhance the existing lines' transmission capacity (IEA, 2013). Hydraulic drivetrain component designs replacing the mechanical gearbox together with comprehensive turbine design optimisation are also possible. Engineers have managed to skirt the "square-cube law" for wind turbines (which dictates that after a certain size, the cost for a larger turbine will grow faster than the energy output it generates), however, researchers are struggling to provide more innovative designs. (Thresher et al., 2008). Notably, most of the capacity relating to wind energy comes from offshore installations, only 0.3% of total installed capacity in the world was attributed to onshore ones in 2015 (Hernández, 2017). This shift to offshore installations was apparent more than a decade ago together with a trend towards larger machines and direct drive machines as well (Mathew, 2006).

1.3.4.1 Wind energy in Greece

The level of wind energy potential in Greece is the second largest in Europe, after Scotland and is at the top ten of European countries with high wind power penetration in electricity production (European Wind Energy Association, 2011). The wind capacity installed at the end of 2011 represented almost 4% of the country's gross final electricity consumption (Mentis, 2014). Among available renewable energy technologies in Greece, wind power is expected to contribute the largest part and have the highest evolution (Kabouris and Kanellos, 2009; Kabouris and Hatziargyriou, 2006; Emmanouil et al., 2016). Most interest around wind farm installations with high wind potential concerns primarily mainland installations. Reasons linked to the infrastructure and the electrical network's capabilities are involved (Kaldellis, 2005). The initial onshore investments with high potential hinder, in turn, investments on the exploitation of offshore wind plants. Another barrier is the security of such installations, meaning the combined effect of Greek seas' depth with geopolitical/military constraints (Pedraza, 2015). The suitability of a wind park installation is determined by the average annual wind speed, which has to be more than 6 m/s and by the existing infrastructure and capabilities among other factors. From that perspective, areas of interest could be the Aegean Sea tunnel, the eastern and western Crete, while there are some big scale wind parks located in Cephalonia, Panahaiko Mountain, Thrace, Evia and Peloponnese (Vita et al., 2009; Emmanouil et al., 2016).

The wind power alternative as a substitute to the imminent lignite shortage has been studied in concurrence with the utilisation of solar power and has produced encouraging results both economically and environmentally (Mentis, 2014). Also, technologies that deliver accurate atmospheric and wave simulations of weather conditions with proper configuration have been examined (Emmanouil et al., 2016). Apart from producing electricity in an eco-friendly fashion, wind energy could even be harnessed in order to substitute the need for fossil fuel electricity production in remote areas (e.g. non interconnected islands). This approach was examined by Lumberopoulos et al. and regards installations of wind-hydrogen systems, which would be able to seasonally store energy in fuel cells.

1.3.5 Energy technologies in buildings

Buildings account for more than one third of final energy consumption globally and approximately 40% of total energy consumption in the EU, whilst about 75% of them are energy inefficient. Space heating and cooling as well as water heating hold almost 50% of the energy consumption in buildings (Blok et al., 2015; Diczfalusy and Taylor, 2011; EEA report, 2017). Key building technologies for space and water heating and cooling are considered the following (Diczfalusy and Taylor, 2011):

- *Active solar thermal* (AST) systems collect the incoming solar radiation and heat up a liquid (or air), which is then used either directly (e.g. for swimming pool heating) or indirectly with a heat exchanger transferring the heat its destination point (e.g. space heating). An emerging technology related to AST systems is solar cooling. Solar cooling can be mainly accommodated by two technologies using solar thermal collectors: thermally driven chillers produce chilled water in *closed cycles* that is compatible with any space conditioning equipment; desiccant evaporative cooling systems, within an *open cycle* approach, can treat air directly in a ventilation system. In colder regions, freeze-protection materials are being developed to accompany these technologies (SETIS, 2015)

- Much attention has been placed upon *combined heat and power systems* (CHP) of building and “campus” scale. Under this technology, electricity and heat are produced simultaneously for space and/or water heating, with the potential provide cooling as well (using thermally driven chillers). This technology in its traditional state is mature, so micro-CHP, biomass CHP and CO_2-free fuel cell systems are considered emerging alternatives
- *Heat pumps* are very efficient, mature technologies that utilise renewable energy (e.g. air, water or ground) and high-grade energy (e.g. electricity) to raise or lower accordingly the temperature. Reversible heat pump systems alternate heat and cooling, while hybrid systems have the ability to simultaneously provide heating and cooling
- *Thermal storage* can maximise the energy efficiency potential of other technologies, enhancing flexibility, whilst facilitating the use of renewables. It includes: *sensible* heat storage using a storage medium that is heated or cooled (e.g. hot water in tanks); *latent* heat storage using the phase change of a substance (e.g. from ice to water) and *thermo-chemical* storage using reversible chemical reactions

Solar energy is thought to be one of the few renewables that could scale up to meet worldwide electricity demand (Energy Futures, 2015), thus, various nascent technologies are being developed for residential applications. For example, building integrated photovoltaics (BIPV) systems could have a double parallel function, as climate screens (replacing the outer building envelope skin) and as a source of generating electricity (Jelle, 2015). Moreover, researchers delve into earth-abundant materials that could be implemented in innovative thin-film technologies with the prospect to replace today’s commercial ones. Such complex materials would not only serve as substitutes for e.g. crystalline silicon solar cells, but also have more novel applications integrated in windows or building facades absorbing ultraviolet and infrared light, while letting through visible light (Energy Futures, 2015). District heating also appears to be a promising technological area, especially when the challenge is to replace the current building stock with renewable systems (Lund et al., 2010).

1.3.5.1 Energy technologies in buildings in Greece

In Greece, the insufficient thermal protection of building make space heating the most energy-consuming activity (Papakostas et al., 2015). The solar thermal market is well-developed and solar energy constituted around 20% of primary energy production with the EU average being at 6.4% in 2015 (Eurostat (b), 2017). Traditionally, the main solar thermal product was the thermosiphonic water heater, while renewable cooling applications are in an early stage within the market. Although there is no data available on these technologies, they are considered very promising (Giakoumi and Iatridis, 2009). Solar systems in Greece are so widely used, that the issuance of a building permit requires that 60% of the domestic hot water needs are covered by solar thermal systems. To that extent, every building (>50m^2) undergoing complete renovation, being sold or leased should issue an energy performance certificate, while the same applies for all building in the public sector (Watch, 2013). However, the upgrade of a building's envelope with "eco" material is not always a sustainable choice (Alexandri and Androutsopoulos, 2017), although the design of a building's envelope with better insulation than the minimum standards require, optimised HVAC and lighting systems can lead to a very increased energy performance (Ascione et al., 2017). Households tend to shift their preferences towards central heating systems adopting alternative ones, albeit not always "greener" (Papakostas et al., 2015).

1.3.6 Hydrogen

Hydrogen is not a primary energy source (e.g. coal and gas). Instead it is an energy carrier, which in the long-term is going to be produced by renewable energy sources. Still, regenerative hydrogen and hydrogen produced from conventional energy can be almost carbon-free if combined with carbon capture and sequestration (CCS) (EC, 2003). The prevailing method of producing hydrogen today is steam methane reforming (SMR) of natural gas (Fraile, 2015). Due to the maturity of this technology one, could conclude that hydrogen cost variations are highly dependent on the price of natural gas.

Hydrogen and fuel cell technologies, which can directly convert chemical energy to electrical energy, ground their advance on the fact that they can be produced from any prevalent primary energy source, be transformed into any form of energy and leave a potentially zero carbon footprint (Körner et al., 2015). In turn, many sectors capitalise on these technologies' progress. Specifically:

- In the *transport* sector fuel cell electric vehicles (FCEVs) are being introduced into the market, which are basically electric vehicles that use a pressurised tank to store hydrogen and a fuel cell for power generation (power-to-fuel). Since in these vehicles regenerative braking is also possible, they could be considered as hybrid cars as well. FCEV are at the gates of commercialisation, however, only a few demonstration projects have been implemented so far throughout Europe, with Germany taking the lead in such efforts (Körner et al., 2015). The standard on board hydrogen storage technology is compressed hydrogen storage, which is increasing in capacity, competing with gasoline ICE in driving ranges. Generally, the mobility market for hydrogen fuel cells is deemed to be the one with the highest growth in the horizon up to 2025 (Fraile, 2015)
- Regarding *variable renewable energy* (VRE) (like solar, wind and wave energy with limited predictability) the issue of supply surplus and deficit arises, which differs by location. In line with this, hydrogen-based technologies can facilitate large-scale electricity storage applications. These application are not only suited for electricity storage (power-to-power), they can also be employed in order to integrate electricity across different sectors. For example, it can serve as a feedstock in industry (power-to-feedstock) or be blended in the natural gas grid (power-to-gas). Notably, the industrial sector represents the largest hydrogen consumer (more than 90%), with ammonia alone accounting for more than 50% of the total industry consumption (Fraile, 2015).
- *Buildings'* energy efficiency could also be promoted with the co-generation of power and heat, since the excess heat produced during power generation could be used for heating purposes. Fuel cell combined heat and power (CHP) technology is maturing into a reliable and commercially-viable solution, although more support has been given in Asia than in Europe (Dodds et al., 2015)

Other hydrogen-based niche applications include: fuel-cell-powered fork lifts, autonomous power systems (stationary or portable off-grid) (Körner et al., 2015), small fuel cells in portable devices (e.g. mobile phones and laptops) or energy converters running on hydrogen (ICEs, Stirling engines and turbines) (EC, 2003). Decarbonisation scenarios often underestimate the technical and economic viability of hydrogen technologies, something that probably requires a revision given their proven sustainable reach (Dodds et al., 2015). Below, a graphical demonstration of the primary energy sources of hydrogen and its applications is exhibited.

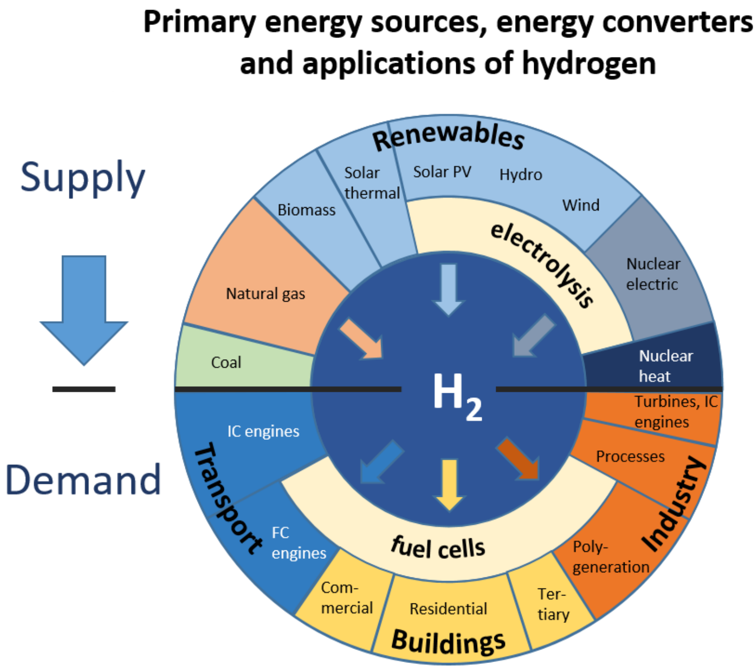


Figure 4. Primary energy sources, energy converters and applications of hydrogen. Adapted from EC, 2003.

1.3.6.1 Hydrogen technologies in Greece

The field of hydrogen and fuel cell technologies in Greece is still making its nascent steps with a more vivid private sector and research activity as concomitants of these technologies' global popularity, although researchers have contributed to the related literature more than a decade ago. Among them, Fatsikostas et al. (2002) examined an efficient and environmentally friendly alternative for electricity production through the reformation of biomass-derived ethanol to a hydrogen-rich gas steam, able to feed fuel cells. The catalytic behaviours of such a process was also studied by Liguras et al. (2003), proposing a noble metal catalyst as a prospective stable candidate. Other authors investigated the exploitation of glycerol for biogas and hydrogen production

(Vlassis et al., 2012).) Polymer electrolyte membrane (PEM) fuel cell technology is the most popular (measured in unit shipments) (Niakolas et al., 2016) and Ziogou et al. (2017) devised an optimum energy management framework (model predictive control) for PEM fuel cell systems.

Research and analysis

2.1 Research methodology

2.1.1 Aim of research

The aim of this research is to examine the nexus between an organisation's approach towards innovation and the incorporation of energy management practices within its functions. In Greece so far this topic has received a rather scant attention, thus, any nuggets of information would be a contribution to the existent literature. Under the optimistic scenario, this study would kindle other researcher's interest and serve as an inception work for anyone willing to delve deeper into the subject.

2.1.2 Sampling

2.1.2.1 Sampling techniques

Including the whole population in a research would be optimum, but since in many research methods this is infeasible, an (ideally representative) part of the population would be sufficient to serve this cause. The rationale behind sampling "feeds" on this specific need (Etikan et al., 2016). Sampling techniques can be classified into two major categories which, in turn, encompass different sampling techniques each (Walliman, 2017; Alvi, 2016; Gruiz et al., 2017):

1) *Probability* sampling (also called random or representative sampling) uses random means for the selection of a sample. Each element and every possible combination of the elements in the sample (persons, groups, classes, types etc.) should have an

equal chance of being selected. Different techniques have been developed in order to serve this goal and manage to select a representative sample. The researcher should examine the homogeneity or heterogeneity of the population and if the latter is present, then they should focus on the way the heterogeneous classes are distributed within the population (e.g. they might be grouped by location, by levels of hierarchy, they might be mixed up together etc.). In addition, under probability sampling the population needs to be precisely defined, while it is recommended when the understanding of a population is intended. Systematic errors and biases are reduced, representative samples are produced and inferences drawn from the sample can be generalised to the whole population. Nevertheless, much time, effort and cost is required in probability sampling. The main techniques of this category are the following:

- *Simple random sampling* (applied at the present study as part of stratified random sampling), where both the population and sample items have an equal probability of being selected. In other words, one or more characteristics have an equal probability of occurrence among the units of the population. All the elements of the population have to be identified (e.g. in the form of a list), while the population has to be homogeneous with regards to a specific characteristic or attribute.
- In s*tratified random sampling* (applied at the present study) the items to be sampled are divided into subgroups (strata) and then simple random sampling or systematic random sampling is applied for each strata. These subgroups should be mutually exclusive and collectively exhaustive regarding the variable they were formulated from. The sample size of each group can be allocated in different ways (e.g. proportional, equal, optimal allocation etc.). Stratified sampling method presumes a heterogeneous population, although strata themselves should be internally homogeneous in the characteristic variable.
- *Systematic random sampling* uses a pattern for the selection of the sample elements, because it is assumed that there is not an equal opportunity of a unit to be selected. However, this method can be applied in both homogeneous and heterogeneous populations. It is particularly preferred when a list of the sample

items is available, but the researcher wants to save the time and effort in the case of a random number generator or a "lottery" procedure.

- *Cluster random sampling* divides the population into clusters with each cluster acting as a small-scale true representation of the population. To that extent, they should be internally heterogeneous concerning the survey variable. Clusters are "natural" groupings of items (e.g. towns, villages, schools, streets etc.) (Sedgwick, 2013).
- In *multistage sampling* multiple probability techniques can be applied within the same research.

2) *Non-probability* sampling (also called non-random or judgement sampling) is based on the selection of a sample by non-random methods. The units of the population do not have an equal chance of participating in the investigation, whilst the population does not need to be precisely defined for a sample to be formulated. Although non-probability sampling does not produce as robust results as probability sampling due to possible systematic errors and biases, non-representative samples and so provides a weak basis for generalisation, however, it is recommended in several instances. For example, in cases when low cost and effort can be channeled to the investigation by the researcher or when time is limited to conduct a thorough investigation. Also, non-probability sampling is well suited for populations that are hardly accessible and when an exploratory research is carried out, the results of which will be subject to further investigation at a later point. The main techniques included in this category are the following (Gruiz et al., 2017; Alvi, 2016):
   - In *volunteer sampling* the members of the sample self-select themselves, meaning that the participants are the ones who approach the investigator and not vice versa. The research is published through advertisements and announcements.
   - In *convenience sampling* the investigator reaches the most convenient and easy-to-access participants and requires low cost and effort, but may be subject to biases and systematic errors. The technique is useful when the population is very broadly defined.

- *Quota sampling*: samples are selected non-randomly using a predetermined quota arbitrarily. This method is considered the non-probability equivalent of stratified sampling.
- *Purposive sampling* prerequisites the expertise of the researcher in the selection of the sampling units, so that they can be justifiably deemed as typical of the population. However, the sample is still not considered to be typical of the population.
- *Snowball sampling*, also called chain sampling, is implemented after one element of the population is reached and asked to recruit future subjects of the population or refer the investigator to these members of the population. The sample, thus, is growing like a rolling snowball (Polit and Beck, 2008). Although the sample is not representative and the researcher cannot draw inferences for the whole population, the method is recommended or exploratory investigations or in "sensitive" sample cases (e.g. drug users etc.).

2.1.2.2 Sampling technique adopted

For our survey stratified sampling was adopted with simple random sampling. The decision of a probability method was decided after zooming into the advantages that probability sampling methods exhibit. Despite the high degree of effort, cost and time often required in conducting such surveys, the advantages for the research and its results act as solid trade-offs. In particular, probability methods allow for generalised inferences to be drawn by the researcher, while possible biases and systematic errors are minimised and generally, the results prove as a more grounded basis for further investigation.

Stratified random sampling in conjunction with simple random sampling was applied in our survey. To elaborate in more detail, the area of study was Attica. Subject to study (the population) was the sum of organisations with offices and registered activity within this region (but not strictly confined to this specific region). The researchers had to deal with the following issues, as part of the chosen sampling technique:

- The population had to be partitioned into several sub-populations (strata) according to a characteristic from which mutually exclusive and collectively exhaustive subgroups could be formulated. This variable was decided to be the field of economic activities (implying a sense of heterogeneity of the population and renders stratified sampling an appropriate technique to that extent). The NACE Statistical classification of economic activities in the European Community (Eurostat N. A. C. E., 2008) was deemed to be the most reliable categorization for stratification. To that extent, every field (section) found within the NACE publication would represent one stratum of our population, with all strata consisting the population as a whole.

- Furthermore, those NACE fields (sections) needed to be addressed, which bear the bulk of the economic activity in Attica in terms of companies count. In this respect, the Pareto principle was deployed in order to pare down strata categories to the absolutely necessary ones. In the report published by GSEE-ADEDY I. N. E (2017) the major sectors of economic activity in Greece are documented and sorted by number of companies per sector. From that report, thirteen major NACE sections were identified and constructed.
- From each strata, independent samples were drawn by applying simple random sampling. Consequently, the sample size from each stratum had also to be decided upon. The proportional allocation technique was implemented, whereby the sample size of each stratum is proportional to the size of the respective stratum (i.e. the number of elements present in this stratum) (Fuller, 2011; Alvi, 2016). In specific, the sample size n_s of a stratum can be computed by the simple formula $n_s = N_s \frac{n}{N}$, where:
    - o Ns = the total sample size of all strata, usually defined by the researcher (in our case Ns = 280).
    - o n/N = the proportion of this particular stratum in relation to the overall population size (in terms of number of companies), as derived by the study of GSEE-ADEDY I. N. E (2017).

Figure 5 exhibits the NACE fields of economic activities (strata) as they were deployed at the present thesis along with the sample size of each stratum. It should be noted that since the calculation of the sample size of each stratum (n_s) was based on the study of GSEE-ADEDY I. N. E (2017), which includes sectors of economic activity on a national level, some differences should exist. Two fields, Manufacturing (section C) and Financial and insurance activities (section

K) were decided to be a bit larger than what they ought to be, since Attica has concentrated activities in these two sectors compared to the rest of the country. In order to best preserve the credibility of the sampling methodology implemented, no further amendments were made.

	NACE classification of economic activities	Sample size of each stratum (n_s)
1	Wholesale and retail trade; repair of motor vehicles and motorcycles (section G)	88
2	Accommodation service activities (section I)	43
3	Other service activities (section S)	39
4	Professional, scientific and technical activities (section M)	23
5	Transportation and storage (section H)	11
6	Human health and social work activities (section Q)	11
7	Manufacturing (section C)	21
8	Education (section P)	12
9	Construction (section F)	7
10	Arts, entertainment and recreation (section R)	8
11	Administrative and support service activities (section N)	3
12	Real estate activities (section L)	2
13	Financial and insurance activities (section K)	10

Figure 5. The sectors of economic activities formulated under the NACE classification of economic activities in the European Community.

Proportional sampling allocation has the advantage that despite the heterogeneity of the population, the variance under proportional allocation is, generally, no larger than that under simple random sampling, which presumes a homogeneous population. Additionally, the sampling weights are all equal under proportional sampling, a second advantage of the method (Fuller, 2011).

- The application of simple random sampling within each stratum presumes the presence of homogeneity. Indeed, the population itself may be heterogeneous, however strata are internally homogeneous in the characteristic variable they were formulated by.

2.1.3 Data collection

There are many ways to categorise research methods in order to collect data. Williams (2011) distinguished between *quantitative, qualitative* and *mixed* methods studies. So, for qualitative research one can conduct case studies, grounded theory, ethnography, content analysis and phenomenological research. On the other hand, quantitative research includes three main subcategories (descriptive, causal comparative and experimental research), with correlational, developmental design, observational studies and survey research being to some degree appropriate for all the above subcategories. In Walliman (2017) one can find a specific approach describing the basics of each method of collecting primary data. These are:

- *Asking questions*. This method, which has been adopted in the present thesis research methodology, is usually called a survey. Questionnaires consist the most pertinent and useful tool for collecting both qualitative and quantitative data. Questionnaires may be structured in a closed-format question type or an open-format question type and if they have a combination of both then it falls under Williams' (2011) mixed methods studies.
- *Conducting interviews*. Unlike questionnaires, interviews provide a flexibility in terms of response and possible required clarifications. They give the opportunity to the researcher to exercise the appropriate probing before adequate information is collected. Interviews might be structured, unstructured, semi-structured, telephone interviews, face-to-face or even group interviews (focus groups).
- *Observing without getting involved*. In this case, the researcher is 'invisible' either in fact or in effect and aims to take an objective view of the phenomena
- *Immersing oneself in a situation*. In this case, the researcher is not only observing, but depending on the situation they might 'immerse' accordingly, something that necessitates the researcher's experience.
- *Doing experiments*. An experiment isolates a particular event to conduct a thorough investigation and their primary objective is to collect data about a cause-effect relationship. However, the generalisation of the results demands internal as well as external validity.
- *Manipulating models or simulations*. Often confused with experiments in the sense that they isolate an event and inspect it, simulations instead provide a representation of an event and mimic a phenomenon in a way that can be manipulated, usually attempting to test a hypothesis.

2.1.4 Questionnaire description

In our survey questionnaires were distributed in order to collect the required data from our sample. Specifically, the questionnaire comprises Likert scale items, Likert-type items, ordered-category items (Uebersax, 2006) as well as simple multiple choice and dichotomous questions:

- A *Likert scale* is a multi-item scale, not a single item (Uebersax, 2006). It is a non-comparative scaling technique, which aims to examine only one character/personality trait, thus being unidimensional. Likert scale items ask respondents to indicate their level of accord given a specific statement by the researcher. The response options are in an ordinal scale of measurement and they range depending on the number of scale points and context of the question (Dane, 2006).
- *Likert-type items*, unlike Likert scales, are single items or questions and the researcher makes no attempt to construct a composite scale by combining individual Likert-type items (Uebersax, 2006; Boone and Boone, 2012)
- Ordered-category items are items with ordered response levels but the response format is neither a Likert nor a similar format scale (e.g. discrete visual analog) (Uebersax, 2006).
- In multiple choice and dichotomous questions one respondent could select strictly one or more than one answers.

Much debate has been centered around the optimal number of response options with authors like Dillman et al. (2009) recommending four or five categories and authors like Fink (1995) recommending five to seven (Pearse, 2011). Typically, a five- or seven-point format is mostly prevalent (Dawes, 2008; Dane, 2006). The questionnaire of the present thesis is based on the five-point scale format.

While devising the questionnaire's questions certain criteria were taken under consideration, mostly in line with Garth's (2011), Burgess's (2001) and Leung's (2001) suggestions:

- There is a nexus between the research aims and the context of the questionnaire.
- The questions were kept short and less than 25 words, comprehensive in meaning and understandable with no "double negatives".

- Ambiguous questions with double meaning were avoided; item contains one statement or question only.
- In order to protect the body of the questionnaire from biased results, particular attention was paid not to create leading questions.
- All question options were indicated by boxes and each box was qualitatively described, providing immediacy and an unambiguous question/response layout.
- The flow of the questionnaire was kept simple and logical with twenty two questions in total.
- A design with minimum headlines and numbers was maintained with consistent wording, underlining of key words and proper auxiliary references.

Subsequently, the whole questionnaire is presented with spot-on notes, anchoring questions to the aim of research.

Questions 1-3 explore the approach of an organisation towards energy management practices in terms of importance, awareness and change of interest due to the economic recession in Greece. All three questions are regarded as individual Likert-type items.

1. **How <u>important</u> do you find the <u>implementation of energy management practices</u> in your organisation?** (Kindly tick only one)

Not important	Slightly important	Moderately important	Important	Very important
☐	☐	☐	☐	☐

2. **To <u>what extent</u> does your organisation <u>stay aware of developments</u> in the energy management sector?** (Kindly tick only one)

Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
☐	☐	☐	☐	☐

3. **To <u>what extent</u> did <u>your organisation's interest</u> towards energy management/efficiency issues change, in the aftermath of the economic downturn in Greece?** (Kindly tick only one)

Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
☐	☐	☐	☐	☐

Question 4 looks into organisational innovation and during the planning phase of the questionnaire, this question was postulated as a composite Likert scale.

4. Please indicate your <u>level of agreement</u> with the following statements, regarding <u>innovation practices</u> in your organisation: (Kindly tick only one per question)

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	The organisation promotes creativity and innovation in order to create better products and/or services	☐	☐	☐	☐	☐
2	The organisation sells unique products and/or provides unique services	☐	☐	☐	☐	☐
3	The organisation operates in such a way, that enables it to adapt to change	☐	☐	☐	☐	☐
4	The leadership of the organisation encourage open discussions and involvement in the expression of ideas	☐	☐	☐	☐	☐
5	Collaboration and mutual exchange of knowledge and information exist among departments and people within the organisation	☐	☐	☐	☐	☐
6	The leadership of the organisation encourage creative thinking and creative decision-making	☐	☐	☐	☐	☐
7	The organisation is "afraid" of change	☐	☐	☐	☐	☐
8	The leadership of the organisation tap their employees' ideas	☐	☐	☐	☐	☐
9	The organisation has determined a policy about innovation	☐	☐	☐	☐	☐
10	The organisation sets targets for innovation	☐	☐	☐	☐	☐
11	There are no barriers to creativity within the organisation	☐	☐	☐	☐	☐

Question 5 (Likert-type item) is supplementary to the previous question and reviews potential innovative practices or at best cross-checks the relationship between organisational innovation and innovative practices.

5. The organisation the last 3 years has introduced: (Kindly tick only one per question)

		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
1	New or highly improved products	☐	☐	☐	☐	☐
2	New or highly improved methods of manufacturing products	☐	☐	☐	☐	☐
3	New or highly improved methods of providing services	☐	☐	☐	☐	☐
4	New or highly improved methods of supplying, delivering or distributing inputs, products and services	☐	☐	☐	☐	☐
5	New or highly improved supporting activities for its operations, like maintenance systems or purchasing, accounting and IT functions	☐	☐	☐	☐	☐

Question 6 is concerned with the adoption incentives of energy management practices in an organisation, while question 7 investigates the level of implementation of specific energy management technologies. Both questions are Likert-type items. Question 8 is a multiple response question and aims to count the number of certifications an organisation owns.

6. Please indicate <u>the extent</u> to which the following <u>statements influenced</u> the decision of adopting energy management practices in your organisation: (Kindly tick only one per question)

Adoption Incentives…		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
1	Reduction / control of the energy cost	☐	☐	☐	☐	☐
2	Easier access to potential funding	☐	☐	☐	☐	☐
3	More efficient use of energy resources	☐	☐	☐	☐	☐
4	Improved reputation and image of the organisation as a responsible one in terms of energy issues	☐	☐	☐	☐	☐
5	Contribution to addressing climate change	☐	☐	☐	☐	☐
6	Compliance with customers' and market's requirements	☐	☐	☐	☐	☐
7	Keeping pace with competition	☐	☐	☐	☐	☐
8	Facilitation of exports	☐	☐	☐	☐	☐
9	Meeting national and international legislation requirements	☐	☐	☐	☐	☐
10	Expectation of change in energy resources' price	☐	☐	☐	☐	☐
11	Other (specify): ... … …	☐	☐	☐	☐	☐

7. Please indicate <u>the extent</u> to which the following energy management technologies are implemented in your organisation: (Kindly tick only one per question)

		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
1	Solar photovoltaic system	☐	☐	☐	☐	☐
2	Heating – cooling system	☐	☐	☐	☐	☐
3	Light emitting diode (LED)	☐	☐	☐	☐	☐
4	Low energy consumption device	☐	☐	☐	☐	☐
5	Enterprise building management system (EBMS)	☐	☐	☐	☐	☐
6	Electricity saving system	☐	☐	☐	☐	☐
7	Heat recovery system	☐	☐	☐	☐	☐
8	Carbon capture and sequestration system (CCS)	☐	☐	☐	☐	☐
9	Electric and hybrid vehicle	☐	☐	☐	☐	☐
10	Highly energy – efficient engine	☐	☐	☐	☐	☐
11	Smart grid	☐	☐	☐	☐	☐
12	Geothermal heating-cooling system	☐	☐	☐	☐	☐

8. Please indicate under which of the following Standards your organisation is certified:

Standard		Certification
1	ISO 14001	☐
2	EMAS	☐
3	ISO 50001	☐
4	ISO 9001	☐
5	Other (specify): … … …	☐

Questions 9-12 are individual Likert-type questions and

9. How do you assess the <u>level of energy management practices implementation</u> in your organisation? (Kindly tick only one per question)

Very negative	Negative	Neutral	Positive	Very positive
☐	☐	☐	☐	☐

10. How do you assess the <u>level of innovation management practices implementation</u> in your organisation? (Kindly tick only one per question)

Very negative	Negative	Neutral	Positive	Very positive
☐	☐	☐	☐	☐

11. How do you assess the <u>level of technology use regarding energy management</u> in your organisation? (Kindly tick only one per question)

Very negative	Negative	Neutral	Positive	Very positive
☐	☐	☐	☐	☐

12. How do you assess the <u>level of employees' encouragement</u> regarding their involvement in energy management in your organisation? (Kindly tick only one per question)

Very negative	Negative	Neutral	Positive	Very positive
☐	☐	☐	☐	☐

Questions 13-22 are general and attempt to create a profile of the organisation: its activities and field of operation, its size, its human resources demographics, its energy consumption profile as well as its approach towards funding sources.

Referring to the type of data, the first three of general questions (13-15) are multiple response questions where only one answer can be given.

<u>GENERAL QUESTIONS</u>

13. Your organisation is: (Kindly tick only one per question)

Greek: ☐ Member of a foreign organisation: ☐

14. Your organisation is: (Kindly tick only one per question)

Capital intensive: ☐ Labour intensive: ☐ Energy intensive: ☐

15. In which industry does your organisation operating in? (kindly tick only one)

Wholesale and retail trade; repair of motor vehicles and motorcycles (section G)		Education (section P)	
Accommodation service activities (section I)		Construction (section F)	
Other service activities (section S)		Arts, entertainment and recreation (section R)	
Professional, scientific and technical activities (section M)		Administrative and support service activities (section N)	
Transportation and storage (section H)		Real estate activities (section L)	
Human health and social work activities (section Q)		Financial and insurance activities (section K)	
Manufacturing (section C)			

Question 16 is analysed as Likert-type question with the "not implemented" serving as auxiliary one to "clean up" the relevant responses.

16. To what extent do you think the following implemented activities within your organisation are energy-consuming? (Kindly tick only one per question)

		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent	Not implemented
1	Production of raw materials	☐	☐	☐	☐	☐	☐
2	Intermediate production	☐	☐	☐	☐	☐	☐
3	Process – production of final product	☐	☐	☐	☐	☐	☐
4	Packaging	☐	☐	☐	☐	☐	☐
5	Storage management – maintenance	☐	☐	☐	☐	☐	☐
6	Transportation and cargo management	☐	☐	☐	☐	☐	☐
7	Trade	☐	☐	☐	☐	☐	☐
8	Product improvement / new product development	☐	☐	☐	☐	☐	☐
9	Other (specify): … … …	☐	☐	☐	☐	☐	☐

Questions 17, 18 and 19 are put in an ordinal scale and are considered as ordered-category items, while question 20 was treated as a Likert-type question.

17. What is the total number of employees in your organisation? (Kindly tick only one per question)

1-9: ☐ 10-49: ☐ 50-249: ☐ 250-749: ☐ 750+: ☐

18. What is the average level of education among the employees in your organisation? (Kindly tick only one per question)

High school graduates: ☐ University graduates: ☐ Postgraduates: ☐ PhD holders: ☐

19. What was your organisation's turnover that came from its activity in Greece in 2012 (in thousand €)? (Kindly tick only one per question)

0-150: ☐ 150-500: ☐ 500-2.000: ☐ 2.000-10.000: ☐ 10.000+: ☐

		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
1	Mazut	☐	☐	☐	☐	☐
2	Gasoline - diesel	☐	☐	☐	☐	☐
3	Oil	☐	☐	☐	☐	☐
4	Electricity	☐	☐	☐	☐	☐
5	Natural gas	☐	☐	☐	☐	☐
6	Solar thermal panels	☐	☐	☐	☐	☐
7	Photovoltaic panels	☐	☐	☐	☐	☐
8	Other (specify): … … …	☐	☐	☐	☐	☐

Question 21 has a Likert-type format, while question 22 is a dichotomous one and more than one answers can be selected.

21. To <u>what extent</u> do you think the following factors can influence the implementation of energy management practices in your organisation? (Kindly tick only one per question)

		Not at all	To a small extent	To a moderate extent	To a great extent	To a very great extent
1	Public funding	☐	☐	☐	☐	☐
2	Tax exemption	☐	☐	☐	☐	☐
3	Funding programme enrolment	☐	☐	☐	☐	☐

22. Has your organisation ever obtained <u>funding via programmes</u> regarding the implementation of energy management practices?

		Yes	No
1	Community	☐	☐
2	National	☐	☐
3	Local	☐	☐
4	Other	☐	☐

2.2 Statistical analysis

2.2.1 Criteria for a statistical analysis

A statistical analysis requires the researcher to know three things (Normando et al., 2010; McCrum-Gardner, 2008):

1) The *data type*. According to its nature, data can be whittled down into two broad categories: quantitative (continuous) and qualitative (categorical). Although defining a scale type is not easy, four scales of measurement can be identified, depending on how data is measured. Namely:
   - Nominal and ordinal, which are qualitative (categorical). **Nominal** variables have two or more categories, with no intrinsic ordering among them, such as sex (male/female), marital status (single/married/divorced/widowed) and so on (IDRE; McCrum-Gardner, 2008). A nominal scale allows for one-to-one substitution (Stevens, 1946) or the assignment of categories but without making any sense to order these from highest to lowest. If the variable has a clear ordering, then we are referring to ordinal variables (IDRE). The **ordinal** scale encompasses the operation of rank-ordering and any 'order-preserving' transformation will leave the scale invariant. Examples of ordinal scales may be the scale of hardness of minerals, scales of intelligence, quality of leather, scales like mild/moderate/severe, or even the Likert scale type which was extensively used at the present thesis (e.g. strongly disagree/disagree/neutral/agree/strongly agree) (Stevens, 1946; McCrum-Gardner, 2008). Even though ordinal variables can be clearly rank-ordered, the intervals between the values may be unequal (IDRE).
   - Interval and ratio, which are quantitative (continuous). **Interval** variables are similar to ordinal variables, except that the spacing between the values of the interval variable are equally spaced. The zero point of such scales is also a matter of convention or convenience (Stevens, 1946). Notably, an average requires a variable to be interval or ratio, since it would be nonsensical to calculate an average of a categorical variable (IDRE). Common examples of an interval scale is the Centigrade or Fahrenheit scale. (Stevens, 1946). **Ratio** scales are very common in physics and have all four prerequisites (equality, rank-order, equality of intervals, and equality of ratios). Among ratio scales is

the scale of cardinal numbers per se – the scale we use to count things – which is so obvious that is often omitted from mention. Other examples include the age (years), weight (kg) or length (cm) (Stevens, 1946).

2) The *type of sample*. Samples can be classified as paired (dependent) or unpaired (independent). Paired (dependent) samples have the same sample size and consist of the same subjects in each group. In unpaired (independent) samples, the sizes may differ and there is not a single group under survey (Normando et al., 2010; du Prel et al., 2010).
3) The *data distribution*. Data may be normal or abnormal and the statistical tests are chosen accordingly. Generally, parametric tests are based on normal distribution, whereas non- parametric tests are based on non-normal distribution (Normando et al., 2010).

The above criteria are not accepted by all statisticians as the sine qua non, often some degree of ambiguity exists. For example, Clason and Dormody (1994) argue that checking for normality first necessitates selecting a post-hoc inference procedure. This is not recommended by some statisticians who advocate for such decisions to be made at the planning stage. Even scales of measurement per se are questioned with regards to the selection of appropriate statistical tests (Jamieson, 2004).

2.2.2 Applied statistical analysis

2.2.2.1 Criteria description

This thesis takes a conventional approach towards statistical analysis, thus all aforementioned criteria were taken under consideration for the selection of the appropriate statistics:

1) Multiple choice and dichotomous questions, which were used at the questionnaire as discussed in 1.4 were regarded as nominal data and were analysed with medians and frequency distributions. Likert scale, Likert-type items and ordered-category items, were considered as ordinal variables; in the last two cases, descriptive statistics with median for central tendency and frequencies for variability as well as non-parametric tests were adopted, whilst for Likert scale data (question 4) the composite mean score was used for

descriptive statistics and again non-parametric correlation (Spearman) for inferential statistics.

However, the topic of the right statistical approach when talking about Likert items in their general form remains controversial among researchers. The debate is pivoting around the fact that this type of data may be rank-ordered (ordinal), but on the other hand, the difference in space between intervals is not implied – meaning that it might be a significant one or even a trifling one. Likert scales specifically, though, presume the existence of a latent continuous variable, which if it could be possible to be measured directly then the scale of measurement would be interval at best (Clason and Dormody, 1994). As a result, the composite score (sum or mean) for Likert scale data should be analysed using descriptive statistics with mean for central tendency and standard deviation for variability (Boone and Boone, 2012). Norman (2010) finds much merit in using robust, parametric statistics on Likert scales "with no fear of coming to the wrong conclusion", a result he found consistent with empirical literature dating back around 80 years. There are numerous researchers who propose the contrary when treating Likert data. For example, Jamieson (2004) is in favour of non-parametric inferential statistics, while Sullivan and Artino (2013) think a Likert scale can be analysed parametrically, but a median/mode and a frequency distribution would have more value describing it. Garth (2011) suggests applying non-parametric methods as an initial condition, although one could also defy this rule, in case the sample is derived from a homogenous population (Lubke and Muthén, 2004).

2) Our sample is single and independent and the subgroups within the sample are also considered as independent, since they have different sizes with different subjects each.
3) The normality check during the preliminary tests has showed a non-normal distribution for each variable.

2.2.2.2 *Statistics*

Preliminary analysis

Before proceeding to the main analysis, it is vital to perform a preliminary analysis. That would provide meaningfulness to the subsequent parametric or non-parametric statistics and also save the researcher time and effort, while giving them some helpful insights on the quality of their data. The article of Roni (2014) has some interesting and concise information on how to perform both analyses and was followed at the current study as well.

- The first check was the *monotone*, whereby responses were checked regarding their variance. Responses with zero variance are considered monotone responses (e.g. in case a respondent answers with a ‘4’ in all questions). Throughout our sample no respondent gave monotone answers, so no answer had to be excluded from the data. The monotone check was applied at the dataset with the ‘VAS.S’ formula in Excel, which calculates the variance based on a sample (ignoring logical values and text in the sample).
- *Missing values analysis (expected maximisation)*. Before any analysis (preliminary or subsequent) the ‘Variable View’ of SPSS had to be constructed. More than eighty (80) variables were inserted and the fields of ‘Name’, ‘Label’, ‘Values’, ‘Missing’ and ‘Measure’ were specifically defined for each variable by the researcher. Missing values were not removed or deleted, but preserved. However, only in two cases they were deliberately excluded from the statistical analysis (in questions 8 and 22). There are various treatments of missing values; from deleting them, to replacing them with the mean, replacing them after multiple imputations (MI) or replacing them after expected maximisation (EM). The latter was implemented in our case. EM is performed after computing variances, covariances and means and stops once this iterative procedure produces very small changes in these parameters. Then the final value replacing the missing one appears to be achieved. EM produces better solutions if missing data is missing completely at random (MCAR), something that is indicated by Little’s MCAR test (p-value > .05). Our results gave a non-significant p-value ($p = .850 > .05$), thus the imputed values derived from EM procedure could have been used in the main analyses. However, the imputed values were decimals

and not integral numbers (like the ones used in Likert items in our questionnaire) and, as a consequence, the EM dataset produced was not used.

- The *normality check* was made with Kolmogorov-Smirnov and Shapiro-Wilk tests for each variable. Visually, it was assessed by the histograms, again for each variable. The Kolmogorov-Smirnov and Shapiro-Wilk tests gave significant p-values, indicating a non-normal distribution. The visual assessment led to the same conclusion. Although the total sample size was large enough and appropriate for exhibiting a normal distribution, the total missing values within the responses were many as well, something that would reasonably affect the normality check. Since our variables were found not to be normally distributed, non-parametric analysis was followed, as advised (e.g. Spearman correlation instead of Pearson correlation) (Nayak and Hazra, 2011; McCrum-Gardner, 2008).
- *Reliability test* was realised by the Cronbach's alpha value. Our sample gave a Cronbach's alpha of .896 and a Cronbach's alpha based on standardised items equal to .911. Both exceed the minimum threshold of .70 and although the aforementioned two values are different, the discrepancy between them is not noteworthy. Besides, the discrepancy is even justifiable, since the reliability test was performed for all variables at once. If components with similar items had been tested, the discrepancy would have been much smaller. In this respect, the reliability test carried out gave a conservative result.
- *Common method bias* generally can threaten the validity of the conclusions drawn upon statistical results (inflating or deflating the outcome) and implies the presence of a systematic variance. Harman's single factor test was run in order to account for common method bias. In particular, the cut-off percentage point set by the test is 50% for variance, while our tested sample gave a 16% variance, much less than the cut-off point. In this way, no apparent single factor (item) is responsible for the majority of variance in the model.

Main analysis

After the preliminary analysis results came positive, the subsequent main analysis could be performed as described below:

- *Factor analysis* was performed for the composite Likert scale (question 4), which aims to investigate the position and attitude of a company towards innovation through a set of Likert-type items (sub-questions). The underlying reason behind factor analysis on this specific question was to reflect any latent (unobserved) variable behind apparent ones. Another reason for performing this analysis was to condense the elements that contribute the most to the composite scale itself. Indeed, the factor analysis boiled down the eleven questions into three components. However, the researchers chose not to produce new variables from the process and maintain all the variables together for the computation of the composite scale variable and the subsequent analysis in general. In future research it would be helpful for a researcher to revisit the elements of question 4 and produce, based on the factor analysis results, new and fewer variables for studying similar issues. The extraction method used for the factor analysis was the Principal Component Analysis (PCA) and the rotation method was Varimax with Kaizer normalisation.

- *Descriptive statistics* employed the use of non-parametric equivalents with the exception of question 4, which is considered a Likert composite scale, so the mean could be used. Specifically, Likert-type items and ordered-category items, were considered as ordinal variables; in these cases, as well as in multiple choice and dichotomous variables, descriptive statistics with median for central tendency and frequencies for variability as well as non-parametric correlation were adopted (Spearman). For Likert scale data (question 4) the composite mean score (Boone and Boone, 2012) was used for descriptive statistics. According to Sullivan and Artino (2013), a Likert scale can be analysed parametrically, but a median/mode and a frequency distribution would have more value describing it, exactly as performed at the present thesis for question 4. Nonetheless, again non-parametric correlation (Spearman) for inferential statistics was applied in this question’s case (as with all other questions), following opinions like Jamieson’s (2004) and Garth’s (2011), who are in favour of non-parametric inferential statistics regarding Likert scale items when heterogeneity is present at the population.
- *Spearman correlation* for inferential statistics (the non-parametric equivalent of e.g. Pearson correlation) was applied throughout all variables to investigate any

possible strong correlations that exist (positive or negative). Then, the ones with a correlation coefficient of more than .800 (absolute value) were chosen to be presented (no negative strong correlations were found). The researchers were also interested in investigating other linkages as well, as presented at the 'findings' section. Figure 6 illustrates a flow chart that facilitates test decision-making when ordinal data ought to be included in the analysis (Gunawardena, 2011).

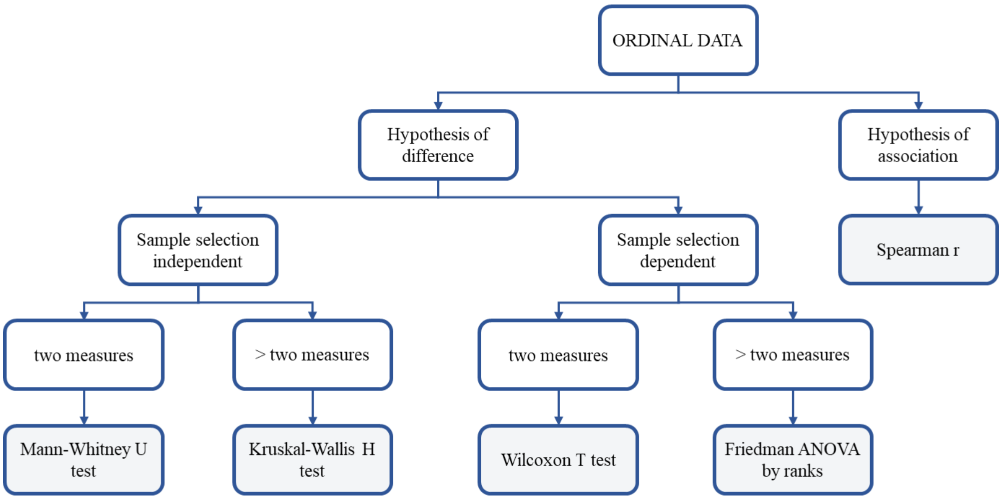


Figure 6. Choosing the correct statistical test when ordinal data need to be analysed. Adapted from Gunawardena, 2011.

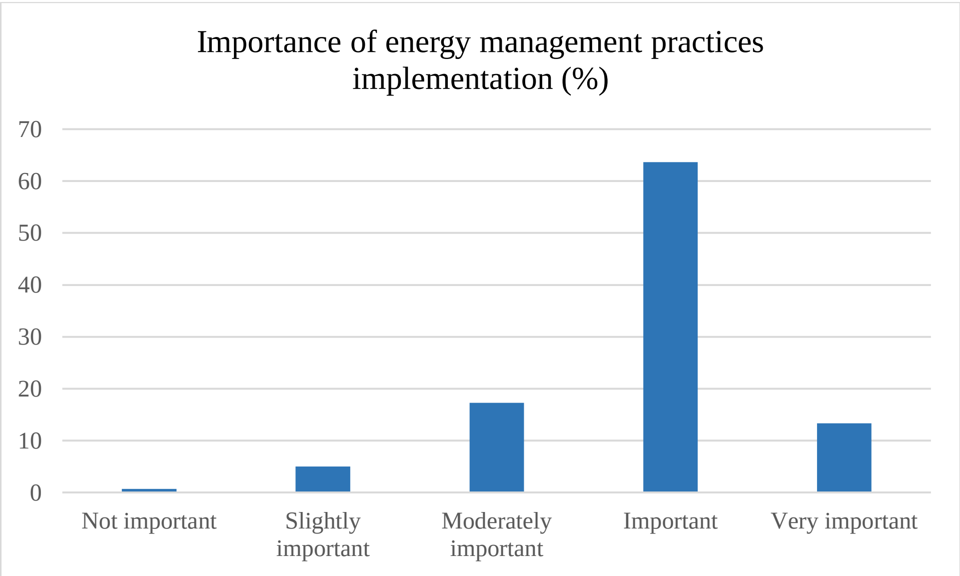
2.2.2.3 Findings

Descriptive statistics findings

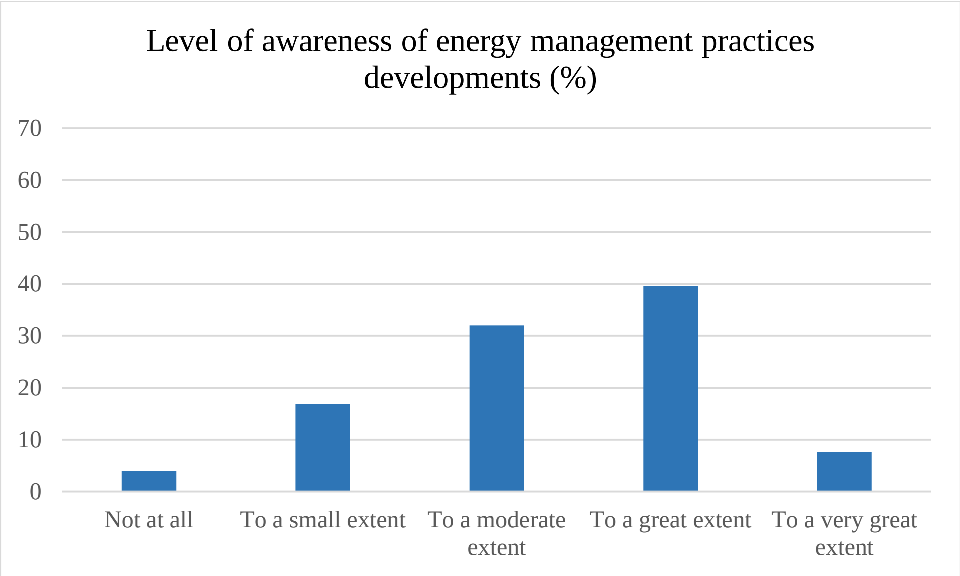
Below the graphs that were constructed from the frequencies results of SPSS are presented. The respective values of means and medians, where applicable, are reported at the Appendix.

How important do you find the implementation of energy management practices in your organisation?

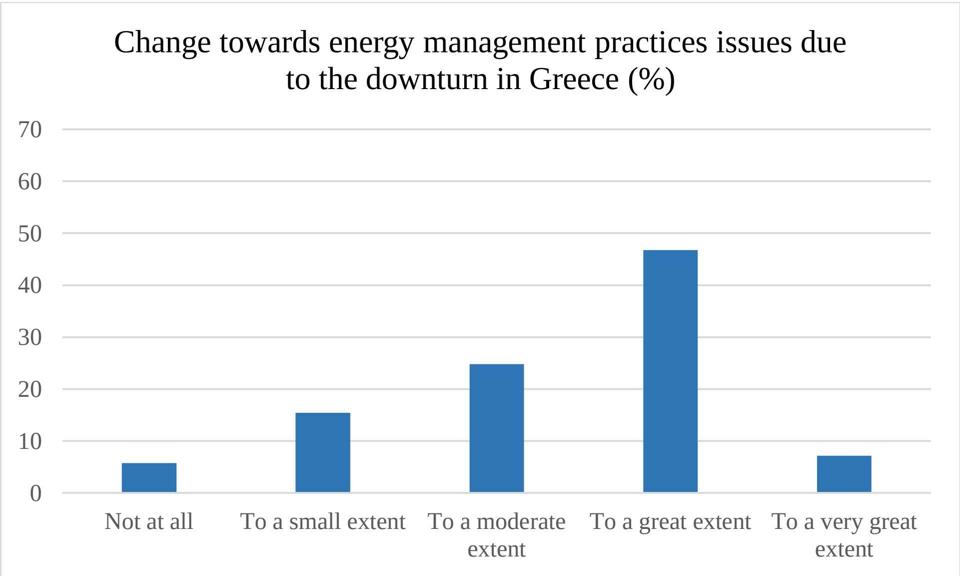
Overall, almost all organisations find the implementation of energy management practices important (question 1) and stay aware of developments in the energy management sector to a moderate or a great extent (question 2), while their interest has changed to a great extent in the aftermath of the economic recession in Greece (question 3), something that was expected as a result.



To what extent does your organisation stay aware of developments in the energy management sector?



To what extent did your organisation's interest towards energy management/efficiency issues change, in the aftermath of the economic downturn in Greece?

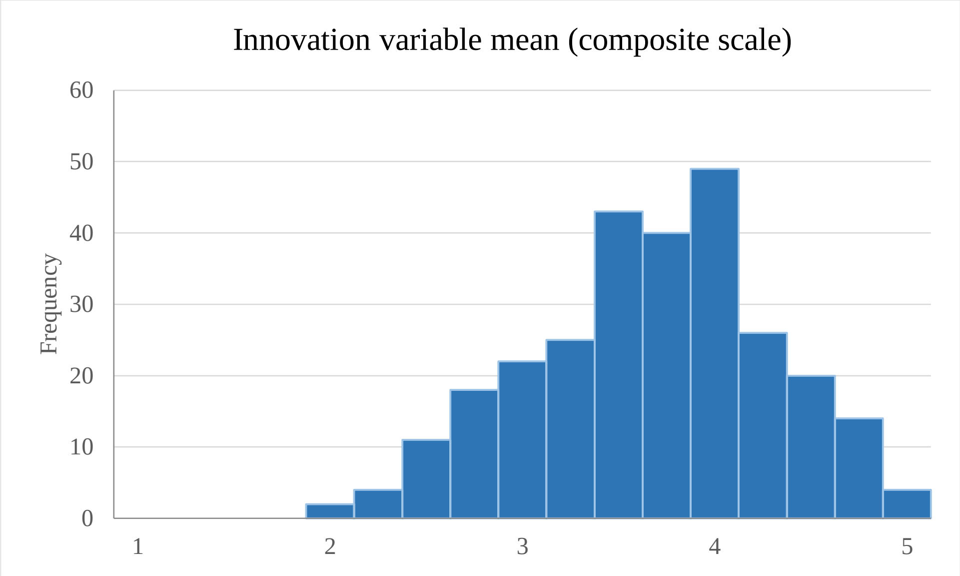


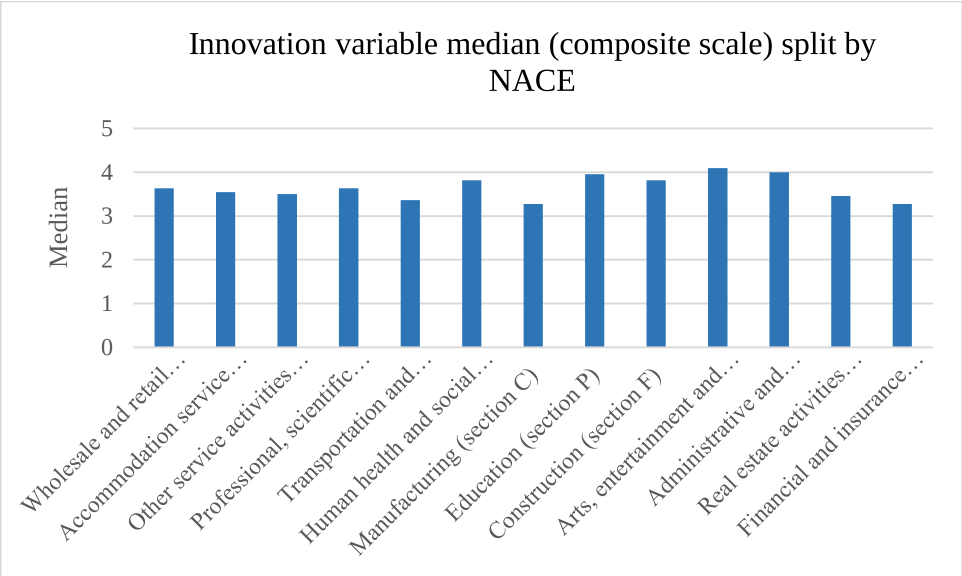
Please indicate your level of agreement with the following statements, regarding innovation practices in your organisation

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	The organisation promotes creativity and innovation in order to create better products and/or services					
2	The organisation sells unique products and/or provides unique services					
3	The organisation operates in such a way, that enables it to adapt to change					
4	The leadership of the organisation encourage open discussions and involvement in the expression of ideas					
5	Collaboration and mutual exchange of knowledge and information exist among departments and people within the organisation					
6	The leadership of the organisation encourage creative thinking and creative decision-making					
7	The organisation is "afraid" of change					
8	The leadership of the organisation tap their employees' ideas					
9	The organisation has determined a policy about innovation					
10	The organisation sets targets for innovation					
11	There are no barriers to creativity within the organisation					

Question 4 was treated as a composite Likert scale. The average (mean) of all sub-questions was, thus, calculated for each respondent. The histogram extracted from the summated scale (individual decimal values required the visual display via a histogram) indicated that most companies consider themselves to encourage organisational innovation practices in general. From this set of answers it would be interesting to show how the median measure of innovation practices fluctuates depending on the NACE sectors classification. The graph depicts an almost unvarying median value across all sectors, but the Manufacturing sector (section C) gave an unexpected low result together with the Financial and insurance activities sector (section K).

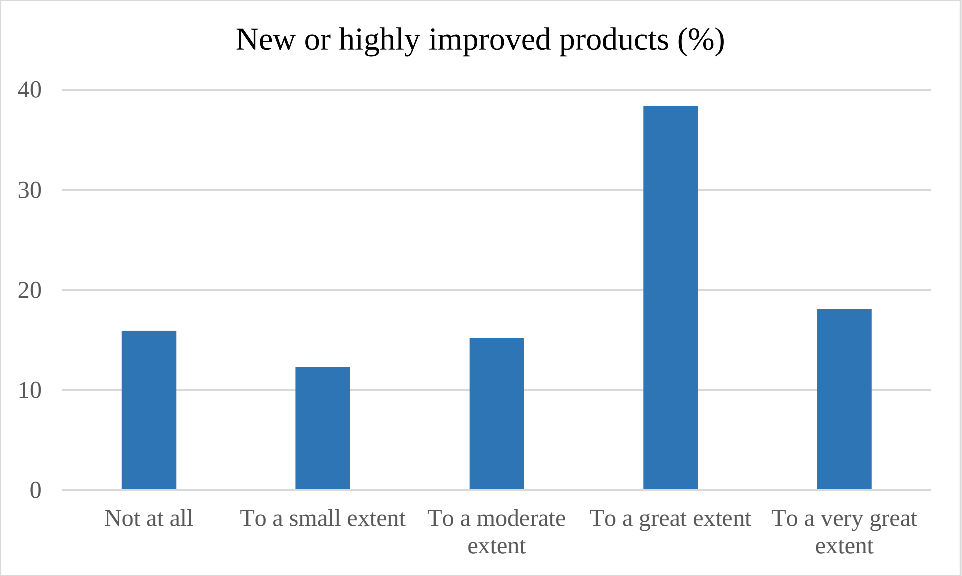
For the convenience of the histogram's interpretation it should be mentioned that 'strongly disagree' corresponds to number 1, 'disagree' corresponds to number 2, 'neutral' corresponds to number 3, 'agree' corresponds to number 4 and 'strongly agree' corresponds to number 5.

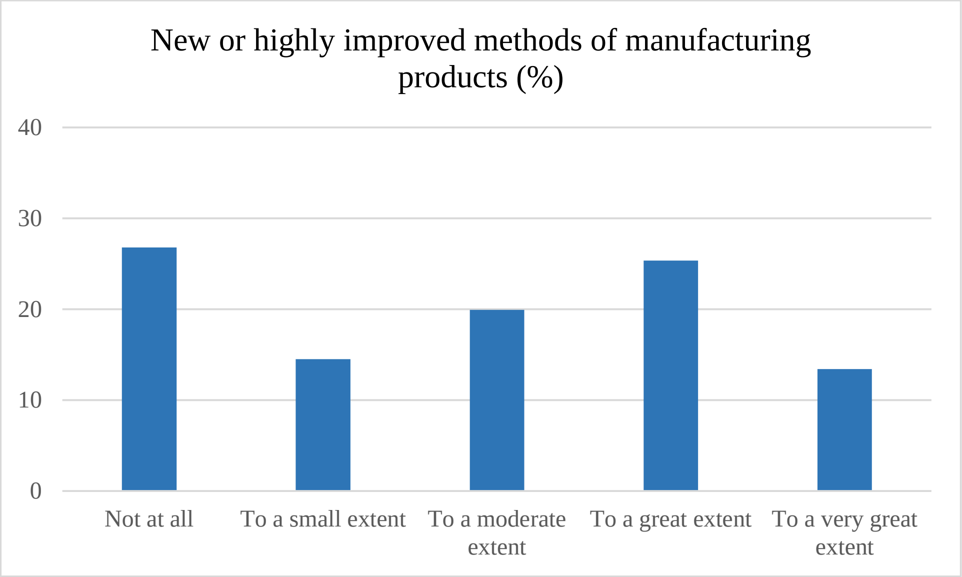


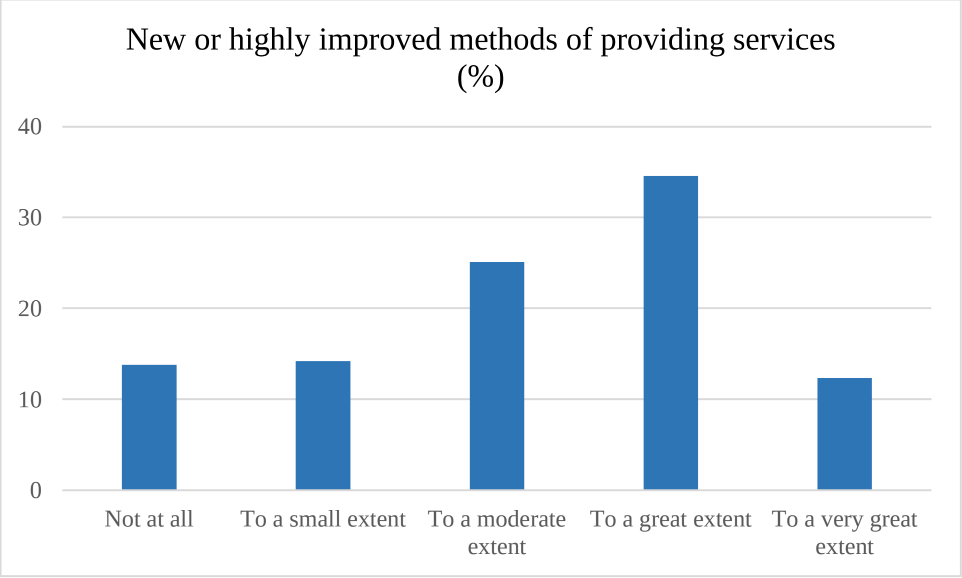


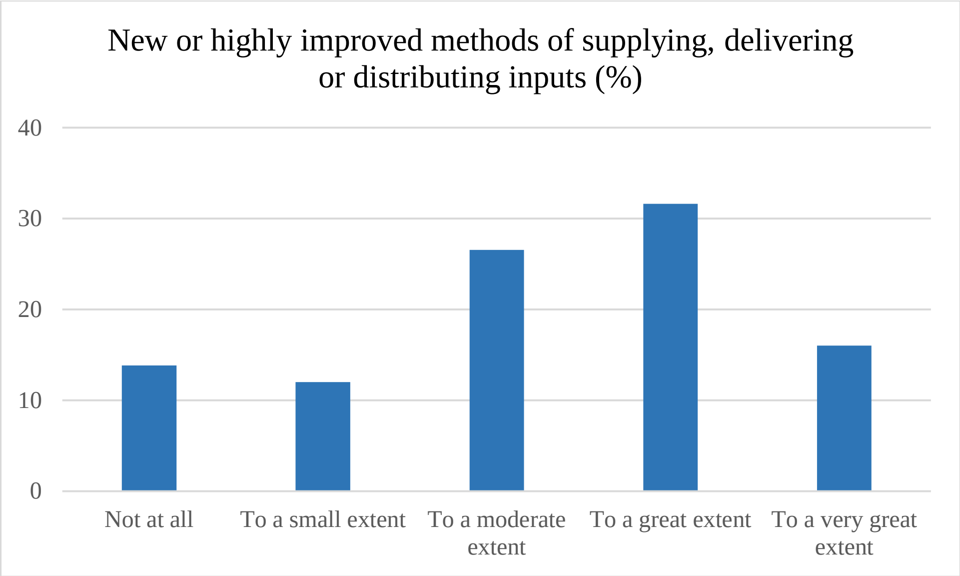
The organisation the last 3 years has introduced…

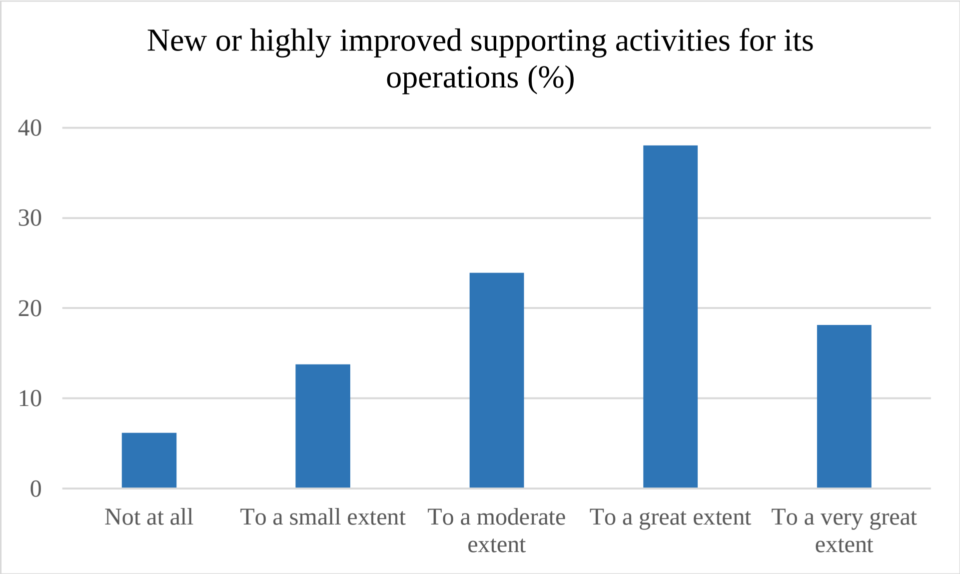
Mostly, organisations the last three (3) years have introduced new or highly improved products and new or highly improved supporting activities for their operations.


New or highly improved products (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


New or highly improved methods of manufacturing products (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

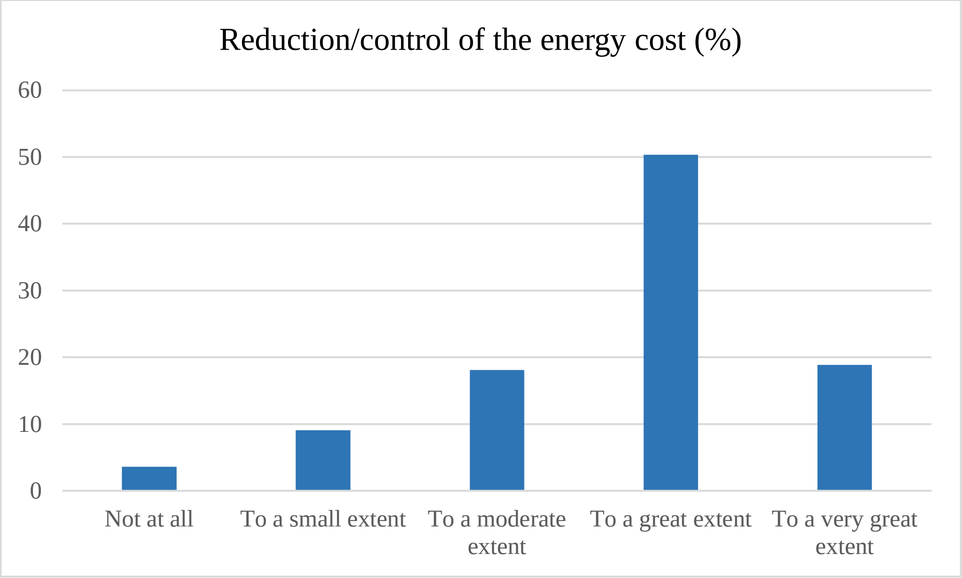

New or highly improved methods of providing services (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

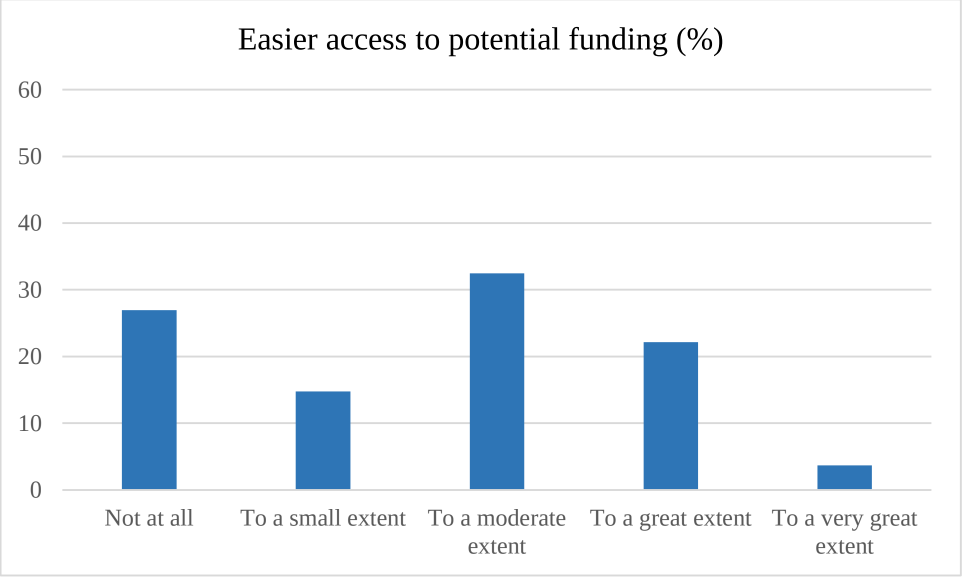


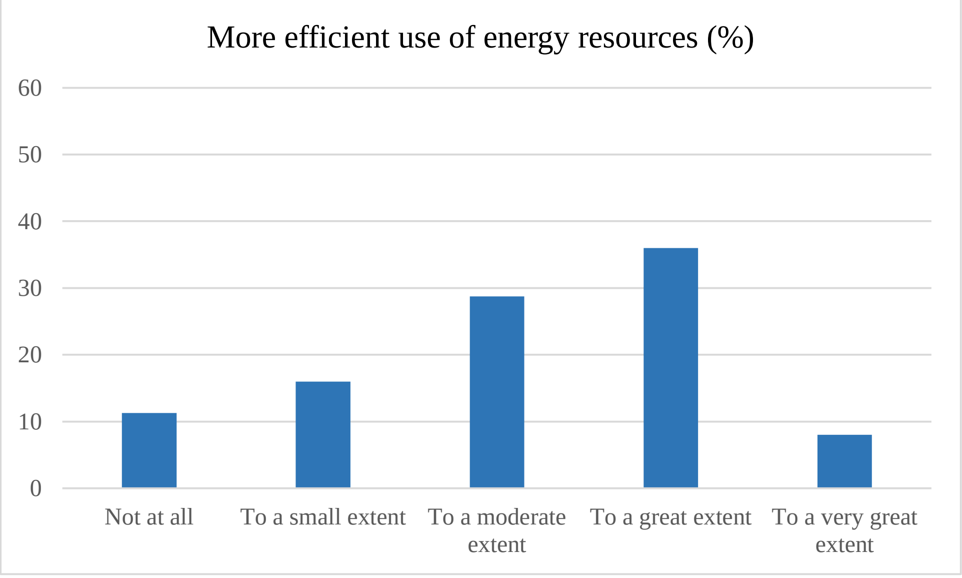


Please indicate the extent to which the following statements influenced the decision of adopting energy management practices in your organisation

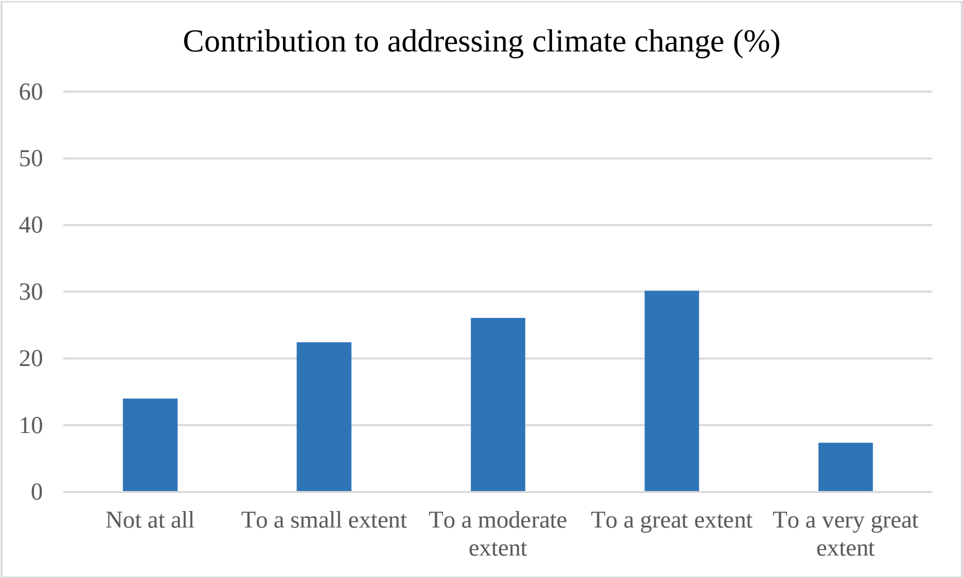
The reduction of cost and the compliance with customers' and market's requirements are the main factors that influence the decision of adopting energy management practices in an organisation. Additionally, the implementation of energy management practices enables businesses to compete in a level playing field within their industry and the market in general.

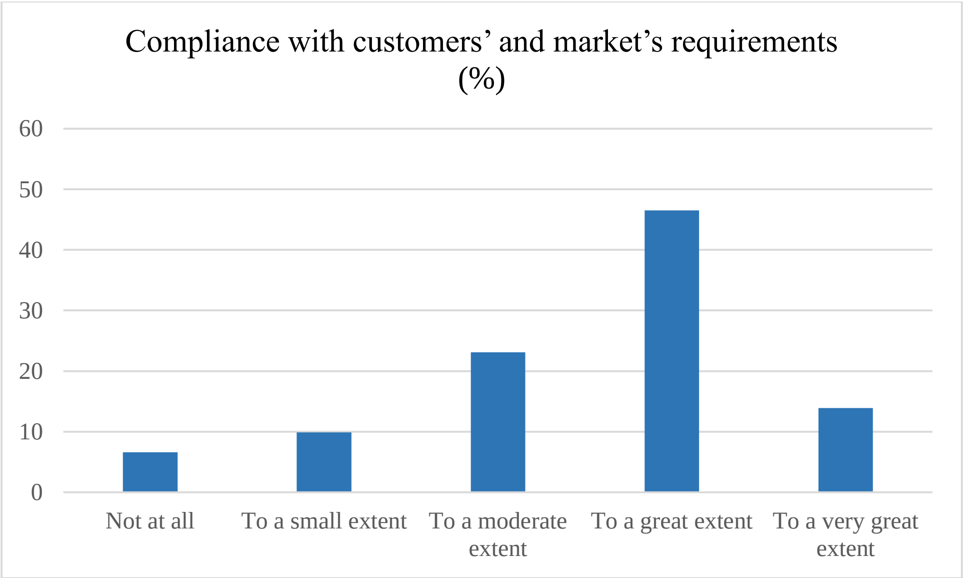

Reduction/control of the energy cost (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

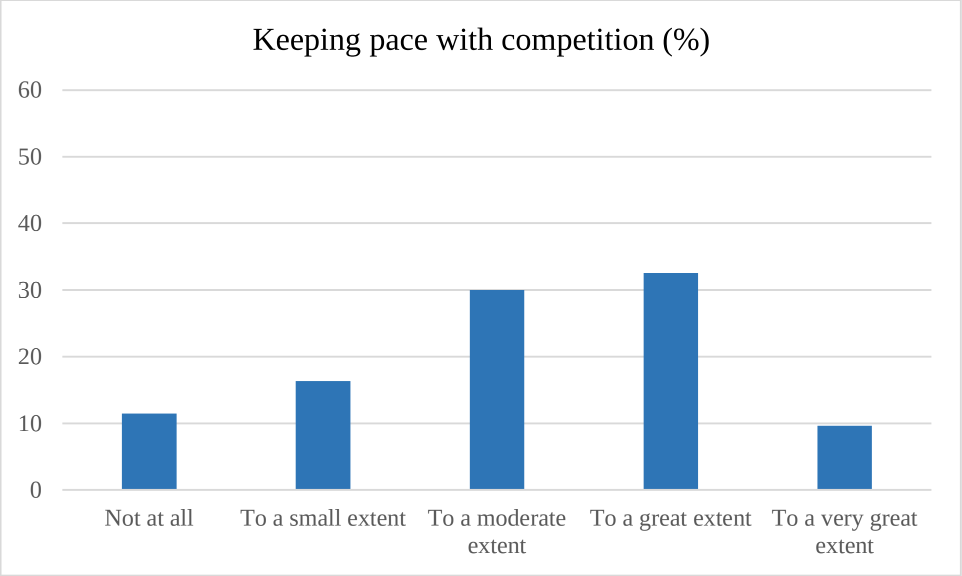

Easier access to potential funding (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

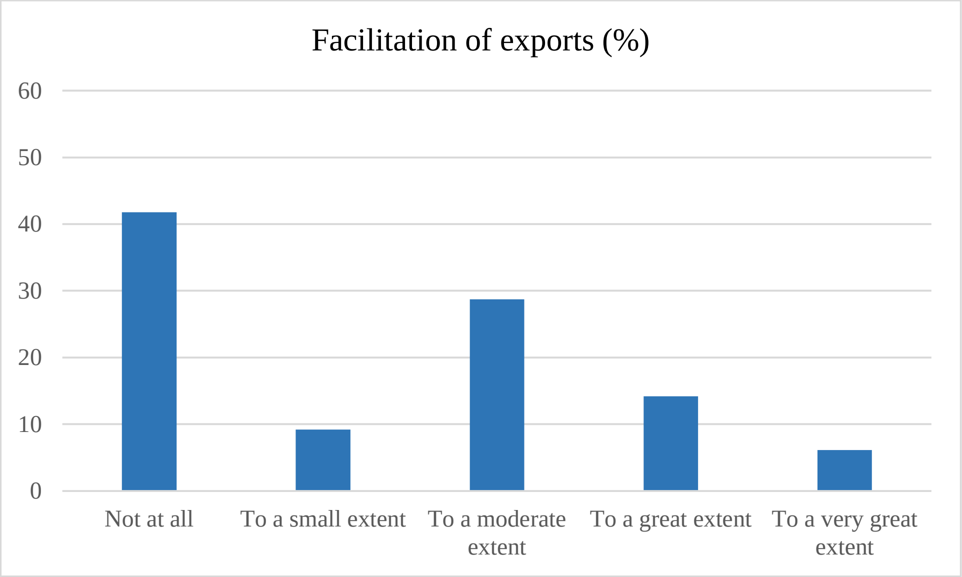

More efficient use of energy resources (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

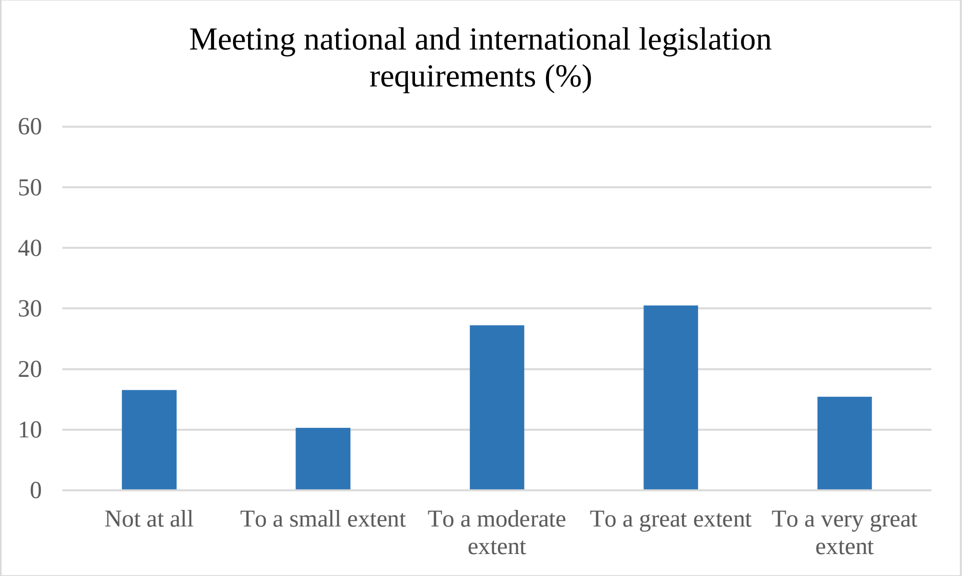

Improved reputation and image of the organisation (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

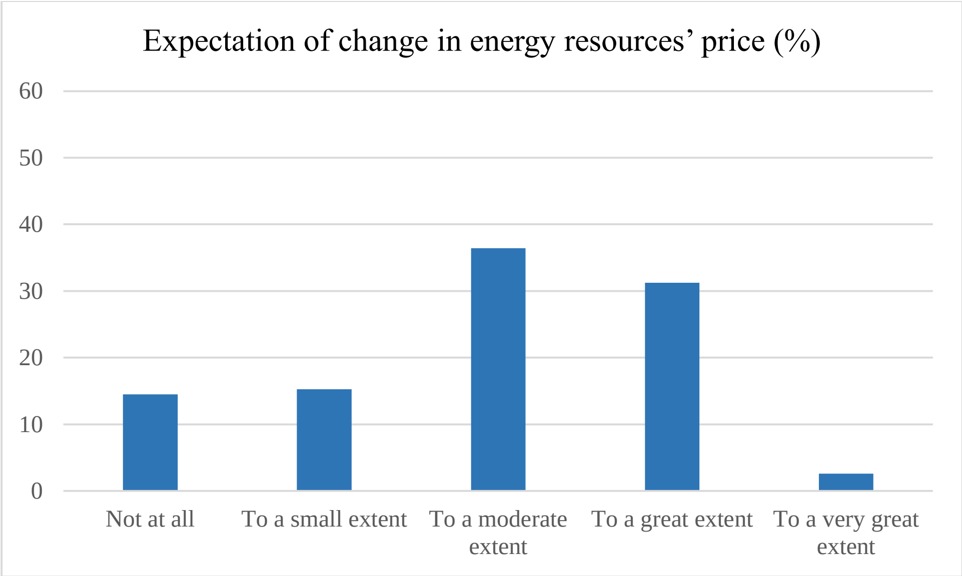

Contribution to addressing climate change (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


Compliance with customers' and market's requirements (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


Keeping pace with competition (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

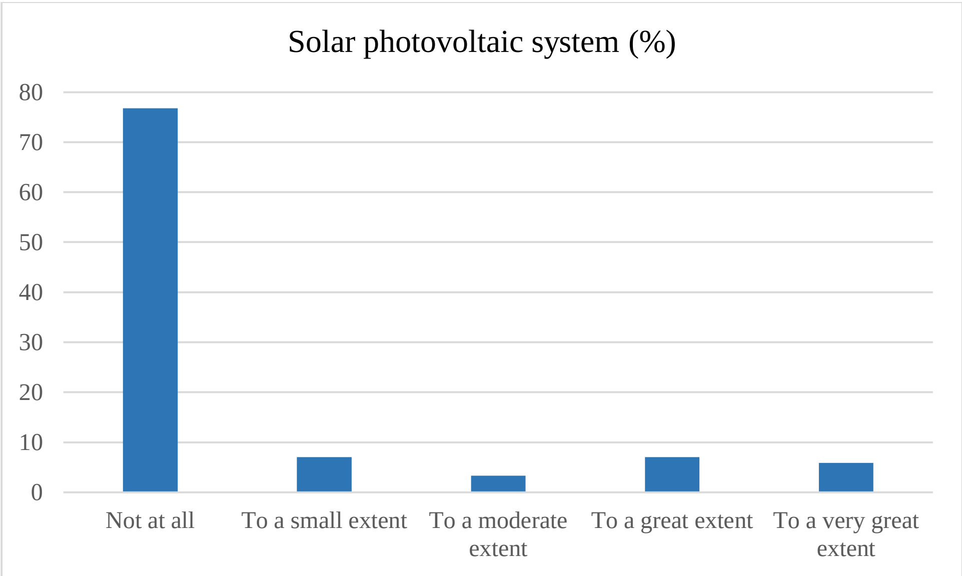

Facilitation of exports (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

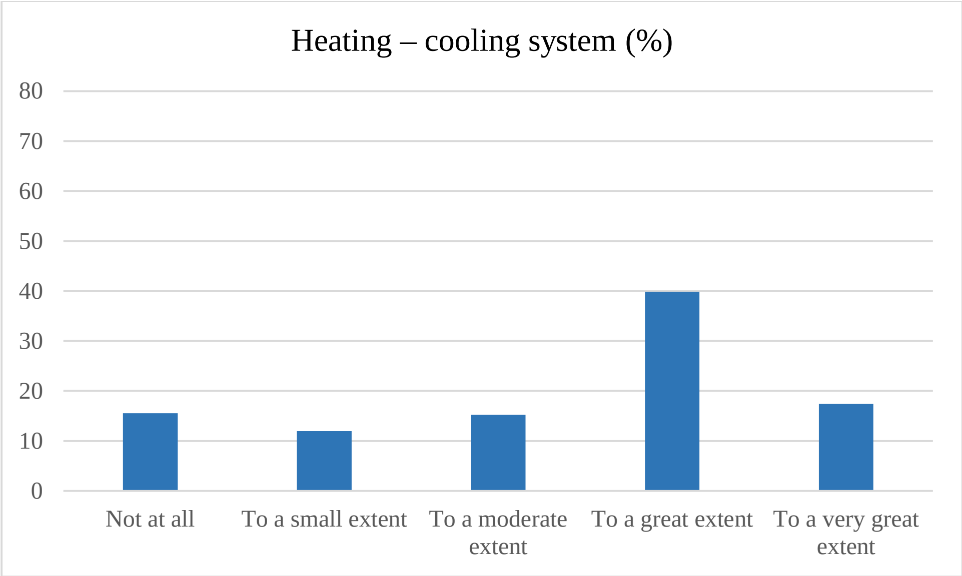

Meeting national and international legislation requirements (%)
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

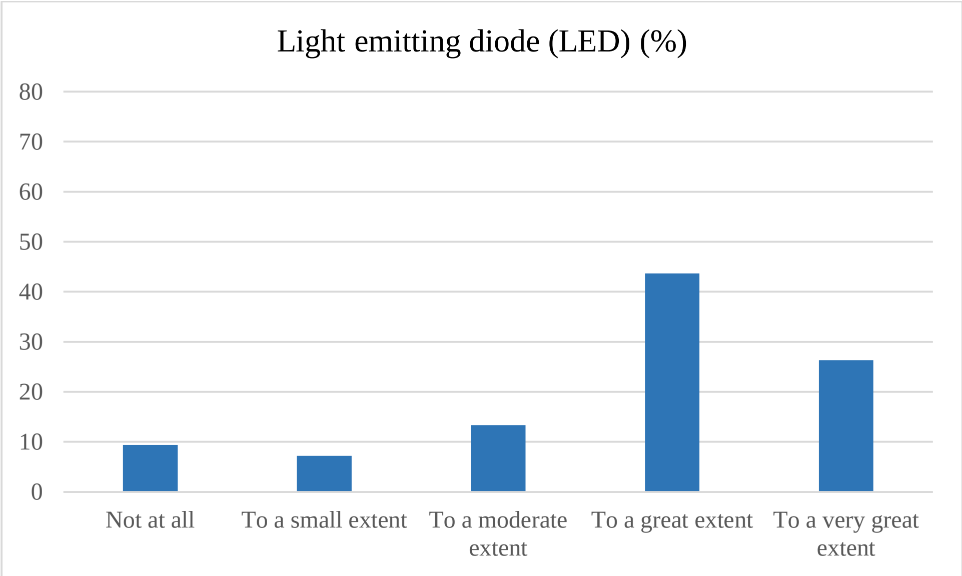


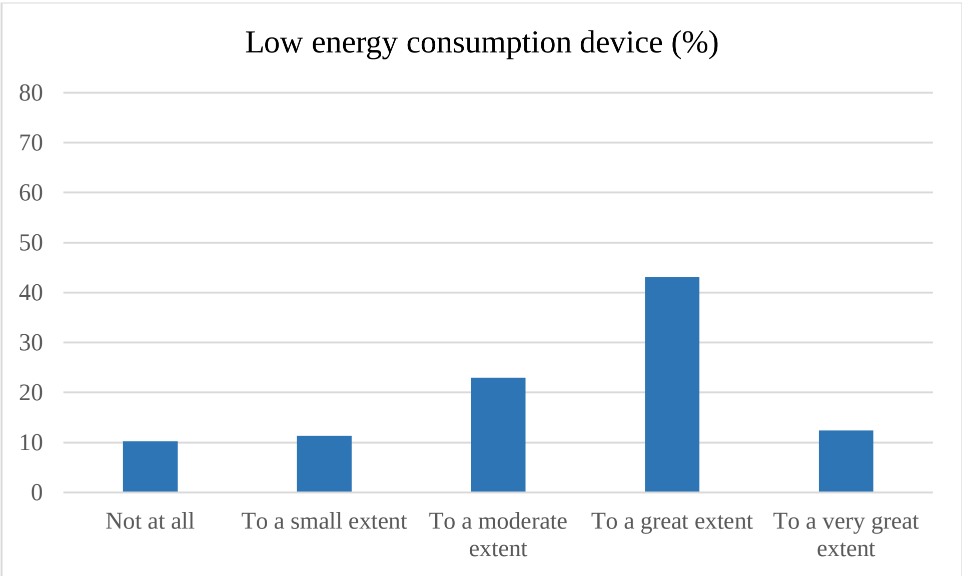
Please indicate the extent to which the following energy management technologies are implemented in your organisation

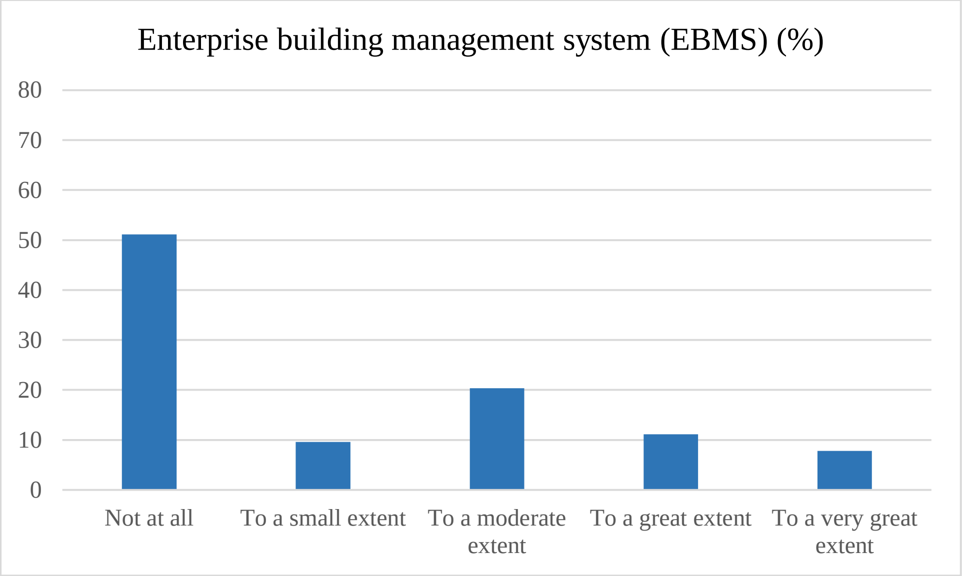
Heating and cooling systems together with light emitting diodes (LEDs) and low energy consumption devices are the ones mostly implemented in the respondent organisations, something reasonable, given that not many organisations are energy-intensive or in the manufacturing sector.

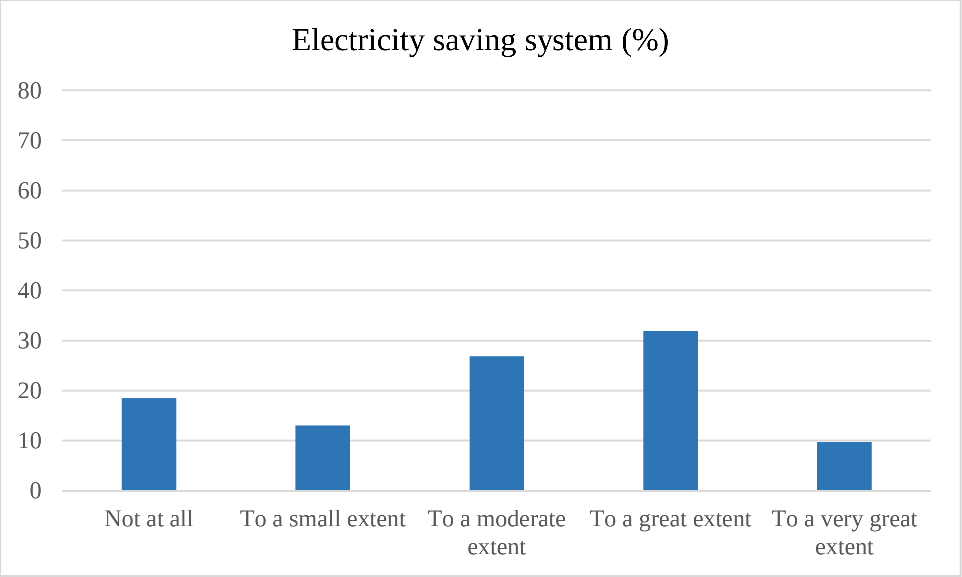


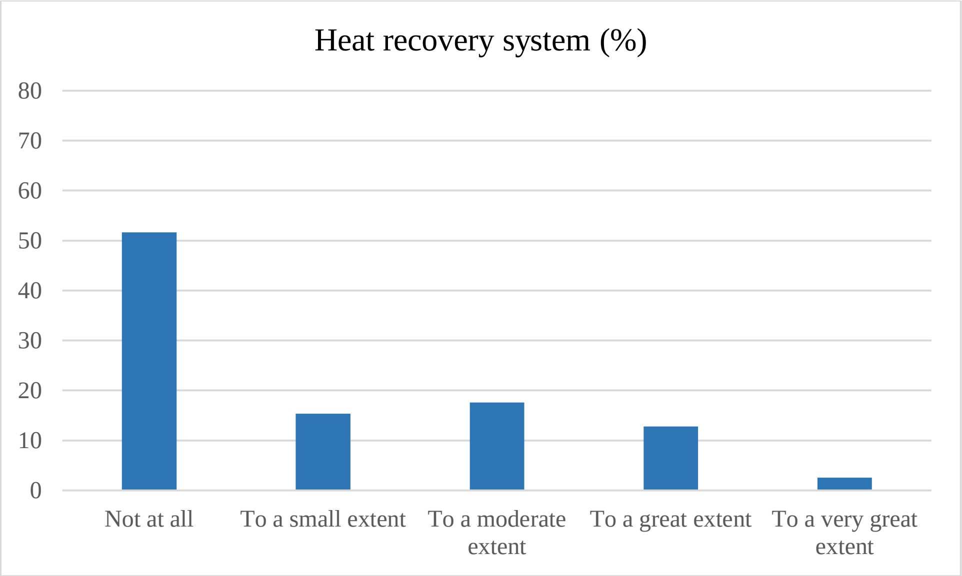

Heating – cooling system (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

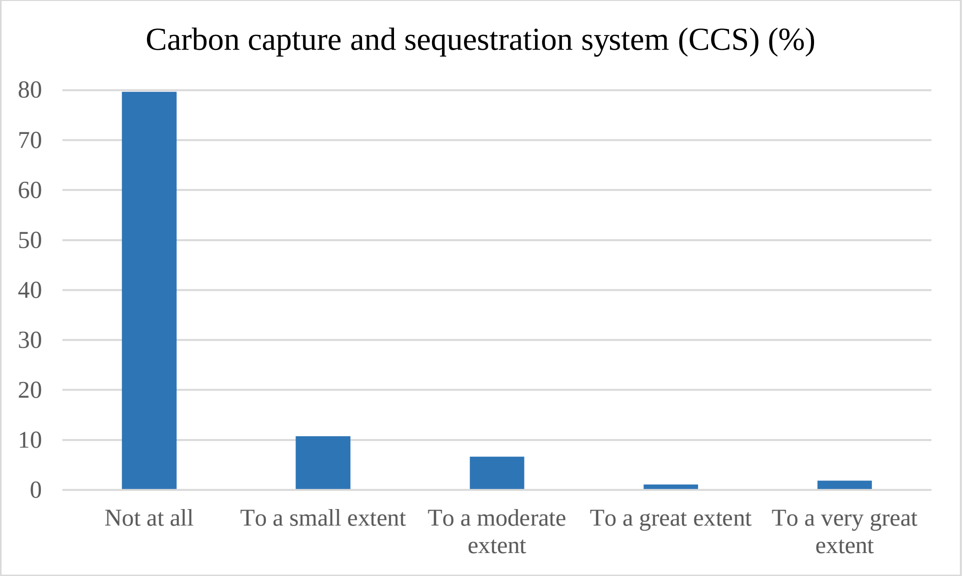

Light emitting diode (LED) (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

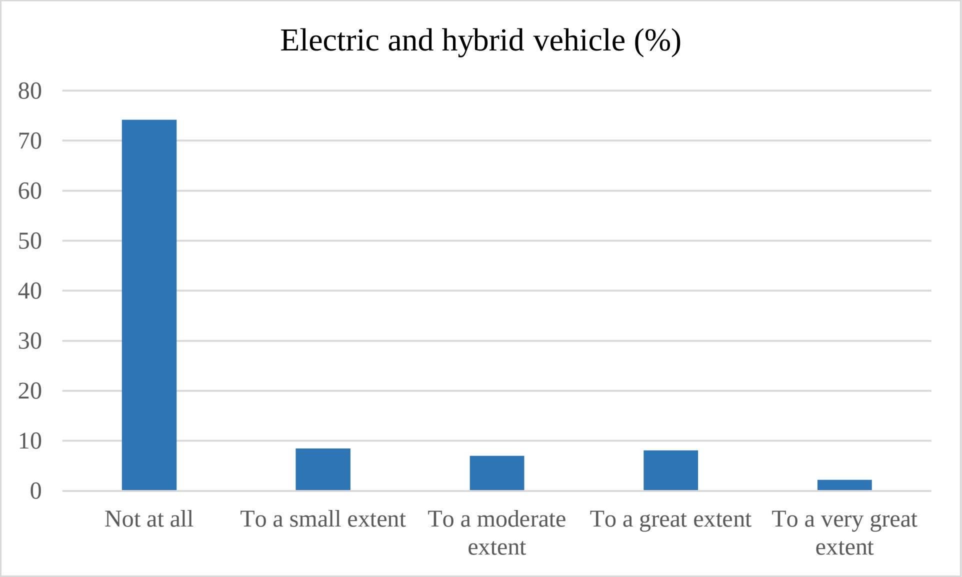

Low energy consumption device (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

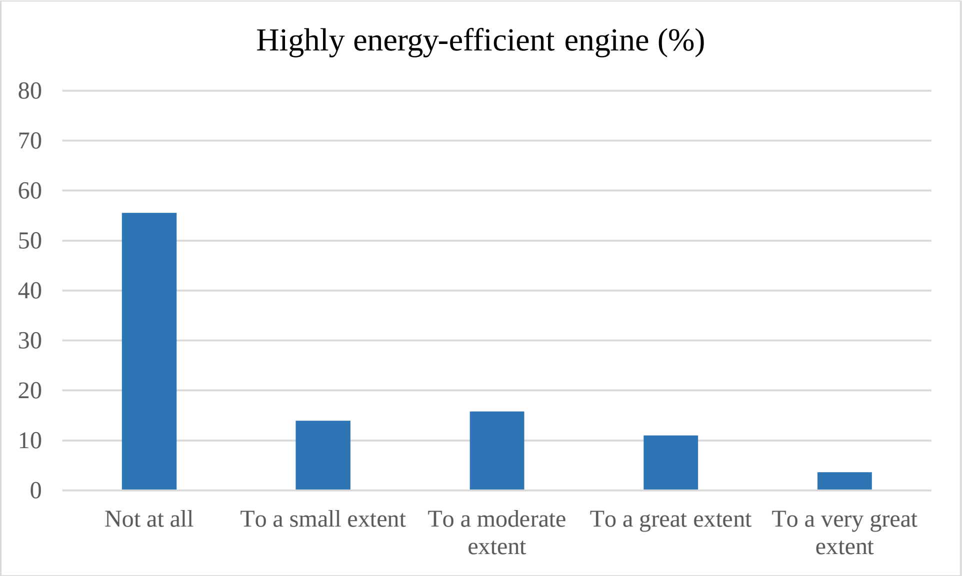

Enterprise building management system (EBMS) (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

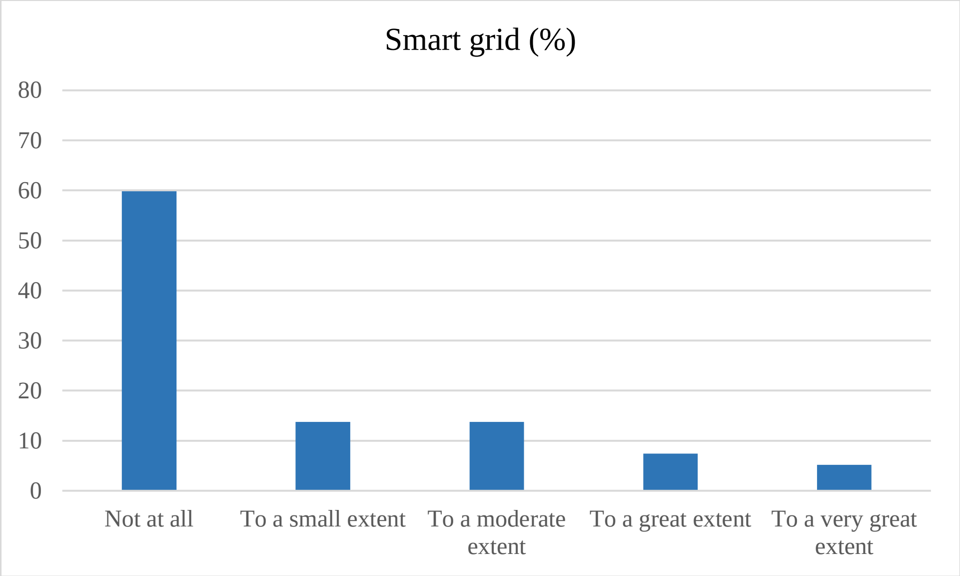

Electricity saving system (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

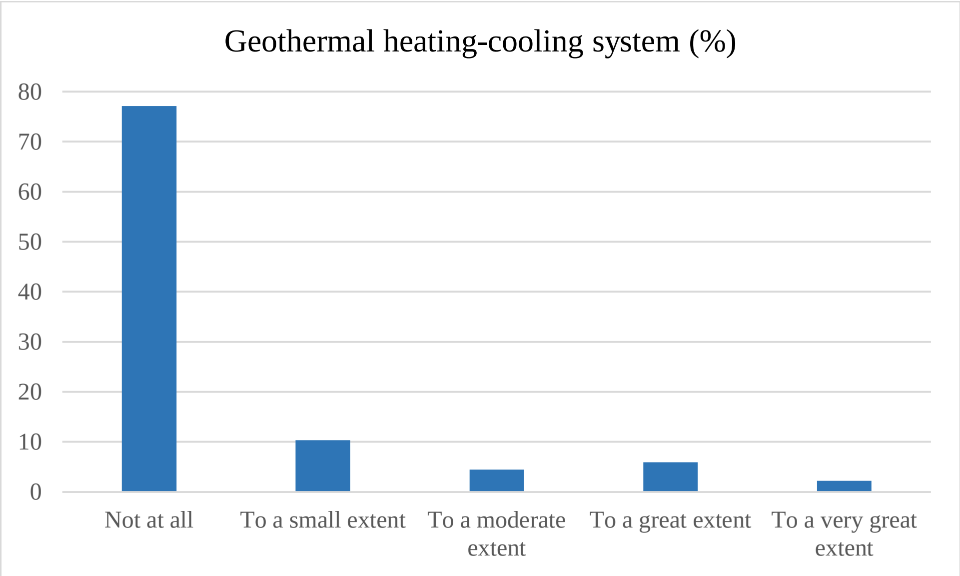

Heat recovery system (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


Carbon capture and sequestration system (CCS) (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


Electric and hybrid vehicle (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

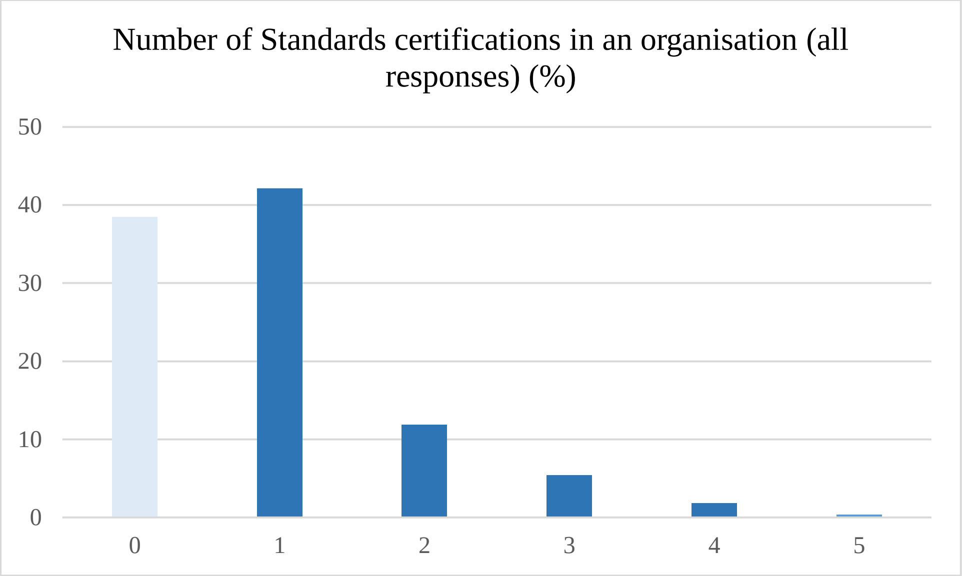

Highly energy-efficient engine (%)
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

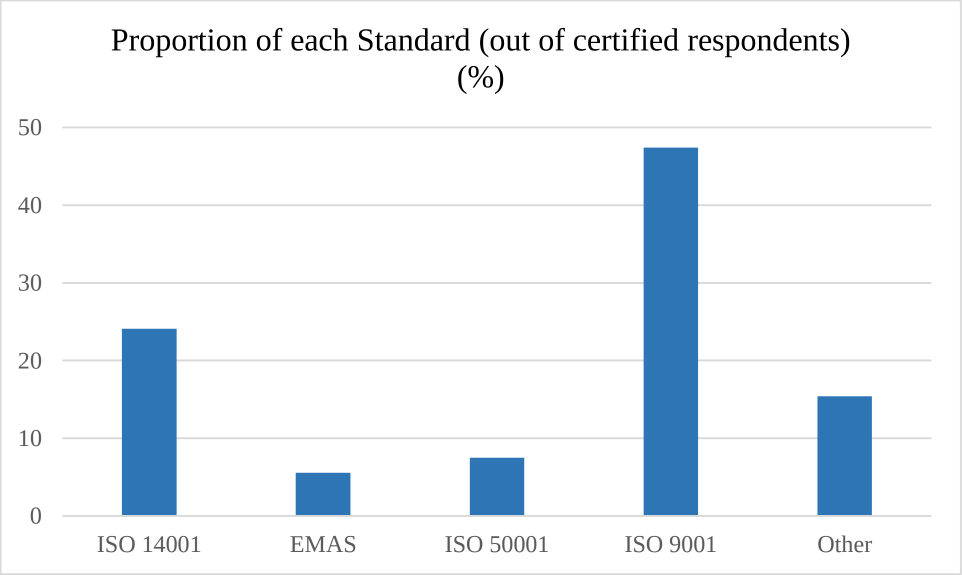


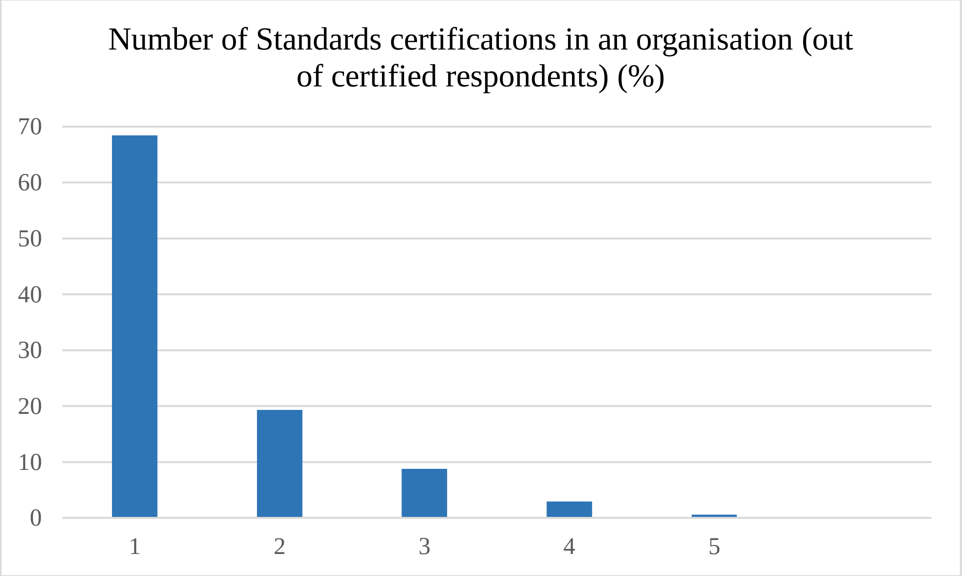


Please indicate under which of the following Standards your organisation is certified

Almost 40% of the organisations participated in the survey have zero (0) Standard certifications. Around 68% of the certified organisations have one Standard certification, while the rest have two or more certifications. Another finding is that within those organisations certified, the ISO 9001 is the most common one with 47.4% and second comes the ISO 14001 with 24.1%.


Number of Standards certifications in an organisation (all responses) (%)
50
40
30
20
10
0
0
1
2
3
4
5


Proportion of each Standard (out of certified respondents) (%)
50
40
30
20
10
0
ISO 14001
EMAS
ISO 50001
ISO 9001
Other

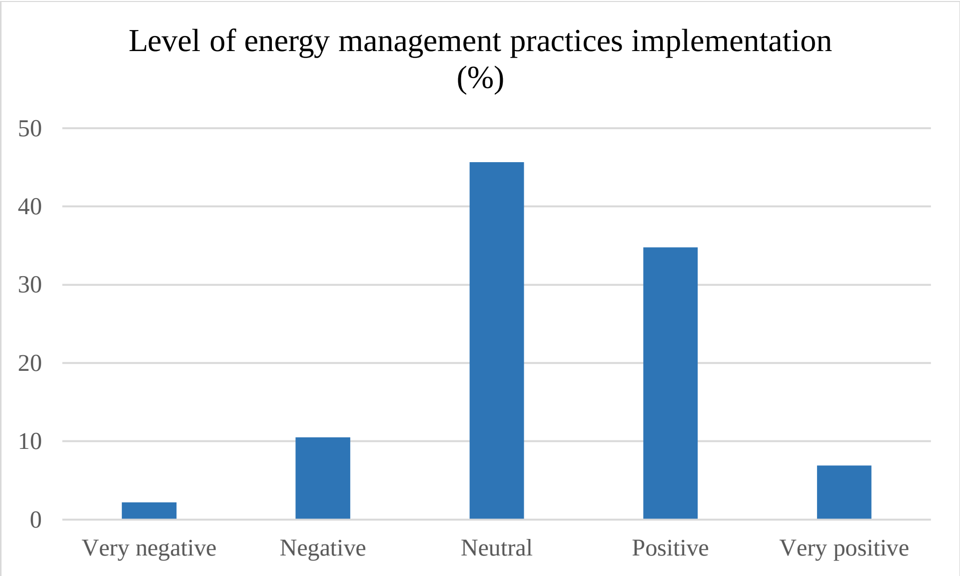

Number of Standards certifications in an organisation (out of certified respondents) (%)
70
60
50
40
30
20
10
0
1
2
3
4
5

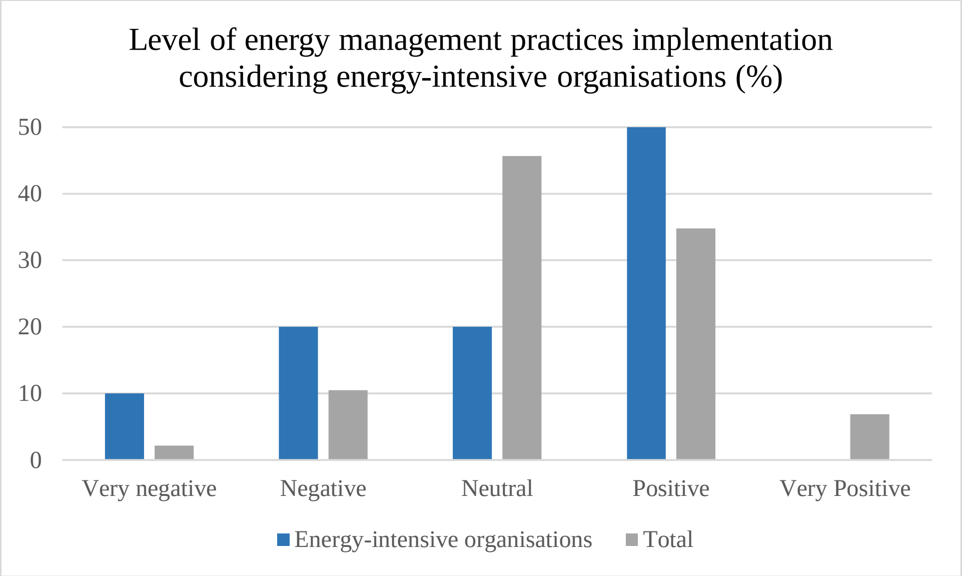
How do you assess the level of energy management practices implementation in your organisation?

The majority of organisations assess their level of energy management practices implementation as mostly neutral or likely positive (question 9). The same graphical depiction is given in question 12, where the level of employees' encouragement in energy management is examined.

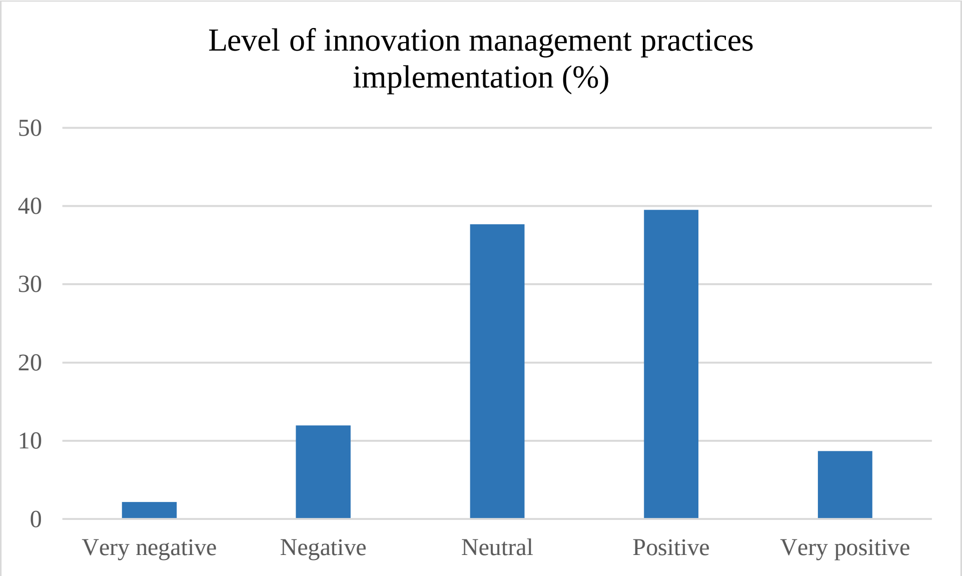
The level of innovation management practices implementation (question 10) was considered almost equally neutral and positive, also very similar to the result of question 11, where the level of technology use was investigated.

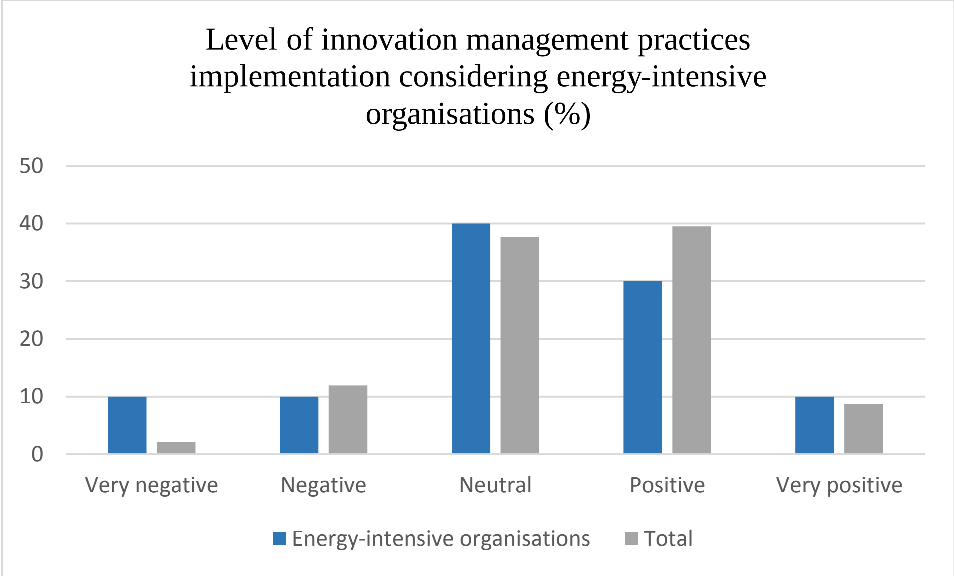
Energy-intensive organisations showed more positive median values compared to the other organisations for the question on the level of energy management practices implementation. On the contrary, these organisations gave relatively low median values when asked about the level of technology use in energy management. These two results seem contradictory and since only 4% of our sample organisations responded as energy-intensive further research would be recommended for a better clarification.



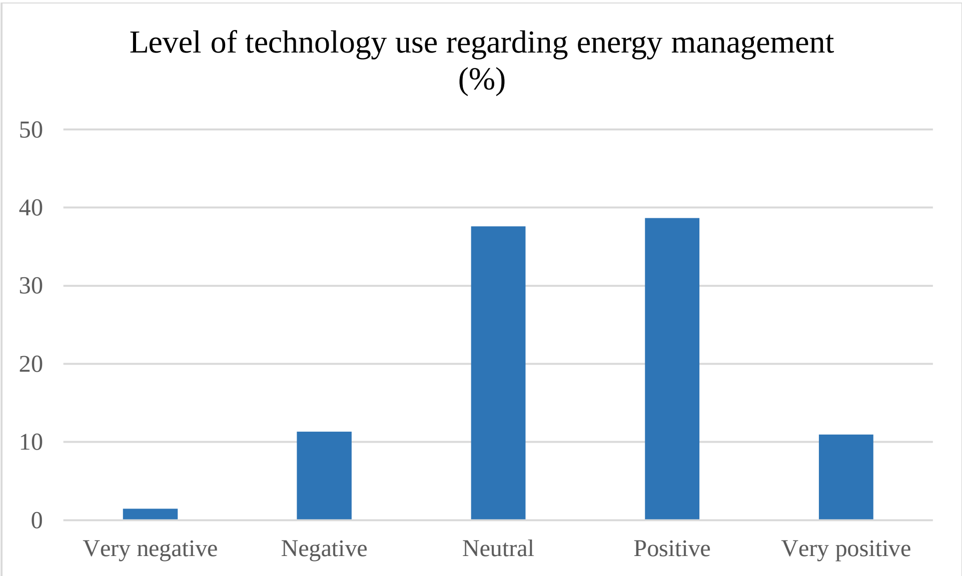


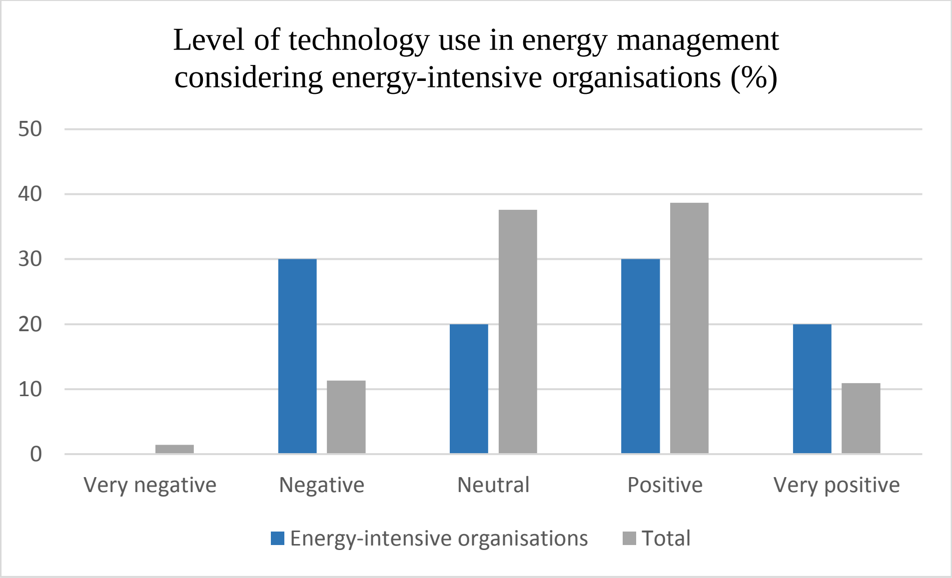
How do you assess the level of innovation management practices implementation in your organisation?



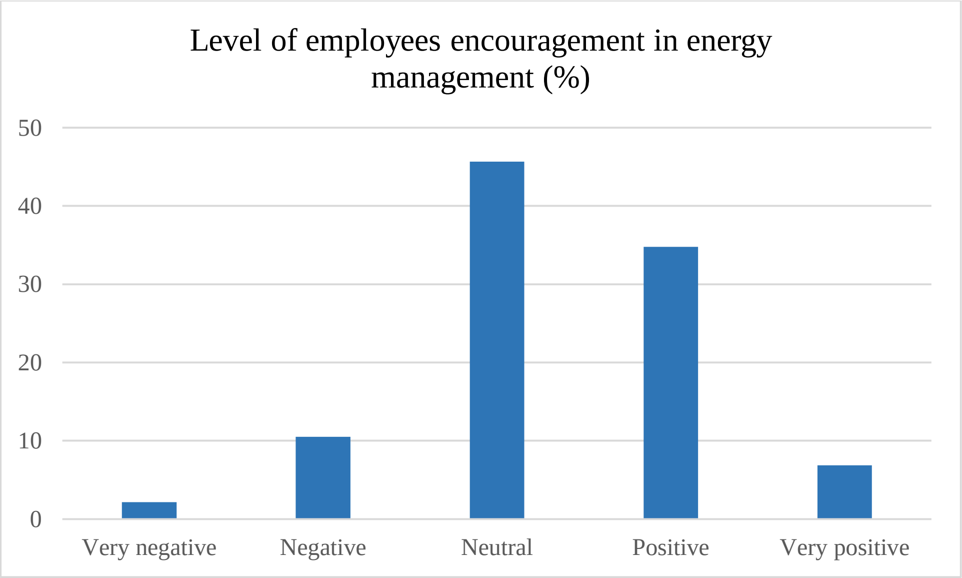


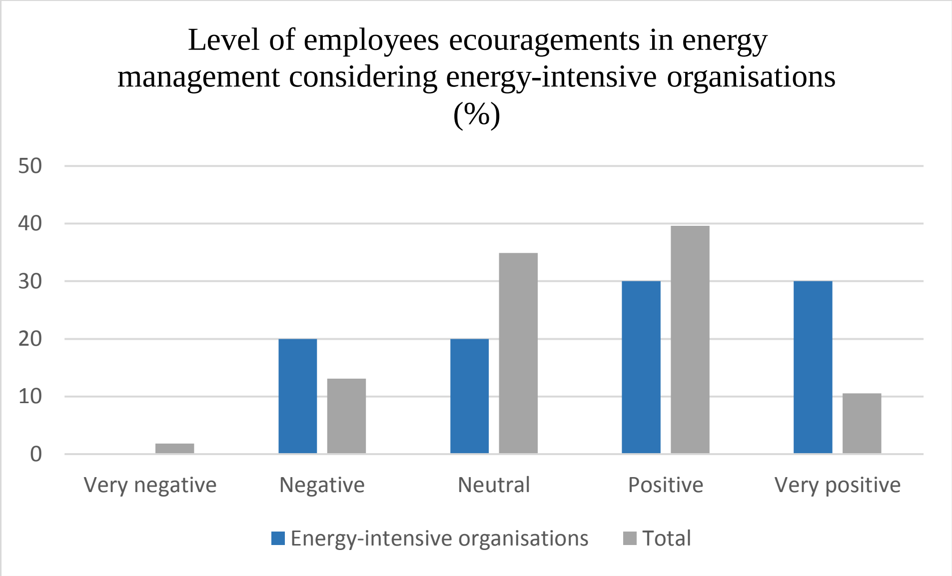
How do you assess the level of technology use regarding energy management in your organisation?





How do you assess the level of employees encouragement regarding their involvement in energy management in your organisation?

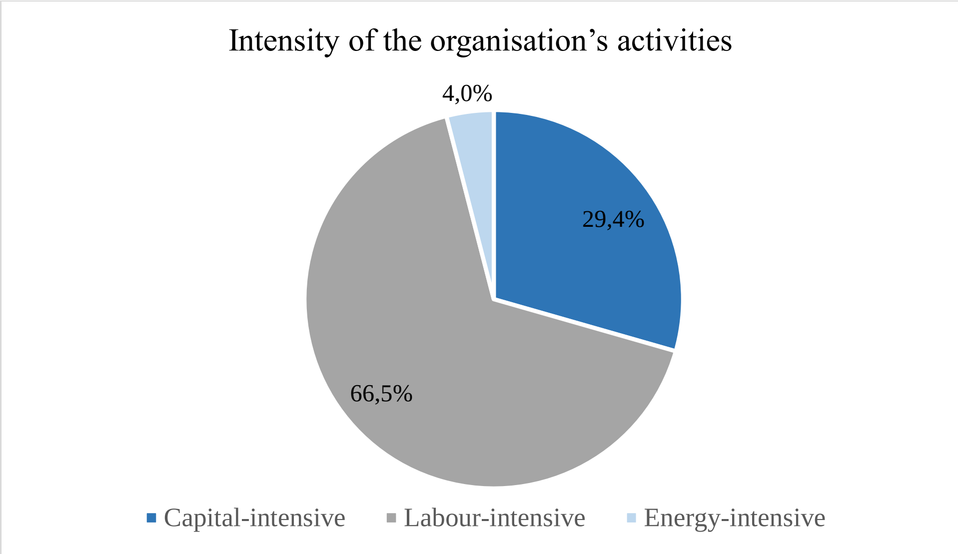




Your organisation is…

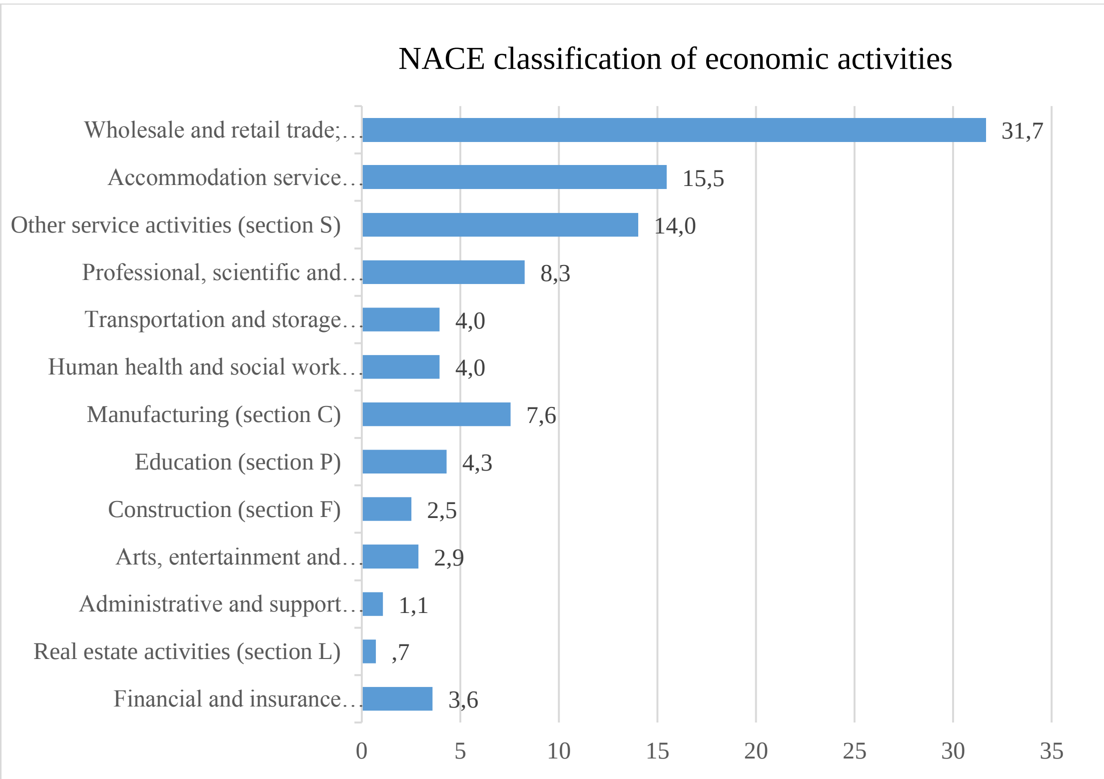
Circa 88% of the organisations involved in the survey are Greek and the rest are members of a foreign organisation (question 13), whilst most of the organisations (66.5%) are labour-intensive and only 4% are energy-intensive (question 14).

Your organisation is…



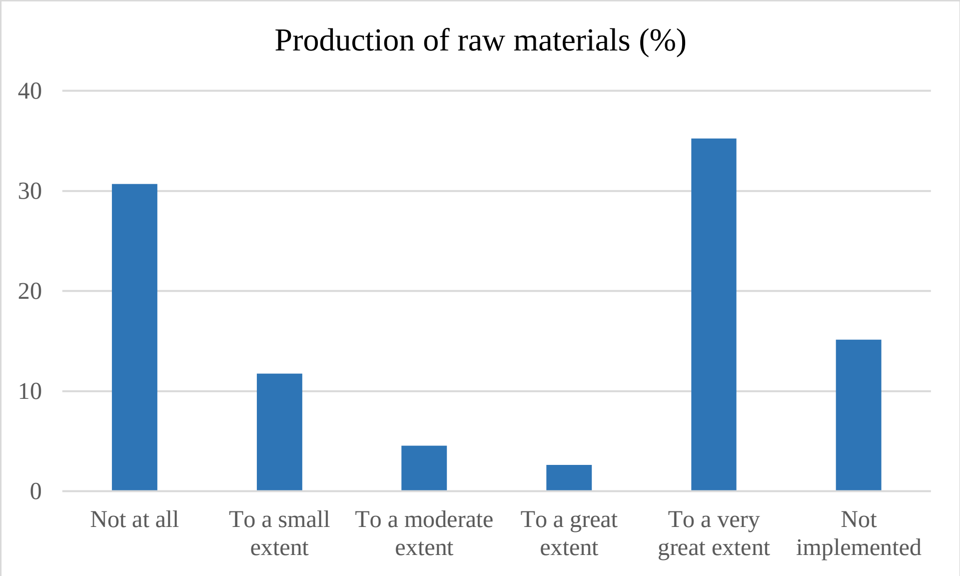
In which industry does your organisation operating in?

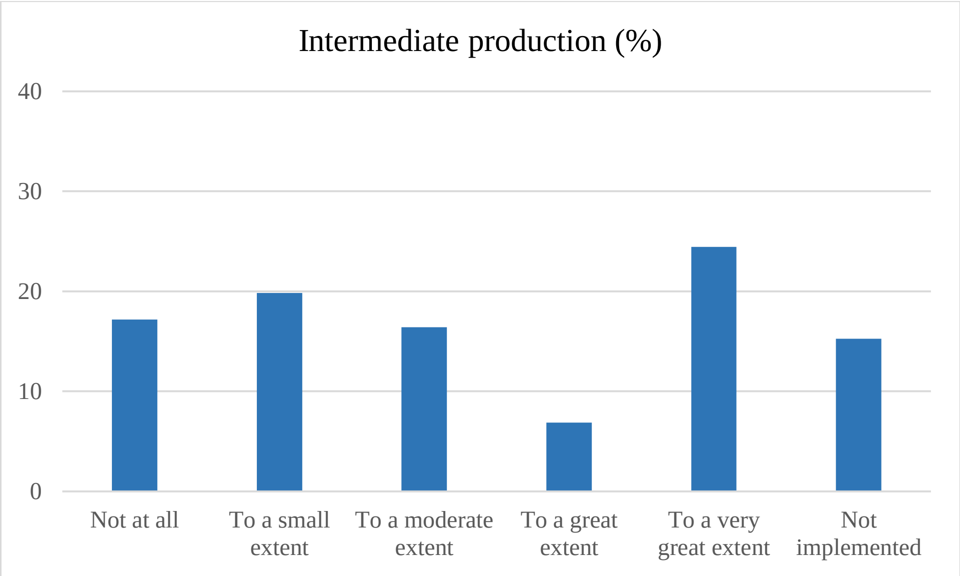
The field of operation as determined during the sampling methodology is displayed below, according to the NACE Statistical classification of economic activities in the European Community (Eurostat N. A. C. E., 2008).

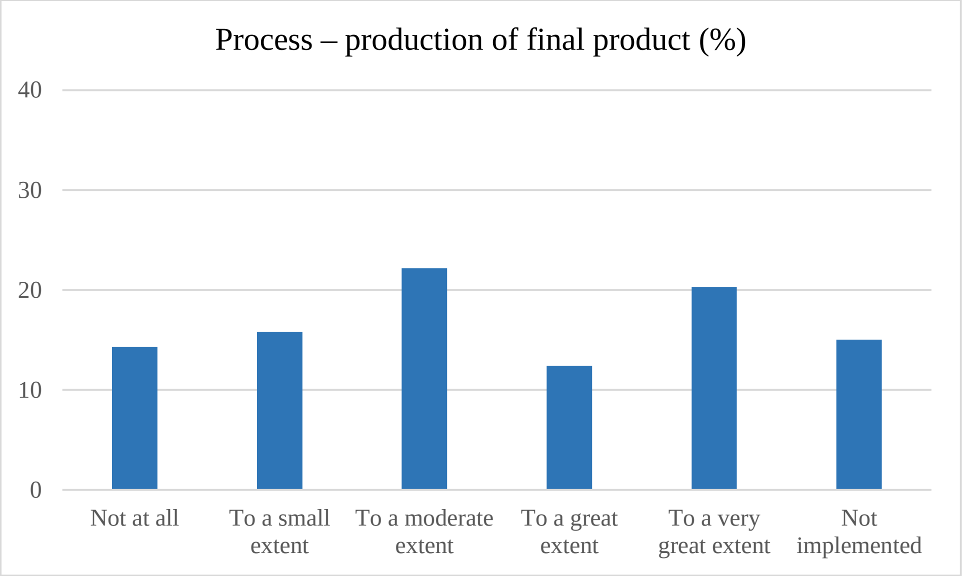


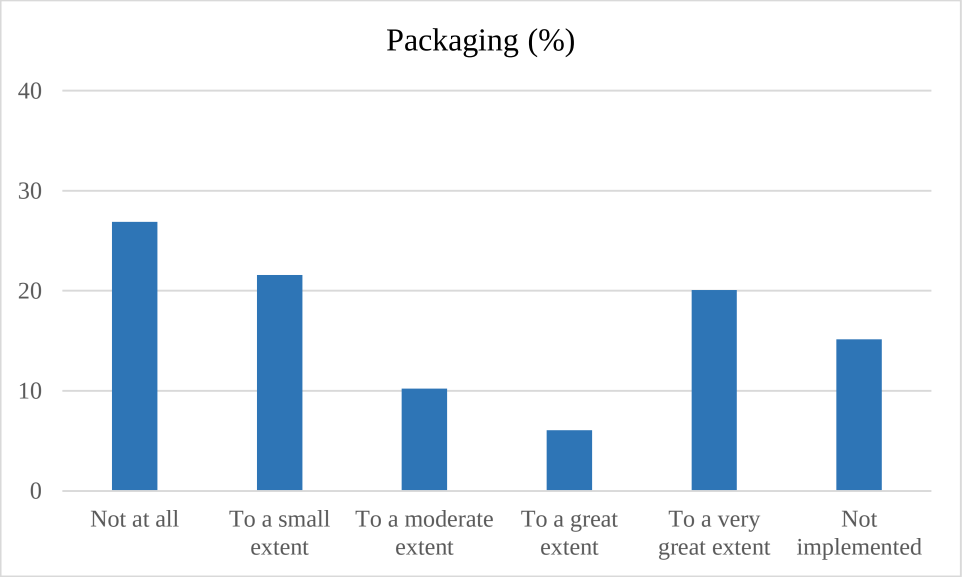
To what extent do you think the following implemented activities within your organisation are energy-consuming?

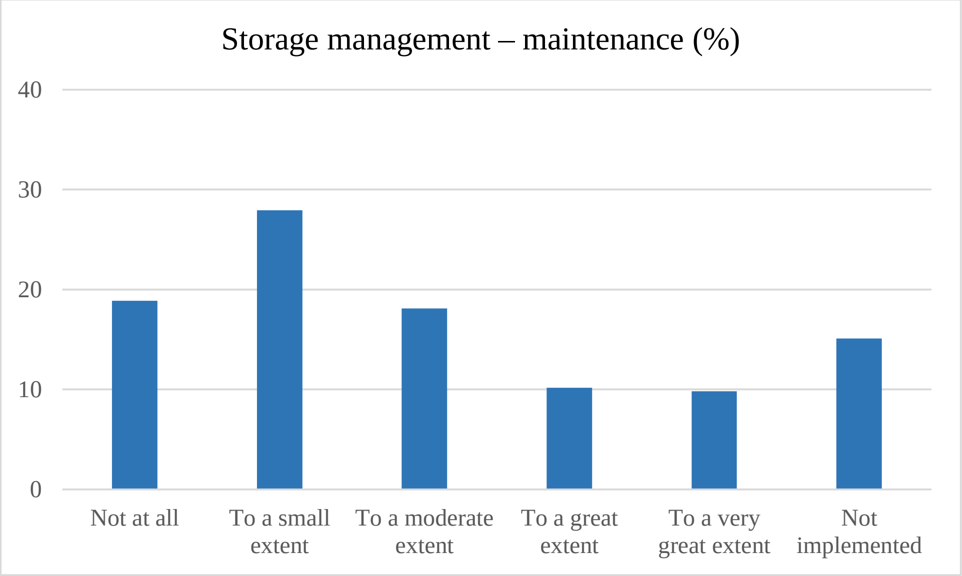
The production of raw materials, the intermediate production and the process - production of the final product are mainly considered as energy-consuming. All the other activities are considered at best moderately energy-consuming.

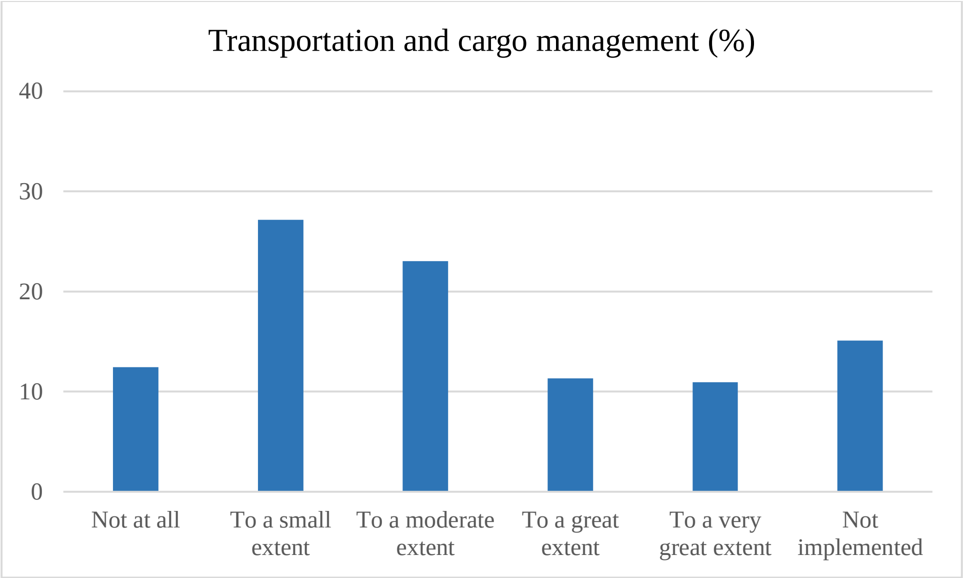


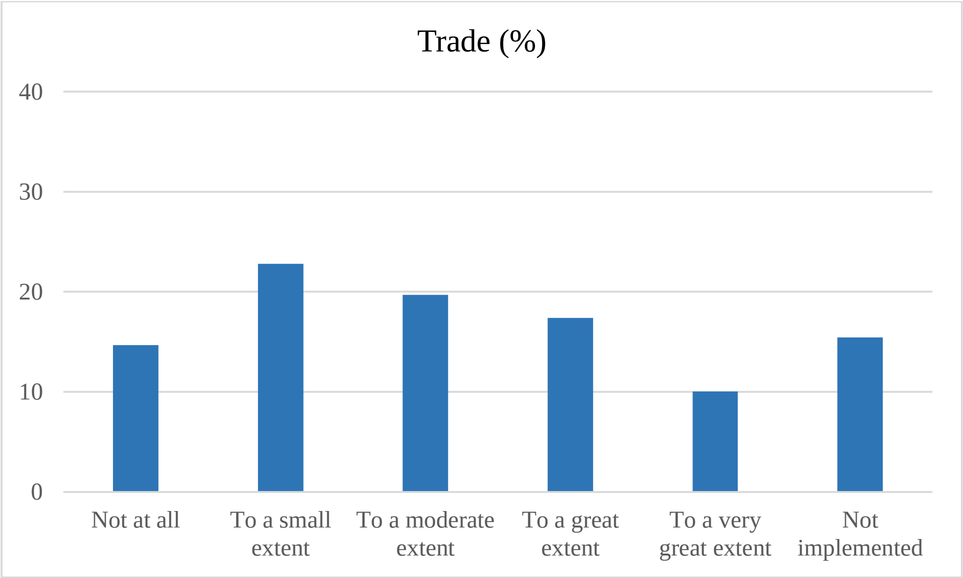


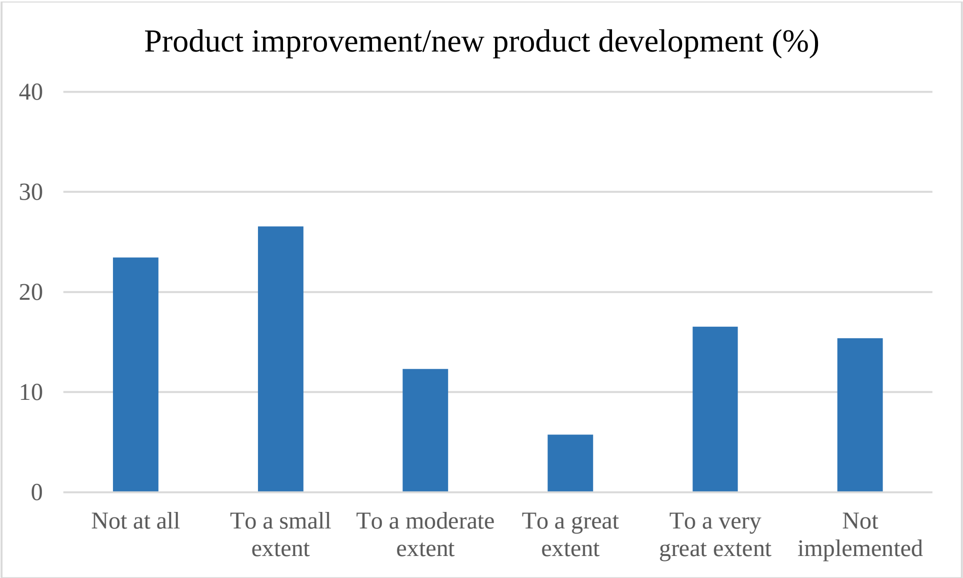

Process – production of final product (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented


Packaging (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented


Storage management – maintenance (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented

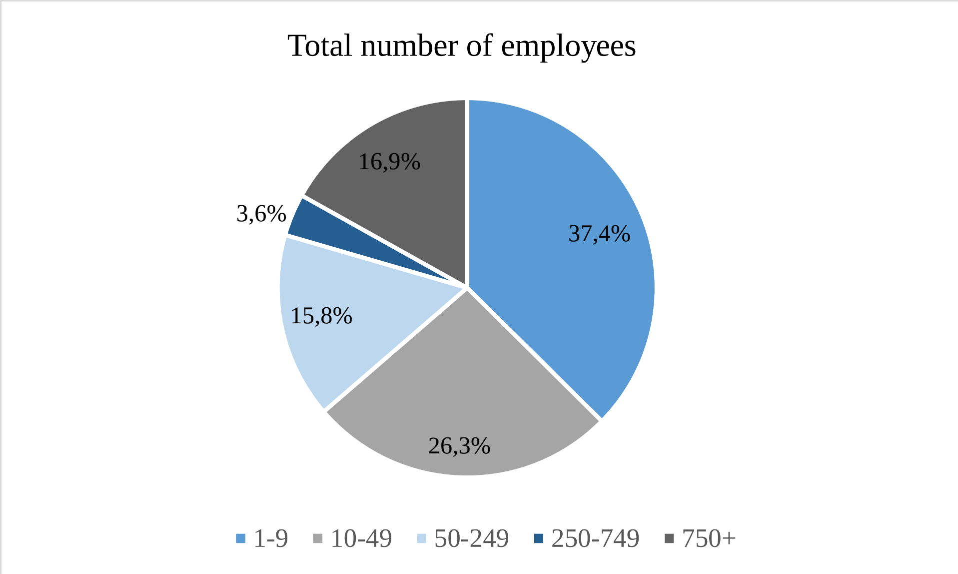

Transportation and cargo management (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented


Trade (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented


Product improvement/new product development (%)
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent
Not implemented

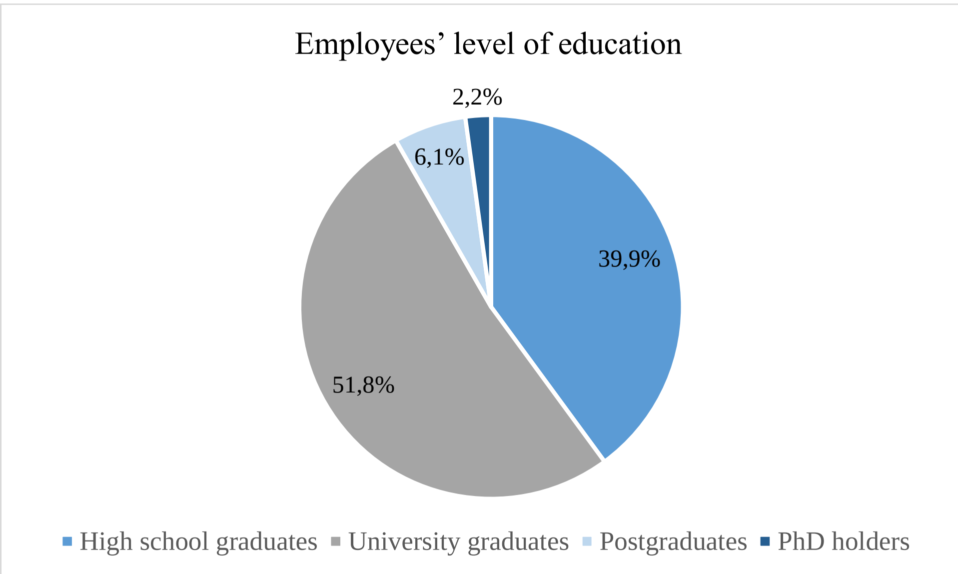
What is the total number of employees in your organisation?

Regarding the number size of the organisations, 37.4% of all companies have 1-9 employees, next come organisations with 10-49 employees with 26.3% and almost equally spit is the share among organisations with 250-749 and more than 750 employees.



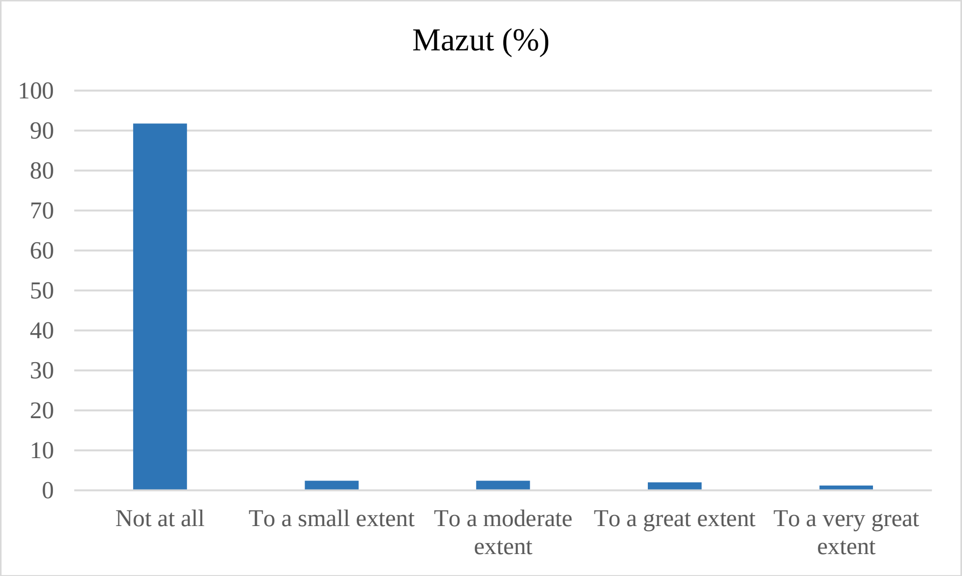
What is the average level of education among the employees in your organisation?

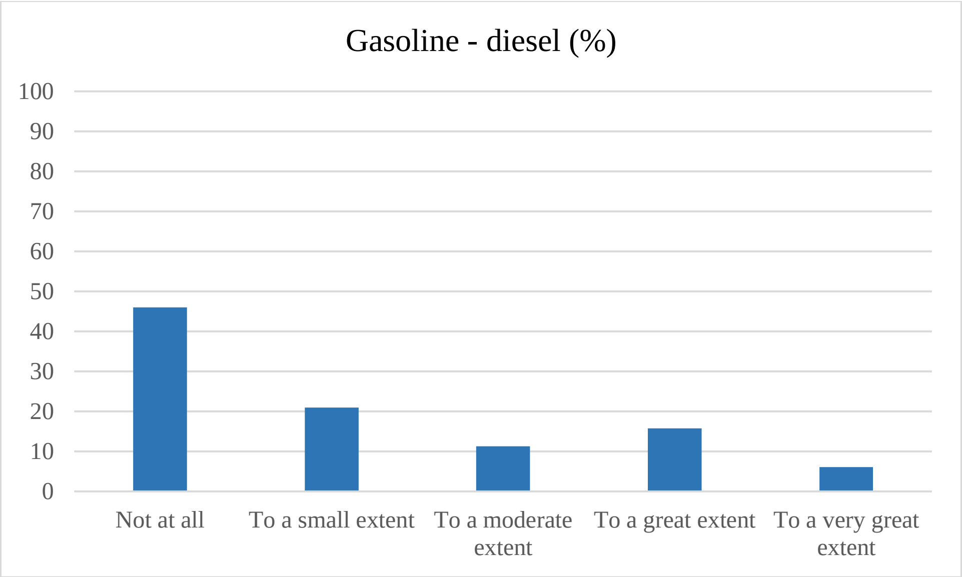
Most organisations have university graduates as employees in a percentage of 51.8% and high school graduates (39.9%).

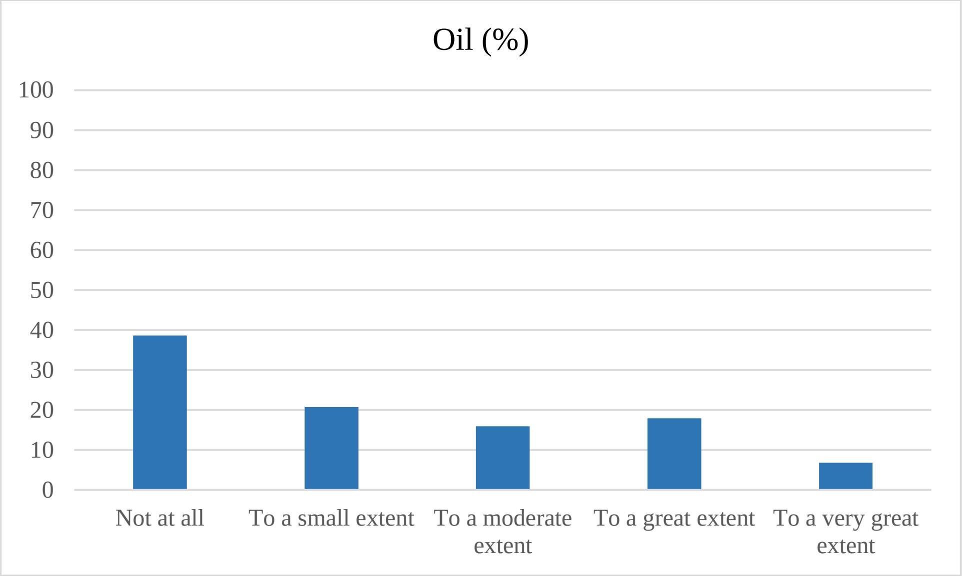


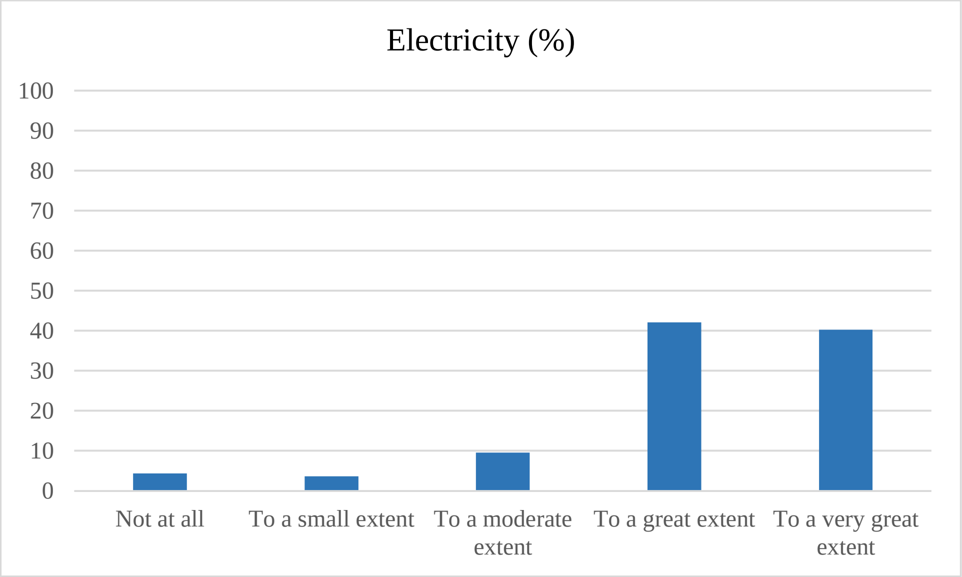
Which type(s) of energy are used in your organisation?

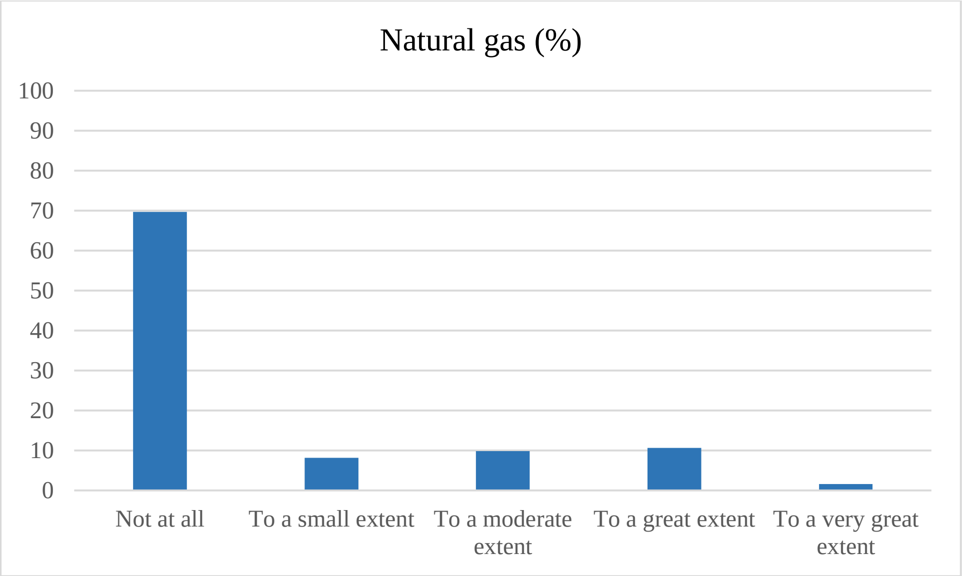
The type of energy used almost unanimously is conventional electricity. All other options are rarely preferred by the respondent organisations. Greece, in general, is lagging behind other developed countries in terms of novel energy supply with the exception of solar energy.

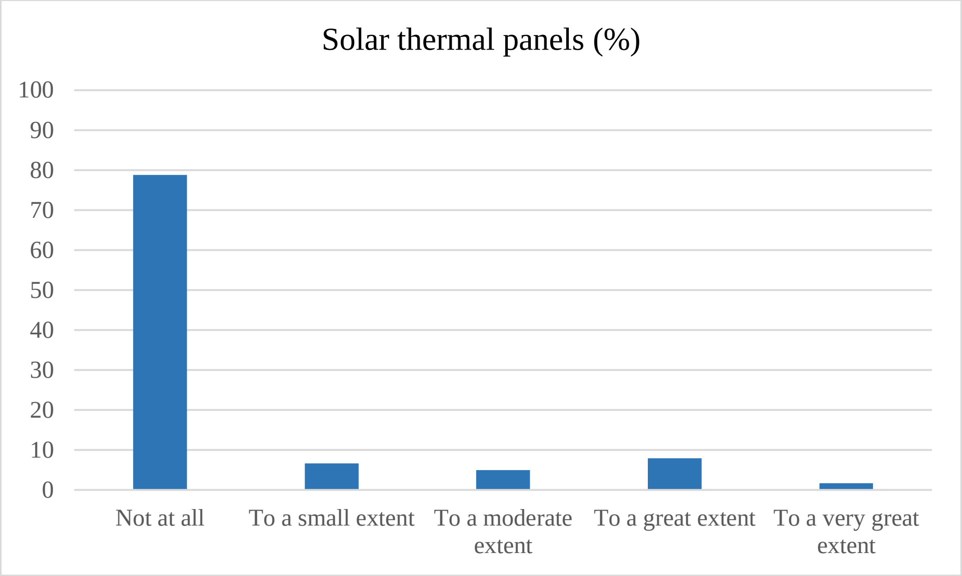


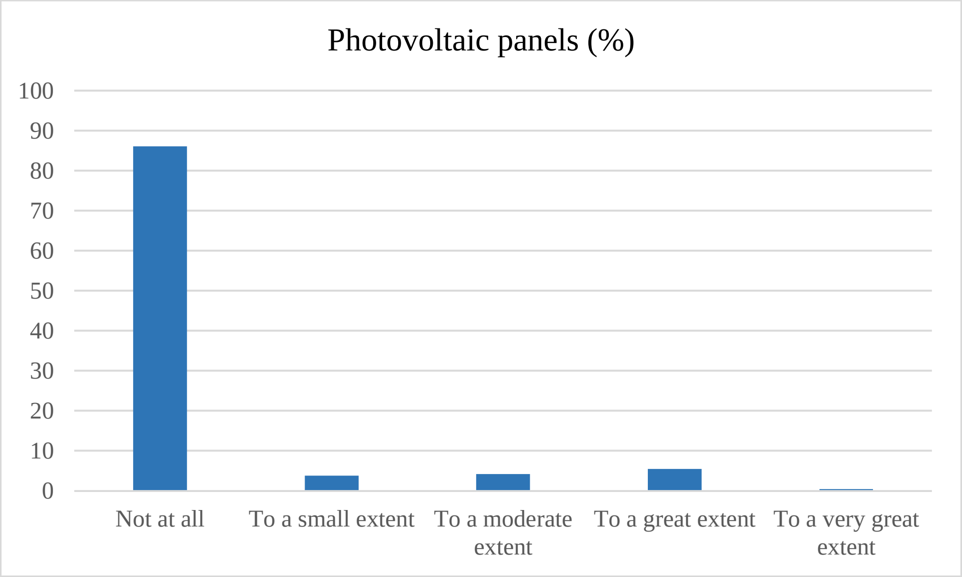



Oil (%)
100
90
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent


Electricity (%)
100
90
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

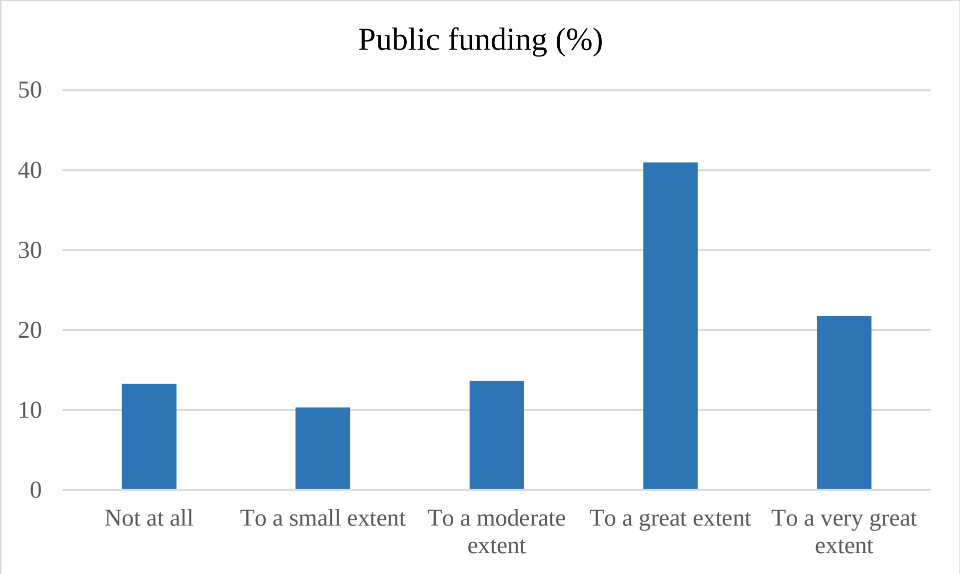

Natural gas (%)
100
90
80
70
60
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

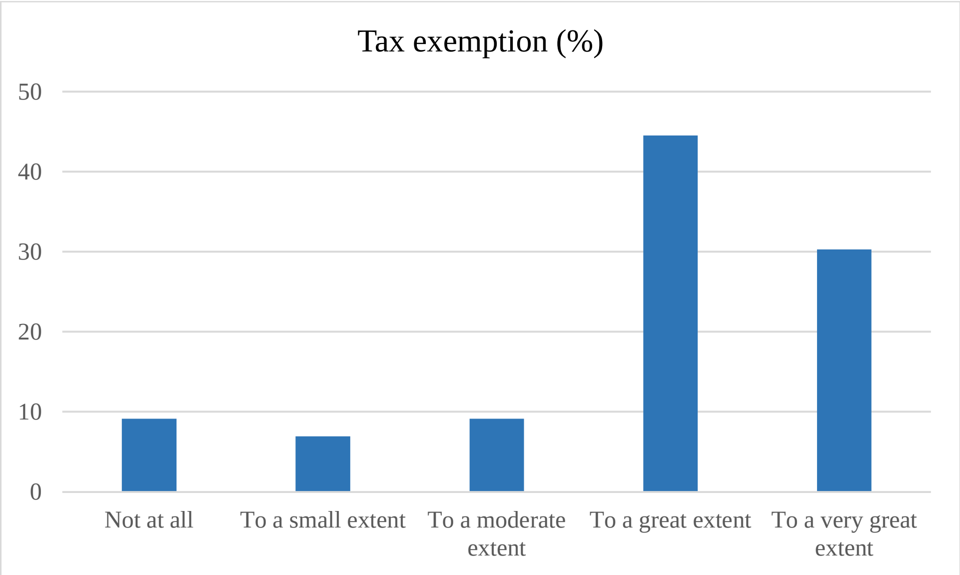


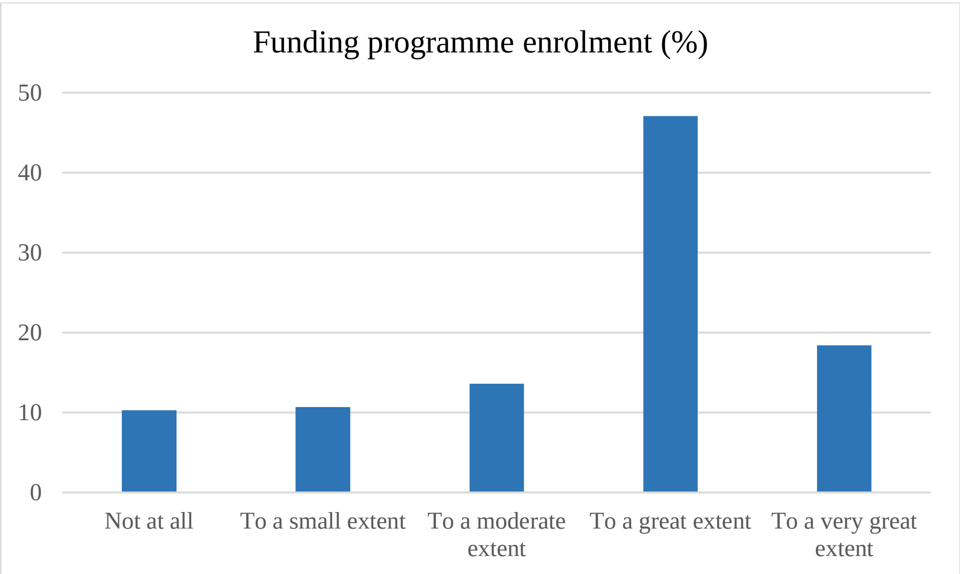


To what extent do you think the following factors can influence the implementation of energy management practices in your organisation?

Organisations surveyed agree to a great extent, that tax exemption and enrolment in a funding programme and public funding can influence the adoption of energy management practices. This finding could potentially have implications to policy-makers, who could draw initial views on how to incentivise businesses towards energy efficient technologies and practices, especially after the striking 70% of all organisations that have never obtained any relevant funding.

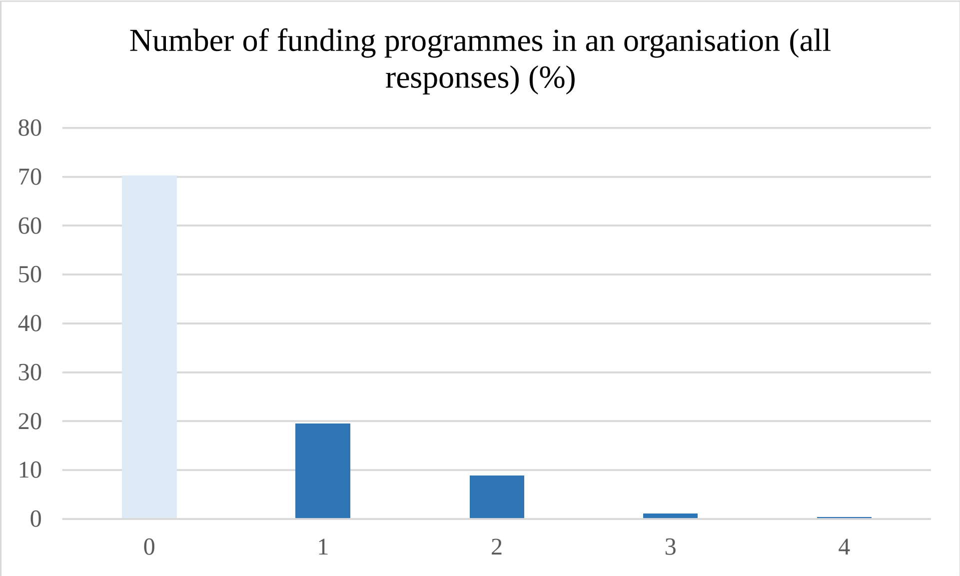

Public funding (%)
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

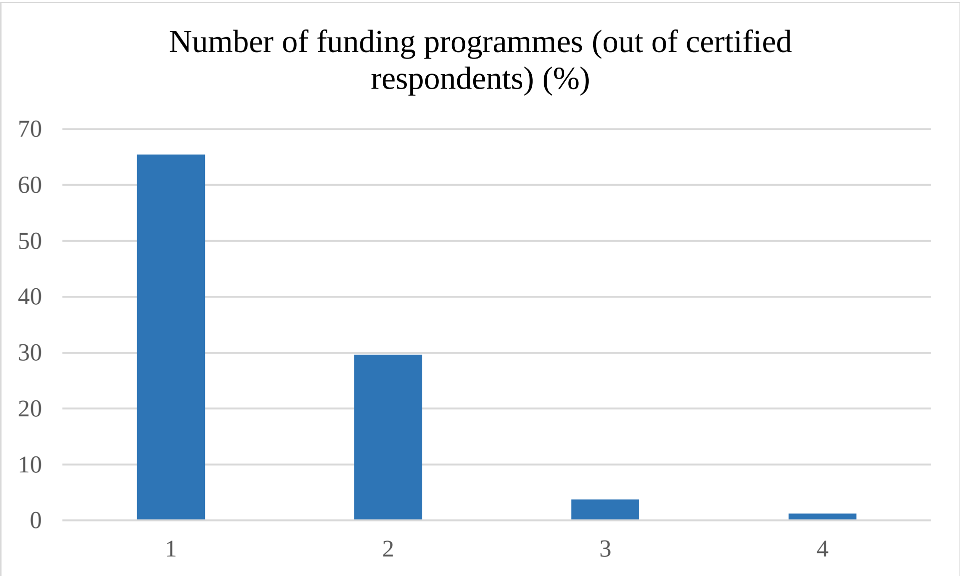

Tax exemption (%)
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

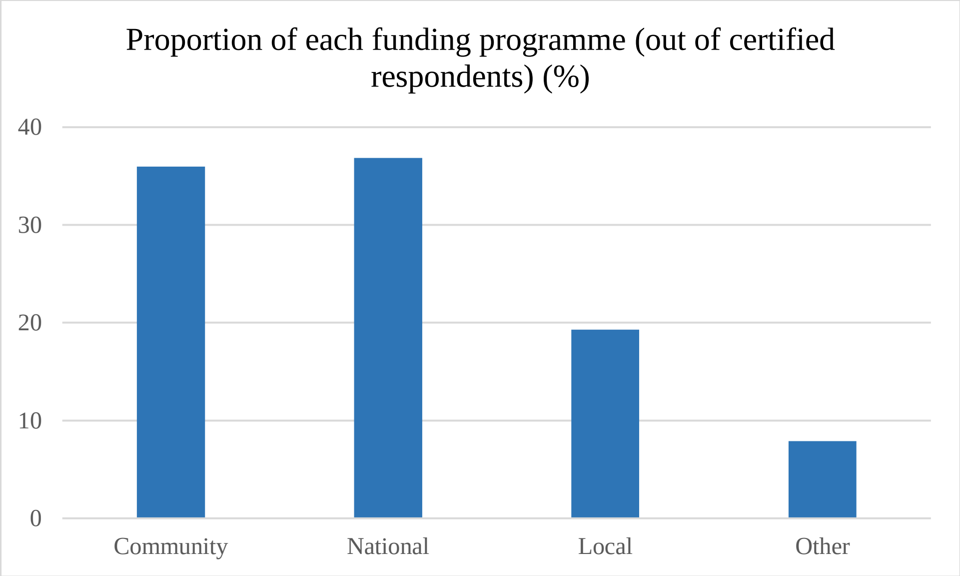

Funding programme enrolment (%)
50
40
30
20
10
0
Not at all
To a small extent
To a moderate extent
To a great extent
To a very great extent

Has your organisation ever obtained funding via programmes regarding the implementation of energy management practices?

Around 70% of the organisations participated in the survey have never obtained funding. Out of those organisations that have obtained funding, circa 65% of them have been granted funding once, while around 35% of them have been granted funding twice or more. National and Community funding are the most common ones with 36.8% and 36% respectively.







Inferential statistics findings

Correlation between questions 9, 10, 11 and 12 for energy-intensive organisations

The researchers attempted to dig into how four different questions (9, 10, 11 and 12) are correlated, given that the examined organisations are energy-intensive. It is reminded that only 4% of the total organisations were energy-intensive. The strongest correlation (0.919) was between the level of technology use in energy management and the level of employees' encouragement in energy management. Even though the examined companies were only ten the correlations gave very positive results, meaning that as expected, the correlation results were satisfying for energy-intensive organisations. However, further research is suggested for a generalisation to be made. All the correlations are depicted at the table below.

Correlations[a]						
			Level of energy management practices implementation	Level of innovation management practices implementation	Level of technology use regarding energy management	Level of employees encouragement in energy management
Spearman's rho	Level of energy management practices implementation	Correlation Coefficient	1.000	.599	.705*	.749*
		Sig. (2-tailed)		.067	.023	.013
		N	10	10	10	10
	Level of innovation management practices implementation	Correlation Coefficient	.599	1.000	.882**	.843**
		Sig. (2-tailed)	.067		.001	.002
		N	10	10	10	10
	Level of technology use regarding energy management	Correlation Coefficient	.705*	.882**	1.000	.919**
		Sig. (2-tailed)	.023	.001		.000
		N	10	10	10	10
	Level of employees encouragement in energy management	Correlation Coefficient	.749*	.843**	.919**	1.000
		Sig. (2-tailed)	.013	.002	.000	
		N	10	10	10	10

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

a. Intensity of the organisation's activities = Energy intensive

Correlation between sub-questions 9 and 10 of question 4

The strongest correlations were found among sub-questions within the same question (namely questions 4 and 6), something that can be expected, is sensible and justifiable.

The organisations which have determined a policy about innovation are most likely to have also set target about it as well. Additionally, the most energy-consuming phases are considered to be the production of raw materials, the intermediate production and the production of the final product, something that could be noticed and confirmed from the respective graphs above.

			The organisation has determined a policy about innovation	The organisation sets targets for innovation
Spearman's rho	The organisation has determined a policy about innovation	Correlation Coefficient	1.000	.801**
		Sig. (2-tailed)		.000
		N	275	274
	The organisation sets targets for innovation	Correlation Coefficient	.801**	1.000
		Sig. (2-tailed)	.000	
		N	274	275

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between sub-questions 1, 2 and 3 of question 6

			Production of raw materials	Intermediate production	Process – production of final product
Spearman's rho	Production of raw materials	Correlation Coefficient	1.000	.827**	.729**
		Sig. (2-tailed)		.000	.000
		N	264	261	261
	Intermediate production	Correlation Coefficient	.827**	1.000	.832**
		Sig. (2-tailed)	.000		.000
		N	261	262	260
	Process – production of final product	Correlation Coefficient	.729**	.832**	1.000
		Sig. (2-tailed)	.000	.000	
		N	261	260	266

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between questions 1 and 9

The following three correlation tables are also presented in order to comment on the low value of the correlation coefficient. In all three cases the correlation between variables resulted in a positive correlation coefficient, yet a stronger positive correlation would be expected. For example, even though the importance of energy management practices implementation would be commonly recognised, the table below suggests that the respective level of implementation of energy management practices would not accord to the same extent.

			Importance of energy management practices implementation	Level of energy management practices implementation
Spearman's rho	Importance of energy management practices implementation	Correlation Coefficient	1.000	.367**
		Sig. (2-tailed)		.000
		N	278	276
	Level of energy management practices implementation	Correlation Coefficient	.367**	1.000
		Sig. (2-tailed)	.000	
		N	276	276

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between questions 4 and 10

			Level of innovation management practices implementation	(mean) Innovation variable composite scale
Spearman's rho	Level of innovation management practices implementation	Correlation Coefficient	1.000	.589**
		Sig. (2-tailed)		.000
		N	276	276
	(mean) Innovation variable composite scale	Correlation Coefficient	.589**	1.000
		Sig. (2-tailed)	.000	
		N	276	278

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between questions 4 and 12

			Level of employees' encouragement in energy management	(mean) Innovation variable composite scale
Spearman's rho	Level of employees' encouragement in energy management	Correlation Coefficient	1.000	.454**
		Sig. (2-tailed)		.000
		N	275	275
	(mean) Innovation variable composite scale	Correlation Coefficient	.454**	1.000
		Sig. (2-tailed)	.000	
		N	275	278

**. Correlation is significant at the 0.01 level (2-tailed).

Techno-economic analysis

3.1 Techno-economic assessment theory

3.1.1 Technology investment appraisal

The techno-economic assessment theory borrows most of its elements from the Manual of Behrens and Hawranek's (1991). Financial feasibility is pivotal for investment decision-making within a company, especially from the investor's perspective. Financial feasibility is achieved when both the return on the total capital invested and the return on the paid-in capital (funds raised by the business from equity) is sufficiently high. However, the decision criteria for investment appraisal encompass a wider context and are not limited to net returns on capital. Thus, they can range from net profits and direct gains to non-cash and indirect benefits. In any case, all benefits should be expressed in monetary terms whenever possible.

3.1.1.1 Discounting methods

Net present value (NPV)

The basic assumption underlying the discounting cash-flow techniques is the time concept of money. In plain text, a given sum of money now is worth more than an equal sum available in the future. The difference between the two values is expressed as a percentage rate and the period of time under consideration is usually a year. The formula for the calculation of the net present value (NPV) is:

$$NPV = \frac{R_1 - C_1}{(1+r)^1} + \frac{R_2 - C_2}{(1+r)^2} + \cdots + \frac{R_n - C_n + S_n}{(1+r)^n} - I$$

Where:

- Ri = the cash inflows during years i (i = 1, 2… n) of the techno-economic assessment, considered at the end of each year
- Ci = the cash outflows during years i (i = 1, 2… n) of the techno-economic assessment, considered at the end of each year
- I = the initial cost of the investment ($R_0 = 0$ and i = 0)
- r = the discount rate considered constant during years i (i = 1, 2… n)
- Sn = the salvage value of the technology investment at the end of year n
- n = the number of years considered for the techno-economic assessment

The value of the discount rate r should be equal either to the cost of capital paid by the borrower or to the actual interest rate on long-term loans in the capital market. Basically, the discount rate should reflect the opportunity cost of capital, meaning that if a potential investor (financier) had invested the same amount of capital elsewhere, they would have obtained possible returns correspondent to this specific discount rate. The discount rate (cut-off rate) also represents the minimum rate of return (determined by the borrower’s cost of capital or long term-loans rates at the capital market), below which the investment would not be considered attractive.

A positive NPV is an indication of profitability above the discount rate and the investment proposal is accepted, whereas a negative NPV leads to the rejection of the investment. A zero value shows that profitability is exactly at the cut-off rate (discount rate) and the investment can be deemed acceptable postulating risks and uncertainties have been taken under consideration. Financial costs such as interest on term loans are part of the financial planning of an investment but should not be included in cash outflows for the computation of the NPV and IRR. This is due to the fact that financial costs are already reflected in the discount rate. Depreciation charges are not classified among cash outflows as a separate item during the computation of NPV and IRR. Since they are incorporated into the investment costs and have been accounted for in fixed investment costs, adding them again as an outflow would result in a double counting. Depreciation is used as a separate item and is useful for finding the taxable profit through the income statement and specifically, the income (corporate) tax, which is then used in the calculation of the NPV and IRR.

Internal rate of return (IRR)

The internal rate of return (IRR) is the discount rate at which the present value of net cash flows is equal to the initial present value of the investment (I), so the NPV formula given above is zero (0). In order that condition to be satisfied, a certain discount rate (called IRR) has to be calculated, for which:

$$\mathrm{NPV} = 0 \qquad => \qquad \frac{R_1 - C_1}{(1+\mathrm{IRR})^1} + \frac{R_2 - C_2}{(1+\mathrm{IRR})^2} + \cdots + \frac{R_n - C_n + S_n}{(1+\mathrm{IRR})^n} - I = 0$$

The IRR is found, basically by trial and error. Different interest rates r are being tried out until NPV=0. An interest rate that gives a positive NPV and an interest rate that gives a negative NPV is a clear indication that IRR is between these two interest rates, since the zero (0) NPV is between the negative and positive value.

The investment proposal is accepted if the IRR is greater than the minimum interest rate (discount/cut-off rate). The discount rate (cost of capital plus any margin for risks and contingencies) is the lowest interest rate for the invested capital. The difference between the IRR and the discount rate of the investment implies a profitability margin, so the higher the difference, the higher the potential profitability of the investment. In other words, the IRR indicates an annual profitability rate of return.

3.1.1.2 Conventional methods

Payback period

The payback period method is the period that is required in order for the initial investment outlay to be recovered, taking into account the accumulated net cash flows of the project. Since the straight payback period method is not concerned with the time value of money, the interest paid and the discount rate in general are ignored.

3.1.1.3 Strengths and weaknesses of the investment appraisal methods

NPV and IRR

The NPV has great advantages compared with the payback period. In particular, it considers the entire life project as well as the time value of money unlike the (straight) payback period, which stops at the time the initial investment outlay is recovered ignoring the time value of money. The NPV, though, does not depict profitability in exact terms, while a selection of an appropriate discount rate is often difficult. A rate of return is more familiar and understandable to the business people, this is why the internal rate of return (IRR) is often preferred.

However, if several investment proposals are being evaluated, then it is not always the project with the highest IRR or the highest NPV the recommended one, as the two methods may result in contradictions. For example, it might be the case that a project with a lower IRR may be preferred to one with a higher IRR if the former's cash flow structure is more desirable or its NPV is considerably higher. Known as the *ranking problem*, it is better illustrated at the Figure 7 below. The preference of a project alternative changes according to the selected discount rate as depicted. The various rates ascribed to the NPV formula at mutually exclusive projects can reflect the corresponding risk levels, a possibility not provided by the IRR method (Milis et al., 2009). It should be noted that even an identical IRR could be produced with different cash flow arrays/planning horizon, so the IRR alone would not be useful for decision-making. Consequently, both the NPV and IRR should be examined, combined with an in-depth analysis of the structure and timing of the cash flows.

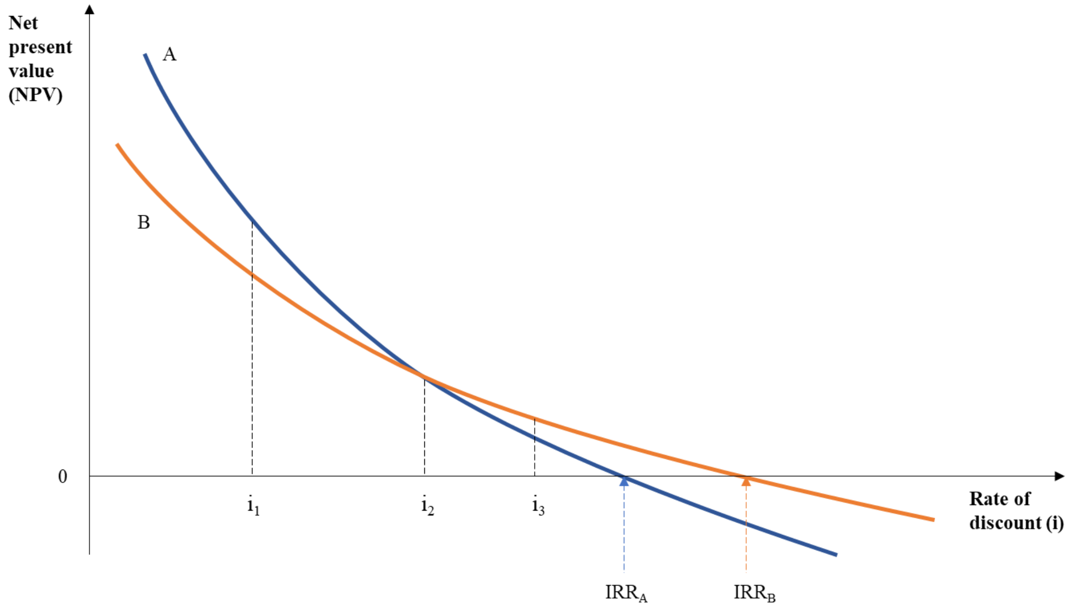


Figure 7. The ranking problem of investments. Adapted from Behrens and Hawranek's (1991).

However, both techniques are criticised for not giving robust results when sophisticated technology projects are being assessed, because they ignore their intangible benefits. Particularly, a negative NPV would lead to the rejection of an investment proposal, even though future growth opportunities are embedded in such new technology investments. Similar cases are those when management acts with flexibility to business environment changes (with input mix alteration or temporary operation shut-down during low price periods etc.) (Anuar, 2005).

Payback period

The payback method is not concerned with the after-payback performance of the investment, focusing mainly on the initial phase, which is a point of criticism on the method itself. Of course, if a project's assessment is purely relied on the payback period, then the aforementioned criticism would be justified. A short payback period implies a high annual net cash flow, thus the payback method can be deemed as an indirect measure of the profitability of the investment. The payback method can also prove useful when risk is critical. For example, in a highly competitive market with low entry barriers, when the technical life cycle of the project is much larger than the technological one or generally, when rapid changes take place and time horizon is key in decision-making. Again, the robustness of the payback period method is enhanced when other methods as well accompany its implementation.

A common aspect of all three methods is that they do not assess the distribution of net cash flows, so they do not answer whether these are increasing or decreasing, constant or fluctuating. This is an additional reason why complementary factors should be considered during a techno-economic assessment (e.g. financial objectives and criteria, risk acceptance, amortisation periods etc.), particularly when no apparent results are produced from different appraisal methods.

3.1.1.4 Contingencies

Physical contingencies have been accounted for in the techno-economic assessment in order to avoid an often too optimistic result. These contingencies refer to probable inaccurate sales forecasts, insufficient engineering, materials and services design. Too optimistic results are very usual especially in the case of new technologies, where limited experience from realised projects is accumulated as opposed to mature technologies, where rich and profuse data is often available. A contingency factor between 1.05 and 1.25 should be chosen according to Lauer (2008) and put on the overall cost (total cash outflow) for a more conservative assessment result.

Financial contingencies such as inflation were embedded in the case with a value of 2.5%. It is noteworthy to mention that inflation holds a strong bearing on a project, as it affects fixed investment costs, working capital, sales and marketing. Since there is a discrepancy in how different components' rates increase, a standard across-the-board rate should be applied to compensate for it. The longer the planning and implementation period the greater the influence of inflation. From a financial perspective, two elements are especially bounded by inflation: *gearing* and the *real rate of return*. Gearing (the ratio of borrowed to owner funds) is positively affected by inflation if loans are a source of financing, because the real cost of the loan declines. This, sometimes, may encourage loan financing disproportionately. The investment decision is also positively influenced, since the IRR is not compared with the discount rate, it is compared with the real rate of return (discount rate – inflation rate).

3.1.1.5 Sensitivity analysis

It is interesting to know how the net cash returns are affected by changes in the value of the variables they are consisted of. This can be facilitated by the application of sensitivity analysis, which should be considered already from the planning stage, when decisions over technology, energy, labour, inputs and components are being taken. This way, dismaying factors about the investment can be avoided, uncertainty can be reduced (Anuar, 2005), optimistic and pessimistic alternatives can be identified and the optimum combination of inputs can be chosen.

In order the critical variables to be identified, the cash-flow structure should be analysed first. These variables with the highest share of cash inflows/outflows are the critical ones, which are then subject to quantities or prices variations. In particular, sensitivity analysis is performed by assigning different values to the critical variables during the application of the investment appraisal methods, a procedure that corresponds to optimistic, normal and pessimistic scenarios.

However, sensitivity analysis was not required in our case study, because the uncertainty is minimised. The project studied techno-economically considers a photovoltaics system, which may be privately purchased on the one hand but is carried out throughout its lifetime by a power purchase agreement (PPA), which by definition minimises uncertainty and secures revenues to a great extent.

3.2 Techno-economic assessment: The case of siting solar photovoltaics on potentially brownfield sites

3.2.1 Project background

Following the interest of the present thesis on the investigation of new energy technologies, a related techno-economic analysis was also prepared. The project deals with the siting of solar photovoltaics on areas, which are potentially contaminated (brownfield lands) and is based on a real feasibility study carried out by the National Renewable Energy Laboratory (NREL) of the USA (Steen et al., 2013). Specifically, the project refers to a commercial-scale PV system with 348kW installed capacity, privately purchased and with a power purchase agreement (PPA) in place. The land, though is assumed state-owned. Since a comparison between the American and European results is made, the analysis borrows many background, technical and financial information from the real study. Certain indicators and information are amended such that the techno-economic analysis applies to a European country and, namely, Germany.

The farm/land on which the technology would be sited is assumed to be a former industrial manufacturing hub, state-owned. Since it is a potentially contaminated land, detailed methods apply for the valuation of the land property. For the purpose of this study no land value was applied, except for a comparison that is made regarding a newly purchased land. The case assumes the operation of privately-purchased solar photovoltaics at a commercial-scale (size), the installation of which requires a 1.5-acre (circa 6070 sq. m) parcel. The site has un-shaded areas and is considered flat, while the existing electric infrastructure and vicinity to transmission and distribution lines make it a potential candidate for a PV installation.

Brownfields may pose various challenges for installing PV systems, although there are many trade-offs to be accounted for:

- Renewable energy on such areas can offer a productive alternative to a practically unproductive land.
- PV systems can be located and developed on limited greenfields, allowing for an undisturbed flora environment.
- Such lands may be deemed unsuitable for commercial or residential redevelopment, but may considered otherwise for renewable energy development.
- Former industrial areas are often located in close proximity to transmission and distribution infrastructure.
- Demanding remediation or cleanup costs could be avoided, by having an economically viable exploitation with renewables in place.
- Direct, indirect as well as induced job opportunities can be created with a positive overall economic impact to the local and regional community.

- Positive would also be the impact on the environment by harnessing cleaner technologies and, thus, reducing greenhouse gas emissions (GHGs).
- By scaling the use of renewable technologies, they become more cost-efficient and bolster national energy independence.
- Renewable systems could provide more stable electricity prices through long-term power purchase agreements (PPAs)

A power purchase agreement (PPA) is examined throughout the system's lifetime in the case study. It should be underlined that by definition "a Power Purchase Agreement (PPA) secures the payment stream for a Build-Own Transfer (BOT) or concession project for an independent power plant (IPP). It is between the purchaser "offtaker" (often a state-owned electricity utility) and a privately owned power producer" (PPPIRC, 2017). A PPA is best recommended a) when one or few major customers are interested in the largest portion of the power produced, b) when certainty of revenue is pursued by the privately owned power producer, c) when there is evident competition in energy production or d) when the purchaser aims for security of supply.

3.2.2 Techno-economic assessment

3.2.2.1 Technical analysis

The solar PV technology

Solar photovoltaics convert the energy from solar radiation directly into electricity. The components that contribute to this conversion are the PV cells. In a nutshell, when sunlight (photons) strikes a PV cell it stimulates electrons (negative charges) in a layer in the cell, which is designed to easily release electrons. The electric field drives the released electrons to another layer in the cell, while this movement of charges constitutes the electric current itself. Connected to the cell can be an external load, which is powered/consumes the electric current. PV cells are assembled into a PV module and the modules are in turn connected both in series and in parallel to form an array with specific voltage and current requirements. Electricity generated by the array is direct current (DC) and with the help of inverters is then converted to alternating current (AC). The alternating current is useable and can be either consumed by any facilities and buildings within the PV site or it can be exported to the electricity grid.

PV systems sizes can vary, from residential (2-10kW), to commercial (100-500kW) and large utility-scale (10+ MW). The latter usually sells back electricity to the grid. In more detail, a typical PV system is consisted of the following components:

- Modules: Depending on the PV material used, modules have a range of conversion efficiencies (the percentage of solar light energy converted to electricity). The most common PV module technologies are the crystalline silicon and thin film.
- Inverters: Inverters enable the seamless connection of DC electricity from the PV array to the electricity grid after they convert it into AC. Inverters' efficiencies can proximate 100%. If the voltage produced by the system is not enough, a step-up transformer can increase it to the appropriate level. For grid-connected PV systems there are two major types of inverters: string and micro-inverters, each type suitable for different types of installations. Inverters usually have a 10-year warranty and are expected to last 10-15 years.
- Balance-of-system (BOS) components, which include: mounting racks and hardware for the panels as well as wiring for electrical connections. When considering a ground-mounted system, like the one studied, an electrical tie-in location should be identified to determine how it would be connected to the grid or on-site facilities. The expected electrical tie-in and inverter location for the PV system under study is assumed to be located at the box of one of the electric utilities companies operating at the country. Wire and rack connections should be checked annually.

PV panels usually come with a 25-year performance warranty. They are very sensitive to shading (either partial or full) because it impedes the optimal collection of solar radiation. Moreover, since each PV cell produces a small amount of voltage and current and the all cells are interconnected to produce a larger current that means that a shaded cell acts as a resistance to the whole series circuit. As a result, the power is dissipated rather than produced.

The feasibility of a PV project is affected by both technical and economic factors. For example, the available area for an array, the solar resource, the distance to transmission lines and major roads (if grid-connected system) and the ground conditions are all pivotal. Economically, a PV project is influenced by the purchase price of the electricity produced, the power purchase agreement (PPA) price, the retail electric rates and various existing financial incentives for installing PV systems.

Technical assumptions

The techno-economic assessment was performed using the NREL System Advisor Model (SAM). Using most of the assumption from the real case study (Steen et al., 2013), some adjustments were made in order to simulate a European-like case.

This study refers to a commercial-scale PV system with 348kW installed capacity, privately purchased and with a power purchase agreement (PPA) in place. The land on which the PV technology would be installed is assumed to be a former industrial manufacturing hub, state-owned and the weather file borrowed for the analysis is the "Germany DEU Munich (INTL)". The useable land for the PV technology would be 1.5 acres (circa 6070 sq. m). Useable areas in general are those which are flat to gently sloping, have southern exposures without obstructions and get at least 6 hours of full sun each day. Since the land is considered potentially contaminated, detailed methods apply for the valuation of the land property. For the purpose of this study no land value was applied, except for a comparison that is made regarding a newly purchased land. The site is assumed to be flat with un-shaded areas and to be in the vicinity of transmission and distribution lines as well as electric infrastructure. Thus, the expected electrical tie-in and inverter of the PV system would be located at the electrical box of one of the electric utilities companies operating at the country. The PV system size is considered commercial-scale with a 348kW installed capacity and privately purchased. The module material is crystalline silicon and with a fixed-mount system tracking. The derate factor from the conversion of DC to AC is 80% and the degradation rate that applied to the total annual AC output is 0.5%. A summary of the photovoltaics system technical information is presented at Table 1 below.

Commercial-scale Private Purchase PV with PPA (348kW)	
Summary of technical information	
Project location	Germany
Weather file	Germany DEU Munich (INTL)
Latitude	48.13 °N
Longitude	11.7 °E
Year of construction / installation	2012
System size / application	Commercial
Number of systems installed	1
Solar cell / module material	Crystalline silicon (mono-c-Si)
Module	SunPower SPR-E19-310-COM
System tracking	Fixed mount
Inverter	SMA: STP 60-US-10 (400VAC) 400V
Total project capacity (kW)	348
DC-AC derate factor	80%
Array tilt (deg)	20
Array azimuth (deg)	180
Array type	Fixed
Degradation rate	0.50%

Table 1. Summary of technical information for the PV project.

3.2.2.2 Financial analysis

Financial assupmtions

In order to compare as similar technical and financial data as possible, the analysis presumes 2012 inputs, where changes were required (e.g. the module costs or the lending rate in Germany). Noteworthy is the fact that significant cost reduction in PV systems has occurred due to the increasing demand and supply and the reflection of economies of scale. Indicative of that is the module cost for example. The PV module price as found in the Module Price Index (Price Index, 2017) was 0.8 $/Wdc in 2012. The economies of scale achieved over the years resulted in a slump of the module price from 0.8 $/Wdc in 2012 to 0.45 $/Wdc in May 2017, almost 44% price-reduction.

The installation cost for the computation of the total installed cost was taken at a value of 4.05 \$/Wdc. The latter was applied as installation labour cost in the SAM model and includes the cost of installing the baseline system and the ballast. The value 4.05 \$/Wdc resulted from the value 5.79 \$/Wdc, which was found in the NREL study as follows:

- The discussed value of 4.05 \$/Wdc includes the PV array cost (module), the BOS components as well as the inverter and electrical equipment. It also included the installation cost with the estimated taxes and a national-average labour rate.
- It was postulated that the bulk of the total installed cost of a PV system is produced by the installation labour parameter. As a consequence, the discussed value is assigned exclusively to the installation labour cost.
- The ratio of solar system costs at commercial-scale between Germany and the USA is approximately 0.7 (REI, 2016).
- The discussed value came after simply multiplying 0.7*5.79 \$/Wdc.

Certain financial data were preserved from the NREL study. These include the permitting and environmental studies cost, the operation and maintenance costs, the IRR target, the analysis period, the inflation rate, the real discount rate, the insurance rate, the property tax rate, the debt percent of total capital cost, the debt term, the replacement cost and the depreciation treatment.

The income tax rate was considered at 42% and no property tax rate is applied, since the land with all the adjacent facilities etc. are considered state-owned. Germany's annual (lending) interest rate in 2012 was 3.6% (Trading Economics), while no interest on reserves is applicable in this case. The depreciation method followed is the modified accelerated cost recovery system (MACRS)

Generally, no financial incentives were assumed at the case, although it should be mentioned that attractive financial, where applicable, act as a contributor to a cost-efficient PV system as they make a renewable developer eligible on tax incentives, accelerated depreciation etc. A summary of the photovoltaics system financial information is presented at Table 2 below.

Commercial-scale Private Purchase PV with PPA (348kW)	
Summary of financial information	
Module cost ($/Wdc)	0.8
Inverter cost ($/Wdc)	0.22
Installation labour ($/Wdc)	4.05
Permitting and environmental studies ($)	218164
Land purchase ($/acre)	0
Sales tax rate	0%
Total installed cost ($)	1973024.5
Operation and maintenance costs ($/yr)	9048
IRR target	15%
Analysis period (years)	25
Inflation rate	2.50%
Real discount rate	5.85%
Income tax rate	42%
Insurance rate (annual)	0.50%
Property tax rate	0%
Net salvage value (% of installed cost)	0
Debt percent of total capital cost	50%
Debt term (years)	15
Annual interest rate	3.60%
Construction loan percent of installed costs	50%
Interest on reserves	0%
Working capital reserve (months of operating cost)	6
Debt service reserve (months of P&I payments)	6
Replacement cost ($/W)	0.25
Depreciation treatment	5-yr MACRS

Table 2. Summary of financial information for the PV project.

3.2.2.3 Results

The findings suggest slightly better financial indicators for the examined case. The clearest indicator for that is the NPV of the projects. However, since the two projects do not have equal total installed costs or operation and maintenance costs, the value of NPV alone should not be a definitive indicator for investment decision-making. In order to compare the two NPVs "in a level playing field":

- The total installed costs plus the operation and maintenance costs were computed. For the NREL project 2023969 $ (2014921 $ + 9048 $) were found, while in the case of Germany 1982072.5 $ (1973024.5 $ + 9048 $) were calculated.
- The ratio between each NPV and the aforementioned total costs was computed as well. The NPV in NREL's case is 185576 $ and in Germany's case is 227768 $, giving a ratio of 9.2% and 11.5% respectively. Thus, the case of Germany was assessed as better that that studied by the NREL.

Other indicators that suggest a better financial performance for the case of Germany are the nominal and real levelised costs of energy (LCOE). In specific, the NREL case has nominal and real LCOE values of 39.67 ¢/kWh and 31.49 ¢/kWh, while Germany's case respective values are 38.86 ¢/kWh and 30.85 ¢/kWh.

The IRR's value was already from the planning phase designated at 15%, achieved after 20 years. That is when the project "breaks even". The IRR after the end of the project was found 15.8%. Equal is the IRR at the NREL project as well.

Nevertheless, in some technical indicators the NREL's case performed better. For example, the annual energy produced is 423073 kWh, whilst in Germany's case the energy produced annually reaches a lower level, namely 359430 kWh. Moreover, the capacity factor in NREL's case was 13.9%, while in our case it appears two percentage points lower, namely 11.9%.

What should also be underpinned is the fact that a sensitivity analysis is redundant at this case, since a power purchase agreement (PPA) is postulated throughout the system's operation, which by definition minimises uncertainty. Under these condition a tool like sensitivity analysis, which aims to lever uncertainty would not be required.

Table 3 below presents the SAM results of the techno-economic analysis performed for the commercial-scale private purchase PV with PPA.

Techno-Economic Analysis Results	
Metric	Value
Annual energy (year 1) (kWh)	359430
Capacity factor (year 1)	11.90%
Energy yield (year 1) (kWh/kW)	1038
Performance ratio (year 1)	0.83
PPA price (year 1) (¢/kWh)	40.13
PPA price escalation (%/year)	1.50%
Levelised PPA price (nominal) (¢/kWh)	45.3
Levelised PPA price (real) (¢/kWh)	35.96
Levelised COE (nominal) (¢/kWh)	38.86
Levelised COE (real) (¢/kWh)	30.85
Net present value ($)	227768
Internal rate of return (IRR)	15.00%
Year IRR is achieved	20
IRR at end of project	15.80%
Net capital cost ($)	1672400
Equity ($)	836200
Size of debt ($)	836200
Minimum DSCR	1.61
Total installed costs ($)	1982072.5

Table 3. Techno-Economic Analysis Results as produced by the SAM model.

Conclusions

The literature review gave some interesting takeaways. First of all, a body of knowledge concur that there is a strong positive relationship between innovation and per capita GDP. At the firm level the hypotheses about a positive relationship between innovation and growth/productivity accords with evidence in literature as well. In a nutshell, "it is war: innovate or die" as succinctly described by Cooper (2005) in an attempt to describe the grim future that awaits organisations failing to innovate. However, only larger markets are able to enrich their innovation by investing in R&D. Countries like Greece, though, with low TFP and possibly ineffective R&D sectors, experience faster rates of growth than high-TFP countries and seem to harness other countries' spillovers in order to improve their innovation. Technology/knowledge externalities (spillovers) act as major contributors to growth, since evidence over the past 120 years suggest that without the contribution of spillovers the average person in the OECD countries would have had 1/3 of the present income. Spillovers stimulate both endogenous firm-level growth and other companies' product activity. However, the firm whose knowledge 'spills over' should bear in mind that the more unconstrained spillovers are the less the profitability of the firm, something that should be carefully addressed by the policy-maker.

In similar fashion, energy efficiency and economic growth was concluded to be positively related. In fact, energy efficiency investments have a positive impact on GDP and employment and can act as a competitive advantage at a country level. At the firm level even, energy efficiency has a positive impact on economic performance, as found by observing its impact on productivity. Proof that energy efficiency does not undermine growth but bolsters it, is the fact that there has been a long-term reduction of per capita energy consumption, whilst at the same time more GDP has been created per unit of energy, as observed over the last 200 years. Although the combined economic benefits of energy-efficient investments exceed the overall spending for these investments, often such investments are ignored. This is referred to as the "energy paradox" and certain barriers such as market failures, behavioural anomalies and model and measurement errors can be attributed to the existence of the phenomenon.

From a technological point of view, societies could make inroads in energy efficiency both from existing and novel/innovative technologies and environmentally, the CO_2

abatement potential could be as high as 40%. However, only few are techno-economically ready to be scaled up to the level where a noteworthy demand change towards fossil fuels could be made. As a result, new energy technologies should be introduced to the market. Some of the new and clean energy technologies are described including bioenergy, geothermal energy, wind energy, energy technologies in buildings and hydrogen technology.

Regarding the second part of the present thesis, the findings suggest that the organisations which have determined a policy about innovation are most likely to have also set targets about it as well. In energy-intensive companies, there is a very strong correlation between the level of technology use in energy management and the level of employees' encouragement in energy management. A strong correlation also exists between the level of innovation management practices and the level of employees' encouragement in energy management, again speaking for energy-intensive organisations. Generally, these organisations showed more positive median values compared to the other organisations for the question on the level of energy management practices implementation. On the contrary, energy-intensive organisations gave considerably negative median values when asked about the level of technology use in energy management. More than 60% of the total organisations agree on the importance of implementation of energy management practices. However, correlation evidence suggests that even though the importance of energy management practices implementation would be commonly recognised, the respective level of implementation of energy management practices would not accord to the same extent. Additionally, a graph was created, which illustrated how the median measure of innovation practices fluctuates depending on the formed NACE sectors. Across all sectors, an almost unvarying median value of innovation came up, but the Manufacturing sector (section C) together with the Financial and insurance activities sector (section K) gave an unexpected low result of innovation median. Moreover, the reduction of cost and the compliance with customers' and market's requirements are the main factors that influence the decision of adopting energy management practices in an organisation. Almost 40% of the organisations participated in the survey have zero (0) Standard certifications and ISO 9001 is the most common one with 47.4%. Organisations surveyed agree to a great extent, that tax exemption and enrolment in a funding programme and public funding can influence the adoption of energy management practices, although only around 30% of them have actually obtained funding.

At the third part, the findings revealed slightly better financial indicators for the examined case (Germany) than the NREL case in the USA. The clearest indicator for that is the NPV of the projects. Other indicators that suggest a better financial performance for the case of Germany are the nominal and real levelised costs of energy (LCOE). In specific, the NREL case has nominal and real LCOE values of 39.67 ¢/kWh and 31.49 ¢/kWh, while Germany's case respective values are 38.86 ¢/kWh and 30.85 ¢/kWh. The IRR's value was already from the planning phase designated at 15%, achieved after 20 years. That is when the project "breaks even". The IRR after the end of the project was found 15.8%. Equal is the IRR at the NREL project as well. Nevertheless, in some technical indicators the NREL's case performed better. For example, the annual energy produced is 423073 kWh, whilst in Germany's case the energy produced annually reaches a lower level, namely 359430 kWh. Moreover, the capacity factor in NREL's case was 13.9%, while in our case it appears two percentage points lower, namely 11.9%.

Discussion

The work of this thesis allows for several issues for discussion, potential future research and limitations.

In the literature review, the fact that innovation and spillovers (and the new energy technologies that are created) act as important constituents of sustainable economic growth both at the country and firm level, became apparent. Thus, the role of the policy-maker becomes core as well. Especially for countries like Greece with possibly inefficient R&D sectors and low TFP, policy makers are suggested to focus on how to boost domestic innovation, while simultaneously setting a policy mix for capitalising on other countries' technology/knowledge spillovers. In this regard, if the "energy paradox" is combined with the fact that in Greece energy-intensive organisations do not hold a large share, then one could conclude that serious impediments could arise with regards to new energy technologies adoption. This could imply that smart incentives should be devised by the national authorities in order to encourage private users to adopt new, clean or energy-efficient technologies, given that Greece is generally lagging behind other developed countries in the use of renewables. As an aside, though, policies and regulations about new energy technologies are out of the present thesis' scope.

Regarding the second part of this thesis, more research should be undertaken at the national level. The components of the survey carried out, as well as components of relevant foreign literature should act as inception points for hypotheses testing. In future studies it would be beneficial to solicit respondent organisations from energy-intensive industries or the manufacturing sector. Additionally, the findings of the survey revealed a gap in policy-making. As aforementioned, more than 60% of the total organisations agree on the importance of implementation of energy management practices, yet only around 30% of them have actually obtained funding. This finding concurs with the discussion of the first part, stating that due policy-making and regulation is fundamental.

One limitation of the research conducted in this thesis concerns the number of missing values within the data. A future researcher could easily address this problem by creating an appropriate online tool. Another limitation is the small share of energy-intensive organisations within the study, which provides a weak basis for generalisation of the results. As suggested, a research that would include more energy-intensive organisations would allow for stronger inferences to be drawn.

At the third part of this thesis a future researcher could assess techno-economically a utility-scale privately-purchased photovoltaics technology with a valid power purchase agreement (PPA) throughout its lifetime. Again the analysis could refer to a European country, Germany for example, with up-to-date data and applicable economic incentives. One limitation of the assessment carried out at the present thesis is the fact that the total installed cost was computed with the use of one aggregate value. Future studies could include recent, spot-on values for each required input and then compare the NPV result to that of the aggregate value.

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Appendices

Preliminary statistical analysis

Monotone check

Monotone check (excerpt)
2.170150987
1.474390244
0.68902439
1.143049933
1.606097561
1.410569106
1.68902439
1.598780488
1.598780488
2.778164925
1.47195122
1.193902439
1.97804878
2.43902439
0.929732869
1.356562137
1.954123113
1.800813008
1.194541231
1.290243902
2.119512195
1.343902439
1.490243902
1.793902439
1.201219512
1.059756098
1.951635846
1.474390244
1.17804878
1.98902439
1.875609756
1.554878049
2.21097561

Missing values analysis (EM)

Univariate Statistics (excerpt)							
			Std.	Missing		No. of Extremes[a,b]	
	N	Mean	Deviation	Count	Percent	Low	High
Q1	278	3.8381	.74007	1	.4		
Q2	278	3.2986	.96924	1	.4	11	0
Q3	278	3.3417	1.01351	1	.4	16	0
Q4_1	278	3.7698	.92159	1	.4	4	0
Q4_2	278	3.4424	1.13140	1	.4	21	0
Q4_3	278	3.7554	.86523	1	.4	2	0
Q4_4	277	3.8375	.99216	2	.7	0	0
Q4_5	275	3.9382	.87951	4	1.4	20	0
Q4_6	278	3.8597	.90631	1	.4	4	0
Q4_8	277	3.5812	.89569	2	.7	7	0
Q4_9	275	2.9200	1.20558	4	1.4	0	0
Q4_10	275	3.0727	1.21208	4	1.4	0	0
Q4_11	276	3.0362	1.20550	3	1.1	0	0

EM Means[a] (excerpt)												
Q1	Q2	Q3	Q4_1	Q4_2	Q4_3	Q4_4	Q4_5	Q4_6	Q4_8	Q4_9	Q4_10	Q4_11
3.8357	3.2949	3.3372	3.7681	3.4425	3.7559	3.8346	3.9463	3.8581	3.5775	2.9139	3.0721	3.0463
a. Little's MCAR test: Chi-Square = 6470.013, DF = 6589, Sig. = .850												

Normality check

Tests of Normality (excerpt)						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Importance of energy management practices	.375	139	.000	.767	139	.000
Level of awareness of energy management	.241	139	.000	.876	139	.000
Change towards energy management practices issues due to the downturn in	.289	139	.000	.850	139	.000
The organisation promotes creativity and innovation	.285	139	.000	.866	139	.000
The organisation sells unique products and/or provides	.236	139	.000	.894	139	.000
The organisation operates in such a way, that enables it to adapt to change	.297	139	.000	.853	139	.000
The leadership of the organisation encourage open discussions and	.294	139	.000	.851	139	.000
Mutual exchange of knowledge and information exist within the	.301	139	.000	.833	139	.000
The leadership of the organisation encourage creative	.298	139	.000	.839	139	.000
The leadership of the organisation tap their employees' ideas	.306	139	.000	.841	139	.000
The organisation has determined a policy about innovation	.188	139	.000	.878	139	.000
The organisation sets targets for innovation	.183	139	.000	.906	139	.000
There are no barriers to creativity within the	.178	139	.000	.915	139	.000

Reliability test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.896	.911	78

Common method bias

Total Variance Explained (excerpt)						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.710	16.295	16.295	12.710	16.295	16.295
2	6.504	8.338	24.634			
3	4.699	6.025	30.658			
4	3.298	4.229	34.887			
5	2.918	3.741	38.628			
6	2.552	3.272	41.900			
7	2.460	3.154	45.054			
8	2.249	2.883	47.937			
9	2.013	2.580	50.518			
10	1.920	2.462	52.979			
11	1.729	2.217	55.196			
12	1.718	2.203	57.399			
13	1.618	2.074	59.473			
14	1.503	1.927	61.400			
15	1.394	1.787	63.187			
16	1.328	1.702	64.889			
17	1.285	1.647	66.537			
18	1.162	1.490	68.027			
19	1.153	1.478	69.504			
20	1.101	1.411	70.916			

Main statistical analysis

How important do you find the implementation of energy management practices in your organisation?

N	Valid	278
	Missing	1
Median		4.0000
Mode		4.00

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important	2	.7	.7	.7
	Slightly important	14	5.0	5.0	5.8
	Moderately important	48	17.2	17.3	23.0
	Important	177	63.4	63.7	86.7
	Very important	37	13.3	13.3	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

To what extent does your organisation stay aware of developments in the energy management sector?

N	Valid	278
	Missing	1
Median		3.0000
Mode		4.00

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	11	3.9	4.0	4.0
	To a small extent	47	16.8	16.9	20.9
	To a moderate extent	89	31.9	32.0	52.9
	To a great extent	110	39.4	39.6	92.4
	To a very great extent	21	7.5	7.6	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

To what extent did your organisation's interest towards energy management/efficiency issues change, in the aftermath of the economic downturn in Greece?

N	Valid	278
	Missing	1
Median		4.0000
Mode		4.00

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	16	5.7	5.8	5.8
	To a small extent	43	15.4	15.5	21.2
	To a moderate extent	69	24.7	24.8	46.0
	To a great extent	130	46.6	46.8	92.8
	To a very great extent	20	7.2	7.2	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

Please indicate your level of agreement with the following statements, regarding innovation practices in your organisation

(mean) Innovation variable composite scale		
N	Valid	278
	Missing	1
Mean		3.5585
Median		3.6364
Mode		3.82

Industry of operation	Median
Wholesale and retail trade; repair of motor vehicles and motorcycles (section G)	3.6364
Accommodation service activities (section I)	3.5455
Other service activities (section S)	3.5000
Professional, scientific and technical activities (section M)	3.6364
Transportation and storage (section H)	3.3636
Human health and social work activities (section Q)	3.8182
Manufacturing (section C)	3.2727
Education (section P)	3.9545
Construction (section F)	3.8182
Arts, entertainment and recreation (section R)	4.0909
Administrative and support service activities (section N)	4.0000
Real estate activities (section L)	3.4545
Financial and insurance activities (section K)	3.2727

The organisation the last 3 years has introduced

		New or highly improved products	New or highly improved methods of manufacturing products	New or highly improved methods of providing services	New or highly improved methods of supplying, delivering or distributing inputs	New or highly improved supporting activities for its operations
N	Valid	276	276	275	275	276
	Missing	3	3	4	4	3
Median		4.0000	3.0000	3.0000	3.0000	4.0000
Mode		4.00	1.00	4.00	4.00	4.00

New or highly improved methods of manufacturing products

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	74	26.5	26.8	26.8
	To a small extent	40	14.3	14.5	41.3
	To a moderate extent	55	19.7	19.9	61.2
	To a great extent	70	25.1	25.4	86.6
	To a very great extent	37	13.3	13.4	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

New or highly improved methods of providing services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	38	13.6	13.8	13.8
	To a small extent	39	14.0	14.2	28.0
	To a moderate extent	69	24.7	25.1	53.1
	To a great extent	95	34.1	34.5	87.6
	To a very great extent	34	12.2	12.4	100.0
	Total	275	98.6	100.0	
Missing	System	4	1.4		
Total		279	100.0		

New or highly improved methods of supplying, delivering or distributing inputs					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	38	13.6	13.8	13.8
	To a small extent	33	11.8	12.0	25.8
	To a moderate extent	73	26.2	26.5	52.4
	To a great extent	87	31.2	31.6	84.0
	To a very great extent	44	15.8	16.0	100.0
	Total	275	98.6	100.0	
Missing	System	4	1.4		
Total		279	100.0		

New or highly improved supporting activities for its operations					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	17	6.1	6.2	6.2
	To a small extent	38	13.6	13.8	19.9
	To a moderate extent	66	23.7	23.9	43.8
	To a great extent	105	37.6	38.0	81.9
	To a very great extent	50	17.9	18.1	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

Please indicate the extent to which the following statements influenced the decision of adopting energy management practices in your organisation

		Reduction / control of the energy cost	Easier access to potential funding	More efficient use of energy resources	Improved reputation and image of the organisation	Contribution to addressing climate change	Compliance with customers' and market's	Keeping pace with competition	Facilitation of exports	Meeting national and international legislation	Expectation of change in energy resources'
N	Valid	276	271	275	274	272	273	270	261	272	269
	Missing	3	8	4	5	7	6	9	18	7	10
Median		4.0000	3.0000	3.0000	3.0000	3.0000	4.0000	3.0000	2.0000	3.0000	3.0000
Mode		4.00	3.00	4.00	4.00	4.00	4.00	4.00	1.00	4.00	3.00

Reduction / control of the energy cost					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	10	3.6	3.6	3.6
	To a small extent	25	9.0	9.1	12.7
	To a moderate extent	50	17.9	18.1	30.8
	To a great extent	139	49.8	50.4	81.2
	To a very great extent	52	18.6	18.8	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

Easier access to potential funding					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	73	26.2	26.9	26.9
	To a small extent	40	14.3	14.8	41.7
	To a moderate extent	88	31.5	32.5	74.2
	To a great extent	60	21.5	22.1	96.3
	To a very great extent	10	3.6	3.7	100.0
	Total	271	97.1	100.0	
Missing	System	8	2.9		
Total		279	100.0		

More efficient use of energy resources					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	31	11.1	11.3	11.3
	To a small extent	44	15.8	16.0	27.3
	To a moderate extent	79	28.3	28.7	56.0
	To a great extent	99	35.5	36.0	92.0
	To a very great extent	22	7.9	8.0	100.0
	Total	275	98.6	100.0	
Missing	System	4	1.4		
Total		279	100.0		

Improved reputation and image of the organisation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	34	12.2	12.4	12.4
	To a small extent	51	18.3	18.6	31.0
	To a moderate extent	74	26.5	27.0	58.0
	To a great extent	87	31.2	31.8	89.8
	To a very great extent	28	10.0	10.2	100.0
	Total	274	98.2	100.0	
Missing	System	5	1.8		
Total		279	100.0		

Contribution to addressing climate change					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	38	13.6	14.0	14.0
	To a small extent	61	21.9	22.4	36.4
	To a moderate extent	71	25.4	26.1	62.5
	To a great extent	82	29.4	30.1	92.6
	To a very great extent	20	7.2	7.4	100.0
	Total	272	97.5	100.0	
Missing	System	7	2.5		
Total		279	100.0		

Compliance with customers' and market's requirements					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	18	6.5	6.6	6.6
	To a small extent	27	9.7	9.9	16.5
	To a moderate extent	63	22.6	23.1	39.6
	To a great extent	127	45.5	46.5	86.1
	To a very great extent	38	13.6	13.9	100.0
	Total	273	97.8	100.0	
Missing	System	6	2.2		
Total		279	100.0		

Keeping pace with competition					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	31	11.1	11.5	11.5
	To a small extent	44	15.8	16.3	27.8
	To a moderate extent	81	29.0	30.0	57.8
	To a great extent	88	31.5	32.6	90.4
	To a very great extent	26	9.3	9.6	100.0
	Total	270	96.8	100.0	
Missing	System	9	3.2		
Total		279	100.0		

Facilitation of exports					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	109	39.1	41.8	41.8
	To a small extent	24	8.6	9.2	51.0
	To a moderate extent	75	26.9	28.7	79.7
	To a great extent	37	13.3	14.2	93.9
	To a very great extent	16	5.7	6.1	100.0
	Total	261	93.5	100.0	
Missing	System	18	6.5		
Total		279	100.0		

Meeting national and international legislation requirements					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	45	16.1	16.5	16.5
	To a small extent	28	10.0	10.3	26.8
	To a moderate extent	74	26.5	27.2	54.0
	To a great extent	83	29.7	30.5	84.6
	To a very great extent	42	15.1	15.4	100.0
	Total	272	97.5	100.0	
Missing	System	7	2.5		
Total		279	100.0		

Expectation of change in energy resources' price					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	39	14.0	14.5	14.5
	To a small extent	41	14.7	15.2	29.7
	To a moderate extent	98	35.1	36.4	66.2
	To a great extent	84	30.1	31.2	97.4
	To a very great extent	7	2.5	2.6	100.0
	Total	269	96.4	100.0	
Missing	System	10	3.6		
Total		279	100.0		

Please indicate the extent to which the following energy management technologies are implemented in your organisation

		Solar photovoltaic system	Heating – cooling system	Light emitting diode (LED)	Low energy consumption device	Enterprise building management system (EBMS)	Electricity saving system	Heat recovery system	Carbon capture and sequestration system	Electric and hybrid vehicle	Highly energy – efficient engine	Smart grid	Geothermal heating-cooling system
N	Valid	271	276	277	274	270	276	273	270	271	272	269	271
	Missing	8	3	2	5	9	3	6	9	8	7	10	8
Median		1.0000	4.0000	4.0000	4.0000	1.0000	3.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Mode		1.00	4.00	4.00	4.00	1.00	4.00	1.00	1.00	1.00	1.00	1.00	1.00

Solar photovoltaic system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	208	74.6	76.8	76.8
	To a small extent	19	6.8	7.0	83.8
	To a moderate extent	9	3.2	3.3	87.1
	To a great extent	19	6.8	7.0	94.1
	To a very great extent	16	5.7	5.9	100.0
	Total	271	97.1	100.0	
Missing	System	8	2.9		
Total		279	100.0		

Heating – cooling system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	43	15.4	15.6	15.6
	To a small extent	33	11.8	12.0	27.5
	To a moderate extent	42	15.1	15.2	42.8
	To a great extent	110	39.4	39.9	82.6
	To a very great extent	48	17.2	17.4	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

Light emitting diode (LED)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	26	9.3	9.4	9.4
	To a small extent	20	7.2	7.2	16.6
	To a moderate extent	37	13.3	13.4	30.0
	To a great extent	121	43.4	43.7	73.6
	To a very great extent	73	26.2	26.4	100.0
	Total	277	99.3	100.0	
Missing	System	2	.7		
Total		279	100.0		

Low energy consumption device					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	28	10.0	10.2	10.2
	To a small extent	31	11.1	11.3	21.5
	To a moderate extent	63	22.6	23.0	44.5
	To a great extent	118	42.3	43.1	87.6
	To a very great extent	34	12.2	12.4	100.0
	Total	274	98.2	100.0	
Missing	System	5	1.8		
Total		279	100.0		

Enterprise building management system (EBMS)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	138	49.5	51.1	51.1
	To a small extent	26	9.3	9.6	60.7
	To a moderate extent	55	19.7	20.4	81.1
	To a great extent	30	10.8	11.1	92.2
	To a very great extent	21	7.5	7.8	100.0
	Total	270	96.8	100.0	
Missing	System	9	3.2		
Total		279	100.0		

Electricity saving system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	51	18.3	18.5	18.5
	To a small extent	36	12.9	13.0	31.5
	To a moderate extent	74	26.5	26.8	58.3
	To a great extent	88	31.5	31.9	90.2
	To a very great extent	27	9.7	9.8	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

Heat recovery system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	141	50.5	51.6	51.6
	To a small extent	42	15.1	15.4	67.0
	To a moderate extent	48	17.2	17.6	84.6
	To a great extent	35	12.5	12.8	97.4
	To a very great extent	7	2.5	2.6	100.0
	Total	273	97.8	100.0	
Missing	System	6	2.2		
Total		279	100.0		

Carbon capture and sequestration system (CCS)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	215	77.1	79.6	79.6
	To a small extent	29	10.4	10.7	90.4
	To a moderate extent	18	6.5	6.7	97.0
	To a great extent	3	1.1	1.1	98.1
	To a very great extent	5	1.8	1.9	100.0
	Total	270	96.8	100.0	
Missing	System	9	3.2		
Total		279	100.0		

Electric and hybrid vehicle					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	201	72.0	74.2	74.2
	To a small extent	23	8.2	8.5	82.7
	To a moderate extent	19	6.8	7.0	89.7
	To a great extent	22	7.9	8.1	97.8
	To a very great extent	6	2.2	2.2	100.0
	Total	271	97.1	100.0	
Missing	System	8	2.9		
Total		279	100.0		

Highly energy – efficient engine					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	151	54.1	55.5	55.5
	To a small extent	38	13.6	14.0	69.5
	To a moderate extent	43	15.4	15.8	85.3
	To a great extent	30	10.8	11.0	96.3
	To a very great extent	10	3.6	3.7	100.0
	Total	272	97.5	100.0	
Missing	System	7	2.5		
Total		279	100.0		

Smart grid					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	161	57.7	59.9	59.9
	To a small extent	37	13.3	13.8	73.6
	To a moderate extent	37	13.3	13.8	87.4
	To a great extent	20	7.2	7.4	94.8
	To a very great extent	14	5.0	5.2	100.0
	Total	269	96.4	100.0	
Missing	System	10	3.6		
Total		279	100.0		

Geothermal heating-cooling system					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	209	74.9	77.1	77.1
	To a small extent	28	10.0	10.3	87.5
	To a moderate extent	12	4.3	4.4	91.9
	To a great extent	16	5.7	5.9	97.8
	To a very great extent	6	2.2	2.2	100.0
	Total	271	97.1	100.0	
Missing	System	8	2.9		
Total		279	100.0		

Please indicate under which of the following Standards your organisation is certified

Q8_sum_all		
N	Valid	278
	Missing	1
Mean		.9101
Median		1.0000

Q8_sum_all					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	107	38.4	38.5	38.5
	1	117	41.9	42.1	80.6
	2	33	11.8	11.9	92.4
	3	15	5.4	5.4	97.8
	4	5	1.8	1.8	99.6
	5	1	.4	.4	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

Q8_sum_certified					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	117	41.9	68.4	68.4
	2	33	11.8	19.3	87.7
	3	15	5.4	8.8	96.5
	4	5	1.8	2.9	99.4
	5	1	.4	.6	100.0
	Total	171	61.3	100.0	
Missing	System	108	38.7		
Total		279	100.0		

ISO 14001					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	217	77.8	78.1	78.1
	Yes	61	21.9	21.9	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

EMAS					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	264	94.6	95.0	95.0
	Yes	14	5.0	5.0	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

ISO 50001					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	259	92.8	93.2	93.2
	Yes	19	6.8	6.8	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

ISO 9001					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	158	56.6	56.8	56.8
	Yes	120	43.0	43.2	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

Other					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	239	85.7	86.0	86.0
	Yes	39	14.0	14.0	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

How do you assess the level of energy management practices implementation in your organisation?

N	Valid	276
	Missing	3
Median		3.0000
Mode		3.00

Level of energy management practices implementation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very negative	6	2.2	2.2	2.2
	Negative	29	10.4	10.5	12.7
	Neutral	126	45.2	45.7	58.3
	Positive	96	34.4	34.8	93.1
	Very positive	19	6.8	6.9	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

How do you assess the level of innovation management practices implementation in your organisation?

N	Valid	276
	Missing	3
Median		3.0000
Mode		4.00

Level of innovation management practices implementation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very negative	6	2.2	2.2	2.2
	Negative	33	11.8	12.0	14.1
	Neutral	104	37.3	37.7	51.8
	Positive	109	39.1	39.5	91.3
	Very positive	24	8.6	8.7	100.0
	Total	276	98.9	100.0	
Missing	System	3	1.1		
Total		279	100.0		

How do you assess the level of technology use regarding energy management in your organisation?

N	Valid	274
	Missing	5
Median		3.0000
Mode		4.00

Level of technology use regarding energy management					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very negative	4	1.4	1.5	1.5
	Negative	31	11.1	11.3	12.8
	Neutral	103	36.9	37.6	50.4
	Positive	106	38.0	38.7	89.1
	Very positive	30	10.8	10.9	100.0
	Total	274	98.2	100.0	
Missing	System	5	1.8		
Total		279	100.0		

How do you assess the level of employees' encouragement regarding their involvement in energy management in your organisation?

N	Valid	275
	Missing	4
Median		4.0000
Mode		4.00

Level of employees' encouragement in energy management					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very negative	5	1.8	1.8	1.8
	Negative	36	12.9	13.1	14.9
	Neutral	96	34.4	34.9	49.8
	Positive	109	39.1	39.6	89.5
	Very positive	29	10.4	10.5	100.0
	Total	275	98.6	100.0	
Missing	System	4	1.4		
Total		279	100.0		

Your organisation is…

Registration of the organisation's activities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Greek	243	87.1	88.4	88.4
	Member of a foreign organisation	32	11.5	11.6	100.0
	Total	275	98.6	100.0	
Missing	System	4	1.4		
Total		279	100.0		

Your organisation is…

Intensity of the organisation's activities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Capital intensive	73	26.2	29.4	29.4
	Labour intensive	165	59.1	66.5	96.0
	Energy intensive	10	3.6	4.0	100.0
	Total	248	88.9	100.0	
Missing	System	31	11.1		
Total		279	100.0		

In which industry does your organisation operating in?

Industry of operation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Wholesale and retail trade; repair of motor vehicles and motorcycles (section G)	88	31.5	31.7	31.7
	Accommodation service activities (section I)	43	15.4	15.5	47.1
	Other service activities (section S)	39	14.0	14.0	61.2
	Professional, scientific and technical activities (section M)	23	8.2	8.3	69.4
	Transportation and storage (section H)	11	3.9	4.0	73.4
	Human health and social work activities (section	11	3.9	4.0	77.3
	Manufacturing (section	21	7.5	7.6	84.9
	Education (section P)	12	4.3	4.3	89.2
	Construction (section F)	7	2.5	2.5	91.7
	Arts, entertainment and recreation (section R)	8	2.9	2.9	94.6
	Administrative and support service activities (section N)	3	1.1	1.1	95.7
	Real estate activities (section L)	2	.7	.7	96.4
	Financial and insurance activities (section K)	10	3.6	3.6	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

To what extent do you think the following implemented activities within your organisation are energy-consuming?

		Production of raw materials	Intermediate production	Process – production of final product	Packaging	Storage management –	Transportation and cargo management	Trade	Product improvement / new
N	Valid	264	262	266	264	265	265	259	260
	Missing	15	17	13	15	14	14	20	19
Median		5.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	2.5000
Mode		5.00	5.00	3.00	1.00	2.00	2.00	2.00	2.00

Production of raw materials					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	81	29.0	30.7	30.7
	To a small extent	31	11.1	11.7	42.4
	To a moderate extent	12	4.3	4.5	47.0
	To a great extent	7	2.5	2.7	49.6
	To a very great extent	93	33.3	35.2	84.8
	Not implemented	40	14.3	15.2	100.0
	Total	264	94.6	100.0	
Missing	System	15	5.4		
Total		279	100.0		

Intermediate production					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	45	16.1	17.2	17.2
	To a small extent	52	18.6	19.8	37.0
	To a moderate extent	43	15.4	16.4	53.4
	To a great extent	18	6.5	6.9	60.3
	To a very great extent	64	22.9	24.4	84.7
	Not implemented	40	14.3	15.3	100.0
	Total	262	93.9	100.0	
Missing	System	17	6.1		
Total		279	100.0		

Process – production of final product					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	38	13.6	14.3	14.3
	To a small extent	42	15.1	15.8	30.1
	To a moderate extent	59	21.1	22.2	52.3
	To a great extent	33	11.8	12.4	64.7
	To a very great extent	54	19.4	20.3	85.0
	Not implemented	40	14.3	15.0	100.0
	Total	266	95.3	100.0	
Missing	System	13	4.7		
Total		279	100.0		

Packaging					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	71	25.4	26.9	26.9
	To a small extent	57	20.4	21.6	48.5
	To a moderate extent	27	9.7	10.2	58.7
	To a great extent	16	5.7	6.1	64.8
	To a very great extent	53	19.0	20.1	84.8
	Not implemented	40	14.3	15.2	100.0
	Total	264	94.6	100.0	
Missing	System	15	5.4		
Total		279	100.0		

Storage management – maintenance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	50	17.9	18.9	18.9
	To a small extent	74	26.5	27.9	46.8
	To a moderate extent	48	17.2	18.1	64.9
	To a great extent	27	9.7	10.2	75.1
	To a very great extent	26	9.3	9.8	84.9
	Not implemented	40	14.3	15.1	100.0
	Total	265	95.0	100.0	
Missing	System	14	5.0		
Total		279	100.0		

Transportation and cargo management					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	33	11.8	12.5	12.5
	To a small extent	72	25.8	27.2	39.6
	To a moderate extent	61	21.9	23.0	62.6
	To a great extent	30	10.8	11.3	74.0
	To a very great extent	29	10.4	10.9	84.9
	Not implemented	40	14.3	15.1	100.0
	Total	265	95.0	100.0	
Missing	System	14	5.0		
Total		279	100.0		

Trade					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	38	13.6	14.7	14.7
	To a small extent	59	21.1	22.8	37.5
	To a moderate extent	51	18.3	19.7	57.1
	To a great extent	45	16.1	17.4	74.5
	To a very great extent	26	9.3	10.0	84.6
	Not implemented	40	14.3	15.4	100.0
	Total	259	92.8	100.0	
Missing	System	20	7.2		
Total		279	100.0		

Product improvement / new product development					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	61	21.9	23.5	23.5
	To a small extent	69	24.7	26.5	50.0
	To a moderate extent	32	11.5	12.3	62.3
	To a great extent	15	5.4	5.8	68.1
	To a very great extent	43	15.4	16.5	84.6
	Not implemented	40	14.3	15.4	100.0
	Total	260	93.2	100.0	
Missing	System	19	6.8		
Total		279	100.0		

What is the total number of employees in your organisation?

Total number of employees					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-9	104	37.3	37.4	37.4
	10-49	73	26.2	26.3	63.7
	50-249	44	15.8	15.8	79.5
	250-749	10	3.6	3.6	83.1
	750+	47	16.8	16.9	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

What is the average level of education among the employees in your organisation?

Employees' level of education					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High school graduates	111	39.8	39.9	39.9
	University graduates	144	51.6	51.8	91.7
	Postgraduates	17	6.1	6.1	97.8
	PhD holders	6	2.2	2.2	100.0
	Total	278	99.6	100.0	
Missing	System	1	.4		
Total		279	100.0		

What was your organisation's turnover that came from its activity in Greece in 2012 (in thousand €)?

Turnover in 2012					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-150	63	22.6	23.6	23.6
	150-500	32	11.5	12.0	35.6
	500-2.000	27	9.7	10.1	45.7
	2.000-10.000	38	13.6	14.2	59.9
	10.000+	107	38.4	40.1	100.0
	Total	267	95.7	100.0	
Missing	System	12	4.3		
Total		279	100.0		

Which type(s) of energy are used in your organisation?

		Mazut	Gasoline - diesel	Oil	Electricity	Natural gas	Solar thermal panels	Photovoltaic panels
N	Valid	243	248	251	273	244	240	238
	Missing	36	31	28	6	35	39	41
Median		1.0000	2.0000	2.0000	4.0000	1.0000	1.0000	1.0000
Mode		1.00	1.00	1.00	4.00	1.00	1.00	1.00

Mazut					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	223	79.9	91.8	91.8
	To a small extent	6	2.2	2.5	94.2
	To a moderate extent	6	2.2	2.5	96.7
	To a great extent	5	1.8	2.1	98.8
	To a very great extent	3	1.1	1.2	100.0
	Total	243	87.1	100.0	
Missing	System	36	12.9		
Total		279	100.0		

Gasoline - diesel					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	114	40.9	46.0	46.0
	To a small extent	52	18.6	21.0	66.9
	To a moderate extent	28	10.0	11.3	78.2
	To a great extent	39	14.0	15.7	94.0
	To a very great extent	15	5.4	6.0	100.0
	Total	248	88.9	100.0	
Missing	System	31	11.1		
Total		279	100.0		

Oil					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	97	34.8	38.6	38.6
	To a small extent	52	18.6	20.7	59.4
	To a moderate extent	40	14.3	15.9	75.3
	To a great extent	45	16.1	17.9	93.2
	To a very great extent	17	6.1	6.8	100.0
	Total	251	90.0	100.0	
Missing	System	28	10.0		
Total		279	100.0		

Electricity					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	12	4.3	4.4	4.4
	To a small extent	10	3.6	3.7	8.1
	To a moderate extent	26	9.3	9.5	17.6
	To a great extent	115	41.2	42.1	59.7
	To a very great extent	110	39.4	40.3	100.0
	Total	273	97.8	100.0	
Missing	System	6	2.2		
Total		279	100.0		

Natural gas					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	170	60.9	69.7	69.7
	To a small extent	20	7.2	8.2	77.9
	To a moderate extent	24	8.6	9.8	87.7
	To a great extent	26	9.3	10.7	98.4
	To a very great extent	4	1.4	1.6	100.0
	Total	244	87.5	100.0	
Missing	System	35	12.5		
Total		279	100.0		

Solar thermal panels					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	189	67.7	78.8	78.8
	To a small extent	16	5.7	6.7	85.4
	To a moderate extent	12	4.3	5.0	90.4
	To a great extent	19	6.8	7.9	98.3
	To a very great extent	4	1.4	1.7	100.0
	Total	240	86.0	100.0	
Missing	System	39	14.0		
Total		279	100.0		

Photovoltaic panels					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	205	73.5	86.1	86.1
	To a small extent	9	3.2	3.8	89.9
	To a moderate extent	10	3.6	4.2	94.1
	To a great extent	13	4.7	5.5	99.6
	To a very great extent	1	.4	.4	100.0
	Total	238	85.3	100.0	
Missing	System	41	14.7		
Total		279	100.0		

To what extent do you think the following factors can influence the implementation of energy management practices in your organisation?

		Public funding	Tax exemption	Funding programme enrolment
N	Valid	271	274	272
	Missing	8	5	7
Median		4.0000	4.0000	4.0000
Mode		4.00	4.00	4.00

Public funding					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	36	12.9	13.3	13.3
	To a small extent	28	10.0	10.3	23.6
	To a moderate extent	37	13.3	13.7	37.3
	To a great extent	111	39.8	41.0	78.2
	To a very great extent	59	21.1	21.8	100.0
	Total	271	97.1	100.0	
Missing	System	8	2.9		
Total		279	100.0		

Tax exemption					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	25	9.0	9.1	9.1
	To a small extent	19	6.8	6.9	16.1
	To a moderate extent	25	9.0	9.1	25.2
	To a great extent	122	43.7	44.5	69.7
	To a very great extent	83	29.7	30.3	100.0
	Total	274	98.2	100.0	
Missing	System	5	1.8		
Total		279	100.0		

Funding programme enrolment					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	28	10.0	10.3	10.3
	To a small extent	29	10.4	10.7	21.0
	To a moderate extent	37	13.3	13.6	34.6
	To a great extent	128	45.9	47.1	81.6
	To a very great extent	50	17.9	18.4	100.0
	Total	272	97.5	100.0	
Missing	System	7	2.5		
Total		279	100.0		

Has your organisation ever obtained funding via programmes regarding the implementation of energy management practices?

Q22_sum_all		
N	Valid	272
	Missing	7
Mean		.4191
Median		0.0000

Q22_sum_all					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	191	68.5	70.2	70.2
	1	53	19.0	19.5	89.7
	2	24	8.6	8.8	98.5
	3	3	1.1	1.1	99.6
	4	1	.4	.4	100.0
	Total	272	97.5	100.0	
Missing	System	7	2.5		
Total		279	100.0		

Q22_sum_certified		
N	Valid	81
	Missing	198
Mean		1.4074
Median		1.0000

Q22_sum_certified					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	53	19.0	65.4	65.4
	2.00	24	8.6	29.6	95.1
	3.00	3	1.1	3.7	98.8
	4.00	1	.4	1.2	100.0
	Total	81	29.0	100.0	
Missing	System	198	71.0		
Total		279	100.0		

Community					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	226	81.0	84.6	84.6
	Yes	41	14.7	15.4	100.0
	Total	267	95.7	100.0	
Missing	System	12	4.3		
Total		279	100.0		

National					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	226	81.0	84.3	84.3
	Yes	42	15.1	15.7	100.0
	Total	268	96.1	100.0	
Missing	System	11	3.9		
Total		279	100.0		

Local					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	241	86.4	91.6	91.6
	Yes	22	7.9	8.4	100.0
	Total	263	94.3	100.0	
Missing	System	16	5.7		
Total		279	100.0		

Other					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	216	77.4	96.0	96.0
	Yes	9	3.2	4.0	100.0
	Total	225	80.6	100.0	
Missing	System	54	19.4		
Total		279	100.0		

Techno-economic analysis SAM model cash flow report

Excerpt 1

	0	1	2	3	4	5	6	7	8	9	10
PRODUCTION (AC KWH)											
Energy (kWh)	0	359430	357633	355845	354066	352295	350534	348781	347037	345302	343576
REVENUES											
PPA price (cents/kWh)	0	40.1329	40.7349	41.346	41.9662	42.5956	43.2346	43.8831	44.5414	45.2095	45.8876
PPA revenue ($)	0	144250	145682	147128	148588	150062	151552	153056	154575	156109	157659
plus PBI if available for debt service:											
Salvage value ($)	0	0	0	0	0	0	0	0	0	0	0
Total revenue ($)	0	144250	145682	147128	148588	150062	151552	153056	154575	156109	157659
Property tax net assessed value ($)	0	1619976	1619976	1619976	1619976	1619976	1619976	1619976	1619976	1619976	1619976
OPERATING EXPENSES											
O&M fixed expense ($)	0	9048	9274	9506	9744	9987	10237	10493	10755	11024	11300
O&M production-based expense ($)	0	0	0	0	0	0	0	0	0	0	0
O&M capacity-based expense ($)	0	0	0	0	0	0	0	0	0	0	0
Property tax expense ($)	0	0	0	0	0	0	0	0	0	0	0
Insurance expense ($)	0	8100	8302	8510	8723	8941	9164	9393	9628	9869	10116
Total operating expenses ($)	0	17148	17577	18016	18466	18928	19401	19886	20383	20893	21415
EBITDA ($)	0	127102	128105	129112	130121	131134	132151	133170	134192	135216	136243
CASH FLOWS FROM OPERATING ACTIVITIES											
EBITDA ($)	0	127102	128105	129112	130121	131134	132151	133170	134192	135216	136243
Interest earned on reserves ($)	0	0	0	0	0	0	0	0	0	0	0
plus PBI if not available for debt service:											
Federal PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
State PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Utility PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Other PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
minus:											
Debt interest payment ($)	0	30103	28555	26950	25288	23566	21782	19934	18019	16036	13981
equals:											
Cash flow from operating activities ($)	0	96999	99550	102161	104833	107568	110368	113236	116172	119181	122263
CASH FLOWS FROM INVESTING ACTIVITIES											
Total installed cost ($)	-1619976										
Debt closing costs ($)	0										
Debt up-front fee ($)	0										
Financing cost ($)	0										
Total construction financing cost	-7290										
Total IBI income ($)	0										
Total CBI income ($)	0										
equals:											
Purchase of property ($)	-1627266										
plus:											
Reserve (increase)/decrease debt service ($)	-36560	0	0	0	0	0	0	0	0	0	0
Reserve (increase)/decrease working capital ($)	-8574	-214	-220	-225	-231	-237	-243	-249	-255	-261	-268
Reserve (increase)/decrease receivables ($)	0	0	0	0	0	0	0	0	0	0	0
Reserve (increase)/decrease major equipment 1 ($)	0	-9461	-9461	-9461	-9461	-9461	-9461	-9461	-9461	-9461	-9461
Reserve (increase)/decrease major equipment 2 ($)	0	0	0	0	0	0	0	0	0	0	0
Reserve (increase)/decrease major equipment 3 ($)	0	0	0	0	0	0	0	0	0	0	0
Reserve capital spending major equipment 1 ($)	0	0	0	0	0	0	0	0	0	0	0
Reserve capital spending major equipment 2 ($)	0	0	0	0	0	0	0	0	0	0	0
Reserve capital spending major equipment 3 ($)	0	0	0	0	0	0	0	0	0	0	0
equals:											
Cash flow from investing activities ($)	-1672400	-9676	-9681	-9687	-9692	-9698	-9704	-9710	-9716	-9723	-9729
CASH FLOWS FROM FINANCING ACTIVITIES											
Total IBI income ($)	0										
Total CBI income ($)	0										
Size of debt ($)	836200										
Issuance of equity ($)	836200										
Debt principal payment ($)	0	43017	44566	46170	47832	49554	51338	53186	55101	57085	59140
equals:											
Cash flow from financing activities ($)	1672400	-43017	-44566	-46170	-47832	-49554	-51338	-53186	-55101	-57085	-59140

Excerpt 2

PRE-TAX PROJECT RETURNS											
Issuance of equity ($)	-836200										
Cash flow from operating activities ($)	0	96999	99550	102161	104833	107568	110368	113236	116172	119181	122263
Cash flow from investing activities ($)	-1672400	-9676	-9681	-9687	-9692	-9698	-9704	-9710	-9716	-9723	-9729
Cash flow from financing activities ($)	1672400	-43017	-44566	-46170	-47832	-49554	-51338	-53186	-55101	-57085	-59140
equals:											
Pre-tax project returns ($)	-836200	44306	45304	46304	47309	48316	49326	50339	51355	52373	53394
AFTER-TAX PROJECT RETURNS											
Pre-tax project returns ($)	-836200	44306	45304	46304	47309	48316	49326	50339	51355	52373	53394
Federal ITC income ($)		451548									
Federal PTC income ($)	0	0	0	0	0	0	0	0	0	0	0
Federal tax benefit/(liability) ($)	0	68367	133364	63388	20908	19678	-12523	-44713	-45948	-47208	-48506
State ITC income ($)	0										
State PTC income ($)	0	0	0	0	0	0	0	0	0	0	0
State tax benefit/(liability) ($)	0	0	0	0	0	0	0	0	0	0	0
After-tax project returns ($)	-836200	564221	178668	109692	68217	67994	36804	5627	5407	5165	4888
RETURN ON EQUITY											
Return on equity input (%)	0	0	0	0	0	0	0	0	0	0	0
Return on equity dollars ($)	0	0	0	0	0	0	0	0	0	0	0
Return on equity ($/kWh)	0	0	0	0	0	0	0	0	0	0	0
AFTER-TAX IRR AND NPV											
After-tax project cumulative IRR (%)	NaN	-32.53	-9.04	1.33	6.1	9.67	11.17	11.36	11.52	11.66	11.77
After-tax project cumulative NPV ($)	-836200	-316162	-164382	-78494	-29264	15963	38526	41706	44522	47002	49164
AFTER-TAX LEVELIZED COE AND PPA PRICE											
Annual costs ($)	-836200	419971	32986	-37435	-80371	-82068	-114748	-147429	-149168	-150944	-152770
PPA revenue ($)	0	144250	145682	147128	148588	150062	151552	153056	154575	156109	157659
Energy (kWh)	0	359430	357633	355845	354066	352295	350534	348781	347037	345302	343576
Present value of annual costs ($)	1374200										
Present value of annual energy (nominal) (kWh)	3536387										
Levelized cost (nominal) (cents/kWh)	38.86										
Present value of PPA revenue ($)	1601968										
Present value of annual energy (nominal) (kWh)	3536387										
Levelized PPA price (nominal) (cents/kWh)	45.3										
STATE INCOME TAXES											
EBITDA ($)	0	127102	128105	129112	130121	131134	132151	133170	134192	135216	136243
Interest earned on reserves ($)	0	0	0	0	0	0	0	0	0	0	0
State taxable IBI income ($)		0									
State taxable CBI income ($)		0									
State taxable PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
minus:											
Debt interest payment ($)	0	30103	28555	26950	25288	23566	21782	19934	18019	16036	13981
Total state tax depreciation ($)	0	259778	417084	253084	154614	154421	80553	6777	6773	6780	6773
equals:											
State taxable income ($)	0	-162779	-317533	-150923	-49781	-46853	29816	106458	109399	112401	115489
State tax rate (%)	0	0	0	0	0	0	0	0	0	0	0
State tax benefit/(liability) ($)	0	0	0	0	0	0	0	0	0	0	0

Excerpt 3

FEDERAL INCOME TAXES											
EBITDA ($)	0	127102	128105	129112	130121	131134	132151	133170	134192	135216	136243
Interest earned on reserves ($)	0	0	0	0	0	0	0	0	0	0	0
State tax benefit/(liability) ($)	0	0	0	0	0	0	0	0	0	0	0
State ITC income ($)	0										
State PTC income ($)	0	0	0	0	0	0	0	0	0	0	0
Federal taxable IBI income ($)		0									
Federal taxable CBI income ($)		0									
Federal taxable PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
minus:											
Debt interest payment ($)	0	30103	28555	26950	25288	23566	21782	19934	18019	16036	13981
Total federal tax depreciation ($)	0	259778	417084	253084	154614	154421	80553	6777	6773	6780	6773
equals:											
Federal taxable income ($)	0	-162779	-317533	-150923	-49781	-46853	29816	106458	109399	112401	115489
Federal tax rate (%)	0	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Federal tax benefit/(liability) ($)	0	68367	133364	63388	20908	19678	-12523	-44713	-45948	-47208	-48506
INCENTIVES											
Federal IBI income ($)	0										
State IBI income ($)	0										
Utility IBI income ($)	0										
Other IBI income ($)	0										
Total IBI income ($)	0										
Federal CBI income ($)	0										
State CBI income ($)	0										
Utility CBI income ($)	0										
Other CBI income ($)	0										
Total CBI income ($)	0										
Federal PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
State PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Utility PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Other PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Total PBI income ($)	0	0	0	0	0	0	0	0	0	0	0
Federal PTC income ($)	0	0	0	0	0	0	0	0	0	0	0
State PTC income ($)	0	0	0	0	0	0	0	0	0	0	0
Federal ITC income ($)		451548									
State ITC income ($)		0									
DEBT REPAYMENT											
Debt total payment ($)	0	73120	73120	73120	73120	73120	73120	73120	73120	73120	73120
Debt interest payment ($)	0	30103	28555	26950	25288	23566	21782	19934	18019	16036	13981
Debt principal payment ($)	0	43017	44566	46170	47832	49554	51338	53186	55101	57085	59140
Debt balance ($)	836200	793183	748617	702447	654614	605060	553722	500535	445434	388349	329210
DSCR (DEBT FRACTION)											
EBITDA ($)	0	127102	128105	129112	130121	131134	132151	133170	134192	135216	136243
minus:											
Reserves major equipment 1 funding ($)	0	9461	9461	9461	9461	9461	9461	9461	9461	9461	9461
Reserves major equipment 2 funding ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 3 funding ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves receivables funding ($)	0	0	0	0	0	0	0	0	0	0	0
equals:											
Cash available for debt service (CAFDS) ($)	0	117641	118644	119650	120660	121673	122689	123708	124730	125755	126782
Debt total payment ($)	0	73120	73120	73120	73120	73120	73120	73120	73120	73120	73120
DSCR (pre-tax)	0	1.61	1.62	1.64	1.65	1.66	1.68	1.69	1.71	1.72	1.73

Excerpt 4

RESERVES											
Reserves debt service funding ($)	36560	0	0	0	0	0	0	0	0	0	0
Reserves debt service disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves debt service balance ($)	36560	36560	36560	36560	36560	36560	36560	36560	36560	36560	36560
Reserves working capital funding ($)	8574	214	220	225	231	237	243	249	255	261	268
Reserves working capital disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves working capital balance ($)	8574	8788	9008	9233	9464	9701	9943	10192	10447	10708	10975
Reserves receivables funding ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves receivables disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves receivables balance ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 1 funding ($)	0	9461	9461	9461	9461	9461	9461	9461	9461	9461	9461
Reserves major equipment 1 disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 1 balance ($)	0	9461	18923	28384	37846	47307	56768	66230	75691	85153	94614
Reserves major equipment 2 funding ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 2 disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 2 balance ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 3 funding ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 3 disbursement ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves major equipment 3 balance ($)	0	0	0	0	0	0	0	0	0	0	0
Reserves total reserves balance ($)	45134	54810	64491	74178	83870	93568	103272	112982	122698	132421	142150
Interest on reserves (%/year)	0										
Interest earned on reserves ($)											

Excerpt 5

DEPRECIATION AND ITC: STATE	% of Total Dep	Gross Amount	IBI Reduction	CBI Reduction	Depreciable Ba	ITC Qualifying	% of ITC Quali	ITC Amount	ITC Basis Disal	ITC Amount	ITC Basis Disallowa
MACRS 5-yr	92.78	1505159.75	0	0	1505159.75	0	0	0	0	0	0
MACRS 15-yr	1.55	25085.99	0	0	25085.99	0	0	0	0	0	0
Straight Line 5-yr	0	0	0	0	0	0	0	0	0	0	0
Straight Line 15-yr	2.58	41809.99	0	0	41809.99	0	0	0	0	0	0
Straight Line 20-yr	3.09	50171.99	0	0	50171.99	0	0	0	0	0	0
Straight Line 39-yr	0	0	0	0	0	0	0	0	0	0	0
Custom	0	0	0	0	0	0	0	0	0	0	0
Total	100	1622227.63	0	0	1622227.63	0	100	0	0	0	0
DEPRECIATION AND ITC: FEDERAL											
MACRS 5-yr	92.78	1505159.75	0	0	1505159.75	1505159.75	100	451547.91	225773.95	0	0
MACRS 15-yr	1.55	25085.99	0	0	25085.99	0	0	0	0	0	0
Straight Line 5-yr	0	0	0	0	0	0	0	0	0	0	0
Straight Line 15-yr	2.58	41809.99	0	0	41809.99	0	0	0	0	0	0
Straight Line 20-yr	3.09	50171.99	0	0	50171.99	0	0	0	0	0	0
Straight Line 39-yr	0	0	0	0	0	0	0	0	0	0	0
Custom	0	0	0	0	0	0	0	0	0	0	0
Total	100	1622227.63	0	0	1622227.63	1505159.75	100	451547.91	225773.95	0	0