





Contents

1. Executive summary	2
2. Introduction	4
A. The Smarter Cities Challenge	4
B. The challenge	6
3. Context, findings and roadmap	7
A. Context and findings	7
B. Roadmap	8
4. Recommendations	12
Recommendation 1: Install solar PV on prime municipal buildings	12
Recommendation 2: Move forward with solar installation on other municipal assets	17
Recommendation 3: Push for a solar renewable energy feed-in tariff (REFIT)	20
Recommendation 4: Incorporate smarter buildings and micro-generation into the Dublin City Development Plan	22
Recommendation 5: Develop leadership in solar funding	24
Recommendation 6: Build community awareness and engagement	26
5. Conclusion	27
6. Appendices	28
A. Additional context and background information	28
B. Project management and technical risk	33
C. Overview of relevant assets	36
D. Acknowledgments	37
E. Team biographies	39
F. References	42
G. Abbreviations	43

1. Executive summary

Introduction

The City of Dublin, Ireland, was one of 16 cities selected to receive a Smarter Cities Challenge® grant from IBM in 2014 as a part of the company's citizenship efforts to build a Smarter Planet®. During a three-week period in October of 2014, a team of four IBM experts and two HSBC client partners worked together to deliver recommendations on a key energy and sustainability challenge identified by Owen Keegan, Dublin's Chief Executive, and his senior leadership team.

Dublin has made some great strides towards sustainability, but the City is not yet in a position to address the European Energy Directive 2020 goals of receiving 16% of its energy from renewable resources. In Dublin, there are more than 430 municipally owned buildings along with hundreds of other assets, such as parks and street furniture, which generate high energy costs for the City. Dublin's Chief Executive, Owen Keegan, and Dublin City Council have asked for a recommendation on whether solar energy is a viable option to address the environmental and financial goals of the City's municipally owned and government buildings. A number of factors make the City a good candidate for solar energy, including the following:

- Solar energy is a proven technology that has decreased in cost in recent years.
- The economy in Ireland is improving.
- The landscape, such as available space, solar irradiance and weather, on-site experts and accessible leaders, makes the City's buildings promising assets.

The challenge

There is a significant amount of municipally owned urban space in Dublin that is unsuitable for wind energy but could potentially benefit from solar technologies, including photovoltaic (PV) and solar thermal energy (STE). The IBM Smarter Cities Challenge team was asked to address the following challenge:

Dublin City Council needs to understand the harvestable energy potential of the City's assets and how municipally owned, distributed solar energy could become economically viable and practically deployed.

Findings and recommendations

In order to build a deep understanding of the City's challenge and its available solution options, the team interviewed a number of stakeholders and experts in the solar energy and renewable energy fields from across Dublin and elsewhere. The team reviewed the available data, including statistical information about solar energy in the region, commercial pricing of solar technology and Dublin City Council's own statistics for energy usage. These findings are what form the basis of the team's recommendations. The key findings are as follows:

- **Technology:** The price of solar power modules has declined significantly over the last decade, dropping from €1.5/kWp in 2010 to less than €0.6/kWp presently.^{1,2}
- **Risks:** Solar PV is a low-risk and low-maintenance technology that has demonstrated consistent performance. Other regions in Ireland, such as County Tipperary, as well as other parts of Europe that experience similar weather patterns have successfully implemented this technology.
- **Energy security:** Diversification of indigenous renewable energy sources is a strategic priority for Ireland, enabling the country to replace some imported energy with a balance of renewables that are not dependent on a single source.
- **Energy efficiency:** In addition to solar energy, the City also must consider energy efficiency and smart building approaches that will reduce overall energy consumption and increase the City's proportion of renewables as compared to non-renewable energy sources.
- **Local energy:** Distributed solar energy allows generation and consumption to occur in the same place. This approach reduces the cost of transmission, which can be an issue for other renewable energy sources.
- **Environmentally friendly:** Solar energy has low carbon dioxide and particulate emissions.
- **Leadership:** Dublin City Council is seeking to promote distributed solar energy on a larger scale. While a sound financial justification remains essential to supporting their plan, solar energy is not a purely financial decision. There is an opportunity for the City to demonstrate leadership in renewable resources initiatives by using solar energy to promote the long-term good of its community.
- **Community:** Residents have expressed positive reactions towards the adoption of solar energy in the city, but it is important to keep communities engaged and informed of the benefits and advantages that solar power will bring. Doing so will help keep residents engaged and their attitudes positive. And it could lead to innovative community funding arrangements.

One key variable the IBM Smarter Cities Challenge team examined was how suitable Dublin is for supporting solar energy. The team determined the following:

- Solar irradiance in Dublin (~1,000 kWh/m²/year)³ is comparable to other cities that have implemented solar energy successfully, including many in northern Germany.
- Dublin has plenty of suitable space to implement solar technology. Among Dublin City Council assets, several buildings have high electric base loads and large roof areas. These buildings represent a valuable asset base as they could potentially offset their high electricity bills by generating solar PV electricity using the large rooftop space that's readily available.
- The city is home to a number of subject matter experts who will be vital in driving successful solar energy projects. Various members of local universities, business leaders and individuals on the Council itself have expertise in solar technology.
- Solar energy solutions present a financially sound investment for the City. Solar PV typically pays back its initial investment in 7 to 13 years if energy prices remain the same — the ROI would be shorter than that, though, if energy prices rise. PV technology is normally guaranteed for 25 years, and its lifespan is often longer in practice. In short, a favourable ROI is possible with low risk.

Based on its findings, the team made the following six recommendations to the City:

1. Install solar PV on prime municipal buildings

Dublin City Council should undertake a systematic process to evaluate the City's 430-plus municipal buildings to determine if roof-mounted solar installations could offset the buildings' energy base load. The price of PV systems has fallen over the years, and the cost of producing solar power in €/kWh over the lifetime of the PV system may be comparable to or lower than the utility price of electricity paid by Dublin City Council.

2. Move forward with solar installation on other municipal assets

Dublin City Council should build on the initial introduction of solar energy across municipally owned buildings and utilise solar power generation in housing complexes, leisure centres, parks, reservoirs and other open spaces. At this stage, there would be more scope to explore more diverse building types and solar power technologies, such as solar battery storage or solar thermal solutions.

3. Push for a solar renewable energy feed-in tariff (REFIT)

Dublin City Council should leverage its influence at the Department of Communications, Energy and Natural Resources' ongoing consultations over the current Green Paper on Energy Policy in Ireland. The Council should push for competitive solar REFITs that would benefit distributed solar energy and small-scale producers. This would help increase the prevalence of solar PV, generating many more use cases that demonstrate the technology's financial advantages.

4. Incorporate smarter buildings and micro-generation into the Dublin City Development Plan

Dublin City Council should build on Dublin's current City Development Plan, encouraging the adoption of smarter building technologies and distributed solar energy in the 2016 - 2022 plan. There is an opportunity for the new plan to incentivise solar energy use in building developments, which could lead to building code policies that support Ireland's renewable energy initiatives.

5. Develop leadership in solar funding

There are multiple funding options for Dublin City Council to consider. These could include direct finance from Dublin City Council's budget, asset-based lending, partial or full funding through an energy service company (ESCO) and community and crowdfunding efforts.

6. Build community awareness and engagement

Dublin City Council should embark on a proactive awareness campaign around the benefits of solar energy. A community that is more educated on and engaged in solar energy will be more inclined to join the City's renewable resources efforts. While this project is focused on municipally owned buildings, the Smarter Cities Challenge team hopes Dublin City Council will set the foundation for many others in the community to follow in later phases.

Conclusion

Each of these recommendations focuses on helping Dublin pursue the widespread implementation of solar energy solutions in a country accustomed to harnessing wind energy. Doing so will help the City achieve its 2020 renewable energy targets and drive long-term energy cost savings.

2. Introduction

The City of Dublin, Ireland, was one of 16 cities selected to receive a Smarter Cities Challenge grant from IBM in 2014 as part of the company's citizenship efforts to build a Smarter Planet. During a three-week period in October 2014, a team of four IBM experts and two HSBC leaders worked to deliver recommendations on a key challenge identified by Owen Keegan, Dublin's Chief Executive, and his senior leadership team:

Understand the harvestable potential of solar energy for Dublin's public assets and how municipally owned, distributed solar energy could become an economically viable solution for the City.

A. The Smarter Cities Challenge

By 2050, cities will be home to more than two-thirds of the world's population. They already wield more economic power and have access to more advanced technological capabilities than ever before. Simultaneously, cities are struggling with a wide range of challenges and threats to sustainability in their core support and governance systems, including transport, water, energy, communications, healthcare and social services.

Meanwhile, trillions of digital devices, connected through the Internet, are producing a vast ocean of data. All of this information — from the flow of markets to the pulse of societies — can be turned into knowledge because we now have the computational power and advanced analytics to make sense of it. With this knowledge, cities could reduce costs, cut waste and improve efficiency, productivity and quality of life for their citizens. In the face of the mammoth challenges of economic crisis and increased demand for services, ample opportunities still exist for the development of innovative solutions.

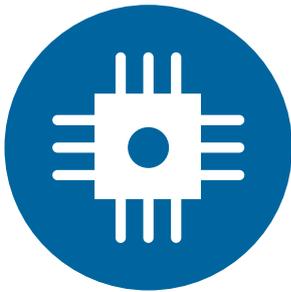
In November 2008, IBM initiated a discussion on how the planet is becoming "smarter". By this it meant that intelligence is becoming infused into the systems and processes that make the world work — into things no one would recognise as computers: cars, appliances, roadways, power grids, clothes and even natural systems, such as agriculture and waterways. By creating more instrumented, interconnected and intelligent systems, citizens and policymakers can harvest new trends and insights from data, providing the basis for more-informed decisions.

A Smarter City uses technology to transform its core systems and optimise finite resources. Because cities grapple on a daily basis with the interaction of water, transportation, energy, public safety and many other systems, IBM is committed to a vision of Smarter Cities® as a vital component of building a Smarter Planet. At the highest levels of maturity, a Smarter City is a knowledge-based system that provides real-time insights to stakeholders and enables decision-makers to manage the city's subsystems proactively. Effective information management is at the heart of this capability, and integration and analytics are the key enablers.

Intelligence is being infused into the way the world works.

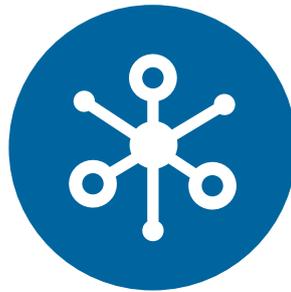
The IBM Smarter Cities Challenge contributes the skills and expertise of top IBM talent to address the critical challenges cities around the world now face. We do this by putting teams on the ground for three weeks to work closely with City leaders and deliver recommendations on how to make each City smarter and more effective. Over the past four years, more than 100 cities have received these grants. The Smarter Cities Challenge is the largest philanthropic initiative IBM has launched, with contributions valued at more than \$50 million to date.

The City of Dublin, Ireland, was selected through a competitive process as one of 16 cities to be awarded a Smarter Cities Challenge grant in 2014.



Instrumented

We can measure, sense and see the condition of practically everything.



Interconnected

People, systems and objects can communicate and interact with one another in entirely new ways.



Intelligent

We can analyse and derive insight from large and diverse sources of information to predict and respond better to change.

Figure 1: Instrumented, interconnected, intelligent

B. The challenge

The City of Dublin asked the IBM team to address the following challenge:

Dublin City Council needs to understand the harvestable energy potential of the City's assets and how municipally owned, distributed solar energy could become economically viable and practically deployed.

Dublin is a city with a rich history and is home to a number of globally recognised buildings and urban spaces that vary in style, age and background. These physical assets are accompanied by a wealth of intellectual and human assets as the city boasts a population of more than one million and has four internationally ranked universities, as well as numerous innovative businesses ranging from start-ups to multinational enterprises.

As the capital of a country that has made great strides in renewable energy — wind power in particular — Dublin still remains dependent on fossil fuel imports for the bulk of its energy needs. There is a significant amount of municipally owned urban space in Dublin that is unsuitable for wind energy but has potential as a location for solar technologies, including photovoltaic (PV) and thermal.

Dublin's Lord Mayor, Christy Burke, said at the start of the engagement, "Advances in technology mean that solar energy is now a real possibility in a city with a climate like Dublin's. Dublin City Council wanted to examine what role the buildings and land that it owns could play in generating and using solar energy."

Dublin's assets that demonstrate potential for solar energy generation include roof space on public buildings, open spaces, waste and water assets and recreational facilities. The wide variety of shape, size, condition and uses of these assets characterise this challenge, as well as the regulatory environment, the country's recent economic history (see Table 1) and concerns over the global environment and climate.

The City also faces the challenge of turning solar energy technologies that have an increasingly proven track record and history of deployment in other countries, but limited penetration into Ireland to date, into realistic and compelling business cases for solar energy adoption in Dublin and beyond.

Ireland's financial challenge

- Irish economy showing signs of recovery, but growth remains low — households are heavily indebted, and mortgage arrears persist
- Growth in GDP was 0.4% in 2012, rising to 0.6% in 2013 — forecast up to 4.5% in 2014
- Ireland exited the IMF/EU/ECB rescue plan in December 2013 — is again a financially sovereign country
- Public debt expected to peak at 126% of GDP in 2014
- Budget deficit rising to 7.3% of GDP in 2014, but goal is to reduce that to less than 3% by 2015

Table 1: Summary of Ireland's recent economic history

3. Context, findings and roadmap

A. Context and findings

Context

Energy in Dublin and the rest of Ireland

Ireland presently imports 85% to 90% of its energy, mainly in the form of oil and gas — representing approximately €6.5 billion per annum.⁴ The EU, looking to decarbonise the energy system by 2050, is a force behind change in the sector. The Energy Efficiency Directive (2012/27/EU) establishes a common framework to ensure that a 2020 target of 20% energy efficiency is achieved, with hefty associated penalties for failure. Ireland is committed under the terms of the European Renewable Energy Directive (2009/28/EC) to a legally binding target of 16% renewable energy by 2020.

In 2010, Dublin City Council took the initiative to produce a Sustainable Energy Action Plan (SEAP) with a goal of reducing Dublin's carbon footprint, becoming an energy-smart and efficient city. Looking to exceed EU expectations, Dublin City Council has committed to reducing its own energy usage (see Table 2) by 33%. Achieving this will depend on implementing a number of energy-efficiency measures, but the use of renewable resources also is vital. By making such an impressive commitment, Dublin City Council is demonstrating its leadership in energy efficiency and renewable resources, like solar power, for the entire city.

Dublin City Council

- 220 GWh of energy used annually
- Largest single energy user is civic offices, at 8.3 GWh annually
- Building styles and conditions are diverse and include a range of energy requirements

Table 2: Dublin City Council energy use

How solar energy fits with Ireland's renewables

Wind power has been a pillar of Ireland's drive to both reduce net energy imports and improve the contribution of renewable sources, with 16.4% of Ireland's electricity in 2013 coming from wind sources.⁵ Wind, however, is highly variable, with production during 2013 ranging between 3MW and 1,540 MW.⁶ This unpredictability, along with transmission issues, means that alternative renewables are needed to provide balance. Solar energy has excellent potential here — it has a different production profile from wind and can be highly localised, making it suitable for installation within the urban areas where energy is used.

On the surface, solar energy might appear an odd choice for Ireland, considering the country's fluctuating climate and relatively high rainfall. However, the amount of daylight, or the solar irradiance, Dublin receives is approximately the same as that received in Leipzig, Germany, home of one of the world's largest solar electricity plants, Waldpolenz Solar Park.

Solar energy is as realistic an option in Dublin as it is in other parts of Europe on the basis of technology and weather. Table 3 details a few solar energy options.

Solar technologies

Solar photovoltaic (PV)

- Produces electricity from direct sunlight and ambient light
- Cost of panels greatly reduced in recent years
- Mechanically simple option — no moving parts

Solar thermal

- Uses sunlight to heat water for domestic and commercial heating
- May be more suitable than PV depending on use
- Cheaper panels but more complex to install
- Can be combined with PV to create a hybrid system, PVT

Table 3: Solar technologies for Dublin to consider

Other renewable energy options to help the country achieve its environmental goals include biomass, anaerobic digestion and heat pumps. Additionally, non-renewable alternatives, such as combined heat and power (CHP) plants, may be an attractive option due to their increased efficiency in some circumstances. For example, CHP is a good choice where there is sufficient local use of both heat and electricity to justify the installation and maintenance costs of a CHP system, which will provide cheaper combined energy than external providers. Leisure centres with swimming pools often fall into this category. This report does not explicitly cover these alternative options, but it does consider how to handle those edge cases in which another option may be a better fit than solar energy.

Solar electricity in Ireland is different from many countries because Ireland does not currently have a renewable energy feed-in tariff (REFIT).⁷ This has a large impact on business models, especially in a country like Ireland that has seen significant financial challenges in the last decade. A REFIT would allow a producer to sell solar energy back to the national grid at an assured and attractive price. Such an approach would allow for well-defined and low-risk business cases and would permit large-scale developments where selling to the grid would be the main business model.

Findings

Dublin exhibits a number of strengths and advantages that will support the implementation of solar energy solutions. There is drive and enthusiasm within Dublin City Council to make renewables work. Dublin's climate and the availability of technology make solar energy an increasingly appropriate choice. The city possesses immense expertise in solar energy within Dublin City Council, as well as in Dublin's academic institutions and private sector innovators.

Introducing solar energy across the city, however, is not a purely technical challenge. The City must find a way to coordinate its efforts, bringing together the available resources and understanding the best assets and business cases to use. The City also must develop and implement a range of initiatives moving forward to continue building on its solar energy efforts.

Dublin faces a number of specific challenges as a public body in Ireland. Procurement of solar installations must be compliant and fair, and debt on the public balance sheet remains a real economic concern for Ireland. The City must demonstrate a solid business justification for its solar energy initiatives, presenting a clear case on technical and financial grounds.

This is not to say that approving solar energy initiatives is only a business decision. There is internal and external demand for Dublin City Council to demonstrate leadership in the renewables field. While the long-term benefits of achieving a leadership position in these initiatives should not take precedence over the need for a sound financial case, it is not only right but also essential to consider this factor when making decisions. Table 4 summarises some of the motivators and challenges behind the City's solar energy efforts.

Drivers

- Tough EU renewable/efficiency targets and even tougher self-imposed ones
- Need to improve energy security
- Use solar energy to balance renewables mix
- Save money and hedge against rising energy prices
- Desire to show leadership in renewables field

Inhibitors

- Financial concerns
- Funding availability
- Debt on public balance sheet
- Public sector procurement challenges
- Understanding the City's potential solar assets
- Inertia and risk aversion

Table 4: Key factors affecting Dublin's solar energy initiatives

The lack of a REFIT for solar energy in Ireland places some constraints on the business models that Dublin can use in its pursuit of this renewable resource. It is not economic to sell PV-generated electricity back to the grid, so the City should focus on local use of solar energy. Put simply, it makes the most sense to use the electricity generated from solar PV within the building where it is generated. This consideration significantly influences the recommendations of this report.

B. Roadmap

The challenge presented to the Smarter Cities Challenge team is very specific to solar energy generation, and this is clearly the focus of Dublin City Council in its challenge presented to the team. Solar technology has a successful history and track record in other countries, but for various reasons is underrepresented in Ireland. In formulating its challenge, the City has recognised that the combined reduction in solar technology cost and the growing uncertainty in global energy prices make solar technology an increasingly viable prospect.

While the focus of the challenge is on solar energy, this is not the only alternative energy source of interest to the City. For example, wind power is widely used in Ireland, and other technologies, such as CHP and heat pumps, are available options. When considering solar energy as part of the City's collective alternative and renewable energy sources, the team has chosen to frame recommendations around a process of informed and structured decision-making. For instance, individual buildings vary greatly in their nature, use and suitability for solar installation, so a logical, repeatable process is needed to facilitate successful implementation.

The recommendations of the IBM team fall into either of two categories:

- **FOCUSED** — A recommendation intended to achieve a specific targeted objective
- **OVERARCHING** — A recommendation for a general course of action designed to promote adoption of solar energy generation in the city

Some recommendations detail specific physical actions that the Council can take to promote solar energy, such as installing technology on specific buildings. Others are less tangible but are of similar impact, such as making the case for change in public policy to benefit distributed solar energy.

The team's interviews with stakeholders made it clear that the City of Dublin is not lacking in technical or business expertise in the field of solar energy. Dublin City Council, as well as academic partners and government organisations have significant expertise, and several Dublin-based businesses have global solar experience. The team's recommendations aim to harness these strengths and build momentum by establishing mechanisms for assessing and framing business cases for solar energy, removing impediments to progress.

Some key factors that affect the recommendations roadmap are as follows:

Renewable energy feed-in tariff (REFIT) in Ireland

Ireland does not currently have a REFIT for solar energy. The result is that, unlike other countries, there is not a strong business case in Ireland for generating electricity from solar PV and selling this back to the grid because the financial return is not favourable. This impacts the type of business case that the City can make for solar PV in Ireland. Rather than installing PV with the intention of selling the electricity using a REFIT, the most-effective business cases for solar PV will be based on local use, where all electricity produced is used by the building from which it is generated.

The team's recommendations take this reality into account in two ways. First, targeted recommendations for solar PV installations are assessed based on a strictly local consumption model. Second, a recommendation is made for Dublin City Council to attempt to influence future government policy to offer a REFIT for solar energy. This REFIT could, in the long term, enable business models for further solar initiatives that use a wider range of the City's assets.

Decision-making process leading to solar energy

The team made a conscious effort to remember this important fact: the primary goal of the City is not simply to generate more energy from renewable sources but to reduce its carbon footprint. This is an important distinction because simply adding solar PV to a given building may not be the best course of action. The City should first look towards opportunities for gains in energy efficiency, trying to use less energy overall. Then, it can look to renewable options, specifically solar, where further efficiency gains are not possible.

The initial decision-making process when implementing renewable energy should address the following broad questions:

1. Can energy efficiencies be made?
2. Is addition of a renewable source appropriate in this case?
3. Which is the most suitable renewable source for this case?

At a finer level, the decision-making process needs to take into account specific features of the building. For example, historic buildings might not be suitable for mounting solar panels, or an energy-inefficient building may be most profitably improved by introducing energy-efficiency measures first. In other cases, local electricity consumption may not be enough to sustain solar PV without a REFIT. It's also important to consider cases in which solar thermal is more appropriate than solar PV. These factors are accounted for in the specific recommendations where appropriate.

Another important factor to consider when looking for opportunities to implement solar technology is routine building refurbishment programmes. Where there is already a need to refurbish a building roof, for example, the incremental cost of adding solar technology is greatly reduced. A successful solar programme should be integrated with the ongoing building maintenance plan.

Financial and procurement considerations

A major consideration for Dublin City Council as a public body is its ability to take on debt. Ireland's recent financial crisis makes this a particularly sensitive issue as the level of public sector debt is still under some scrutiny by international markets and organisations. Similarly, budgets across the public sector are constrained.

Grants are available to support renewable installations that include solar technology, such as those from the Sustainable Energy Authority of Ireland (SEAI), but these are not likely to cover the full cost. There is significant opportunity to leverage private financial contributions via power purchase agreements (PPA) and other investment options, such as community funding.

It is essential that Dublin City Council present business cases that are well formed and indicate a clear return on investment (ROI). The projected financial investment should be factored in, as well as the impact of any debts on the City's balance sheet. While EU procurement rules can be viewed in many quarters as an impediment to the purchasing process, if used well they can actually drive an efficient and cost-effective solar purchase.

One approach that has worked well in County Tipperary is to call for tenders based on a target cost of energy per watt generated. So, rather than tender for a certain square meterage of solar panels with a given capacity, suppliers could be asked to tender based on an expected cost in Euro per kWh of electricity produced. The tender evaluation would then apply expert advice to assess the technical solution offered. This helps the decision-making process because it allows for a more transparent assessment of long-term costs and capital expenditures.

When considering the ROI of solar energy generation, the City also must be mindful of the potential opportunity cost related to its choices. As the City has limited funds for investment, it should consider how different forms of sustainable energy, other than solar, might benefit a particular building or how certain buildings are best suited for sustainable energy.

A critical success factor for the project is active engagement and leadership from the top level of Dublin City Council. While the technical and business case for solar energy in Dublin is strong, a certain amount of drive will be necessary to overcome the perceived risk of investment at the start of the process. The Dublin City Council needs to establish a strong project management team tasked to drive progress for each of the recommendations, summarised in Figure 2.

The team's recommendations are detailed below, with timing for each of the recommendations captured in Figure 3.

Focused

1. Install solar PV on prime municipal buildings

Dublin City Council has some buildings that are prime locations for solar PV systems. These sites have good roof space and a local electricity consumption level that is high enough to ensure cost effectiveness even without a REFIT. These buildings should be considered flagship solar projects.

2. Move forward with solar installation on other municipal assets

Dublin City Council owns many other buildings that are also good potential candidates for solar energy installation. Dublin City Council should develop its decision-making process for distributed solar energy based on building type and energy load to develop a list of suitable second-wave candidates for solar energy production. It should also create a refined method for selecting future candidates.

3. Push for a solar REFIT

In the longer term, more of Dublin's assets can effectively implement solar energy technology if a REFIT tariff is in place for solar PV. Dublin City Council should use its influence in national consultations to make the case for a solar REFIT.

4. Incorporate smarter buildings and micro-generation into the Dublin City Development Plan

The City Development Plan drives the direction of development across the city, affecting both public and private projects. There is an opportunity with the next iteration of the plan to solidify the position of renewable energy resources and encourage the adoption of smarter building technologies. This will have a long-term impact on the City and its ongoing energy approach.

Overarching

5. Develop leadership in solar funding

Dublin is well placed to explore innovative financial arrangements to further drive solar penetration in both the public and private sectors. By working with local entrepreneurs and start-ups, the City can foster new ways of providing funding for the capital cost of solar energy, such as partial or full funding through an ESCO or crowdfunding.

6. Build community awareness and engagement

Support and engagement from the community is vital for solar energy projects to thrive in Dublin. While most people have generally positive sentiments towards solar energy, many do not fully understand how it will benefit the city or why it is worth the investment. Dublin City Council should work with the community on solar power initiatives, building awareness and engagement that moves more residents to action.



Figure 2: Summary of recommendations

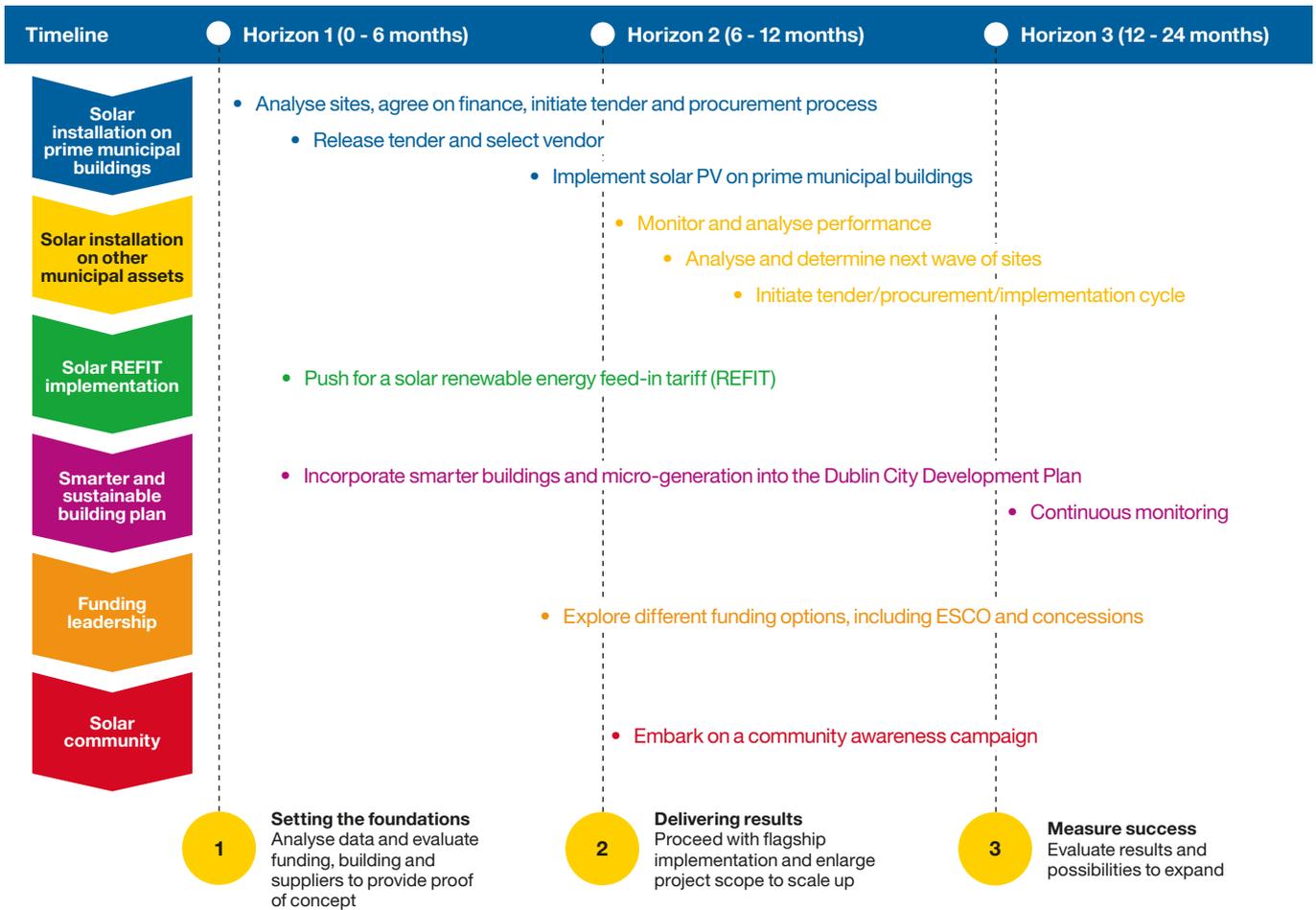


Figure 3: Recommendation timeline

4. Recommendations

Recommendation 1: Install solar PV on prime municipal buildings

Dublin City Council should complete solar photovoltaic (PV) installations on key municipally owned buildings, including civic offices, libraries and fire stations.

Scope and expected outcomes

Scope

Dublin City Council has more than 430 municipally owned buildings, some of which have high electric base loads along with large roof areas that represent a valuable asset base. Moreover, the council itself manages and operates some of these buildings, including the civic offices.

Dublin City Council should undertake a systematic process to evaluate these buildings for roof-mounted solar installations that could offset some of the building's base load. The price of PV systems has fallen over the years. Consequently, the cost of producing solar power in €/kWh over the lifetime of the PV system may become comparable to or lower than the utility price of electricity paid by Dublin City Council.

Expected outcomes

- Complete pioneer installations of solar PV on prime municipal buildings that best fit the solar use case
- Better understand the practice of solar implementation, leading to refined techniques for analysing buildings for energy use and suitability for solar power, as well as improved processes for tendering and procurement
- Achieve long-term cost savings, a reduced carbon footprint and positive community perceptions
- Technically and financially assess the prospect of roof-mounted solar for select municipal buildings, based on criteria, such as electric base load, useable roof area and estimated annual solar power production
- Accurately estimate the capital costs of installation, price/kWh of producing solar power over the estimated lifetime of PV system and potential savings in comparison to current and estimated future electricity prices

Cost of inaction

- Dublin City Council will miss a prime opportunity to take a leadership role in urban sustainability.
- The inefficient use of valuable assets, such as roof areas, will result in unnecessarily high energy bills.
- Dublin City Council may ultimately fail to meet EU targets, potentially leading to penalties.

Proposed owner and stakeholders

Owners:

- Dublin City Council
- City of Dublin Energy Management Agency (Codema)

Stakeholders:

- Codema to build a case study for each building, beginning with the main civic offices building, by considering the base loads, roof space and cost of PV systems; Dublin City Council to provide building parameter data
- Dublin City Council

Suggested resources needed

- Codema
- Dublin City Council
- Independent consultants (if necessary)

Cost estimate: Medium. This will depend on the size of PV system, the price of panels and installation

Recommendation 1: Install solar PV on prime municipal buildings (continued)

Dependencies	Key milestones, activities and timeframe
<p>Different financial models must be considered to generate capital for the installations (see Recommendation 5).</p>	<p>Analysis, planning, procurement and installation on some of the key municipal office buildings could be completed within about 6 - 8 months, requiring the following activities:</p> <ul style="list-style-type: none"> • Select suitable municipal buildings and determine their base loads • Determine building parameters, such as useable roof area suitable for solar PV systems (considering orientation and tilt) • Estimate the solar power generation possible with each building, along with total capital costs for the PV system (panels plus balance of systems) • Determine the cost/kWh of solar generation • Evaluate existing sources of power for the building • Based on estimated savings and finance models, determine a candidate list of buildings for solar installations • Evaluate finance models and initiate procurement and tendering process • Monitor the installed PV systems for performance
Priority status	
High	

Case study: Main Civic Offices (MCO)

In support of the above recommendation and to illustrate some of the steps in analysing a building for rooftop solar, this case study evaluates one of the municipal buildings for rooftop solar and estimates the capital costs, savings and price per kWh of generated solar power.

Dublin City Council owns a wide variety of buildings in Dublin, including municipal offices, fire brigade stations, libraries, leisure centres, depots and several other types of buildings. These buildings vary by age, utility, roof structure and energy consumption.

The key factors that need to be considered in evaluating a building for roof-mounted solar include the following:

- Roof type and shading
- Consumption, base load and electricity price
- Existing sources of energy supply and energy consumption in the building

Buildings with large electric base loads are generally suitable for solar PVs so that all the electricity generated could be utilised within the building and no electricity is leaked back into the distribution network (Ireland has yet to implement a feed-in tariff for solar). A building with a flat roof or tilted south-facing roof is generally ideal for solar installation in order to obtain maximum yield.

A building that already has a CHP system (such as a few of the leisure centres), for instance one that is running on gas, might not be ideal for PV installation if the cost of solar power generated exceeds the cost of the electricity it displaces. Similarly, certain buildings may be suitable for solar thermal instead of solar PV, for example, if heating water for space heating and showers is the major source of energy consumption within the building. In the case of old heritage buildings, for example, only internal valleys may be useable for solar panels in order to safeguard the aesthetics of the building.

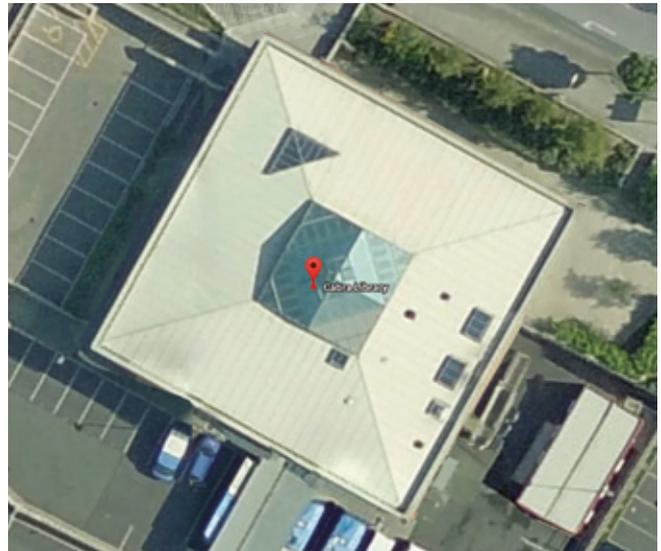


Figure 4: Sample roof structures of municipal buildings. Left: Main Civic Offices on Wood Quay; Right: Cabra Library on Navan Road (Source: Google Maps)

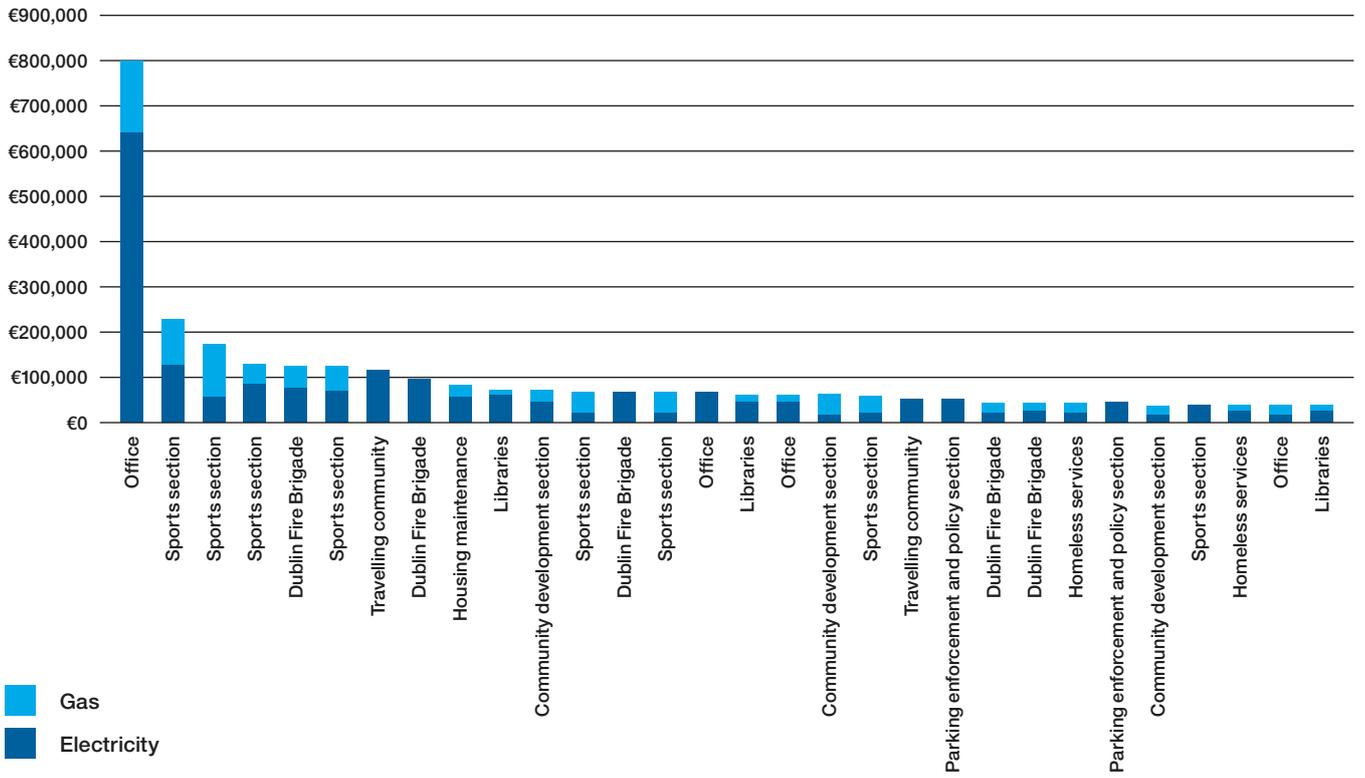


Figure 5: Top 30 Dublin City Council buildings ranked by annual energy bills and listed by building category (Source: Codema)

Among all Dublin City Council assets, the Main Civic Offices (MCO) building consumes the most energy and has the highest electricity bill (4.8GWh of electricity per annum) (see Figure 5). MCO has a large electric base load (Blocks 3 and 4 alone consume upwards of 100 kWh) and a large roof area (totalling approximately 1,100 m² of useable south-facing space), and it is fully operated by the Dublin City Council. It currently costs Dublin City Council approximately 13 cents and 15 cents per kWh of electricity consumed during summer and winter days, respectively.

Table 5 summarises the costs and savings from a 150 kWp rooftop PV system, assuming an annual yield of 900 kWh per kWp.^{8,9} In each scenario, the price per kWh of electricity generated from solar is lower compared to the price of electricity charged today by the ESCO. Based on historical trends over the last few years, electricity prices in Ireland are expected to rise in the future. Therefore, it is likely that the savings will be even greater than those estimated in this table.

In other buildings with lower consumption, the price per kWh of electricity paid by Dublin City Council is higher. The far-right-hand column in Table 5 with 15 cents/kWh is indicative of this use case (SEAI estimates seven different slabs of electricity prices based on annual consumption, which vary from 10 cents to 21 cents for commercial buildings in Ireland).¹⁰ As the size of the installed PV system increases, the costs are expected to be lower. Similarly, some of the buildings may be good candidates for integrated solar because those costs may be lower as well.

In summary, installation of rooftop solar is not only economical but also profitable over a longer time scale. Moreover, other local councils in Ireland, such as Limerick and Tipperary, also have used the roofs of civic office buildings for solar installations. Tipperary has installed 800 panels covering nine public buildings, including civic offices, libraries and fire stations. Additionally, the Commissioners of Irish Lights headquarters has a 6.9 kWp PV system, and Limerick Library Headquarters installed a 10.7 kWp PV system.

PV price (€) per kWp	Price (€) of 150 kWp PV system	Electricity price (€) per kWh over lifetime of PV system		Payback period (years) with current electricity prices		ROI (%) in 20 years	
		20 years	25 years	13 ¢	15 ¢	13 ¢	15 ¢
1,500	225,000	8.3	6.7	12.8	11.1	56	80
1,700	255,000	9.4	7.6	14.5	12.6	38	59
1,900	285,000	10.6	8.4	16.2	14.1	23	42

Table 5: Cost/benefit analysis of rooftop solar for different costs and lifetimes of PV installations (based on unsubsidised costs)

Recommendation 2: Move forward with solar installation on other municipal assets

Dublin City Council should extend solar power generation to include social housing complexes and other municipally owned buildings, as well as parks, open spaces and reservoirs. This should begin immediately following the successful implementation of Recommendation 1, which calls for solar PV installations on municipally owned offices, fire stations and libraries.

Scope and expected outcomes

Scope

The scope of this recommendation includes current and upcoming social housing complexes, parks and open land spaces.

Social housing complexes

Dublin City Council has more than 25,000 housing units spread over multiple complexes. A plan is in the works to redevelop some of the existing complexes, as well to construct new housing units to fulfil high demand among Dublin residents.

Although tenants cover electricity consumption costs within each housing unit, Dublin City Council pays the electricity costs for common areas within each complex. Here is a ranking of the common areas that consume the most electricity:

1. Children's play areas
2. Sports facilities
3. Common lighting in parking areas
4. Balcony lighting
5. Video surveillance equipment

These housing complexes possess large roof areas that can be used to generate solar energy (see Figure 6). Such areas could be easily retrofitted with solar panels to effectively generate power for the common areas, helping to reduce the Dublin City Council electricity bill for social housing complexes.

In order to lobby resident support and co-operation, Dublin City Council should develop community awareness campaigns around the sustainability benefits of solar power. Dublin City Council also might consider providing some kind of incentive or subsidy to the tenants to improve acceptance and participation levels.

For newly constructed units, Dublin City Council should consider providing solar-powered water heating for residents, in addition to powering the common areas previously mentioned. This will help tenants further reduce their electricity or gas expenses, allowing them to recover their subsidised charge more quickly for this facility upgrade.

Parks, gardens, open spaces and reservoirs

Dublin City Council operates more than 250 parks and gardens across Dublin. Most of the parks are used for various sports activities, and some parks are located nearby leisure centres and other public buildings. We recommend that Dublin City Council conduct a detailed feasibility assessment of solar installations in these parks. At first glance, it appears that certain park areas could be used to create small solar farms without compromising park amenities. Such farms would power the buildings, shelters and leisure centres located in or adjacent to the park.

Once a feed-in tariff for solar power is established in Ireland, more open spaces and reservoirs could be used to build larger solar farms and feed the energy into the grid. This measure would generate revenue for Dublin City Council, while also helping it meet its sustainability goals.

Expected outcomes

Implementation of this recommendation would help in the following ways:

- Leverage the vast roof spaces available on social housing for solar PV installations, with generated energy used to power common-area lighting, sports areas, children's play areas and video surveillance equipment
- Use solar energy for water heating purposes in senior citizen housing complexes
- Set aside select spaces in parks for small solar farms to power nearby leisure centres and sports complex buildings
- If a feed-in tariff for solar power is enacted in Ireland, install larger solar farms in open spaces around Dublin to generate significantly more energy than generated in rooftop spaces
- Energy generated will be used by Dublin City Council both for its own consumption and to be fed back into the grid for additional revenue

Recommendation 2: Move forward with solar installation on other municipal assets (continued)

Scope and expected outcomes

Cost of inaction

- Continued exposure to increasing energy expenses over the long term
- Elevated concerns over energy security and heavy dependence on fossil fuels
- Difficulty in meeting overall carbon-reduction goals
- A lost opportunity to establish Dublin City Council as leader in smarter sustainability initiatives in Ireland and the EU

Proposed owner and stakeholders

Owner: Dublin City Council

Stakeholders:

- Codema
- Dublin City Council

Suggested resources needed

- Codema engineers or technical consultants to assess solar power generation potential
- Capital funding based on business case for each housing complex and park/open space
- Project management and implementation resources to execute the work and monitor the usage and effectiveness of the solar installations

Cost estimate: High

Dependencies

The successful execution of Recommendation 1 (Install solar PV on prime municipal buildings)

Key milestones, activities and timeframe

- Evaluate housing complexes well suited for solar PV installations on rooftops (6 - 12 months after the start date of Recommendation 1)
- After feed-in tariffs are in place, evaluate potential solar farm sites in parks and open spaces (12 - 24 months after Recommendation 1 implementation begins)
- Key activities include the following:
 - Assessment
 - Technical design
 - RFP release
 - Tendering*
 - Contract finalisation
 - System delivery
 - Installation

* For faster execution and economies of scale, certain housing complexes and buildings could be combined to create project packages, each with a single tender.

Priority

High



Figure 6: Dublin public housing complexes with rooftops suitable for solar PV installations (Source: Google Maps)

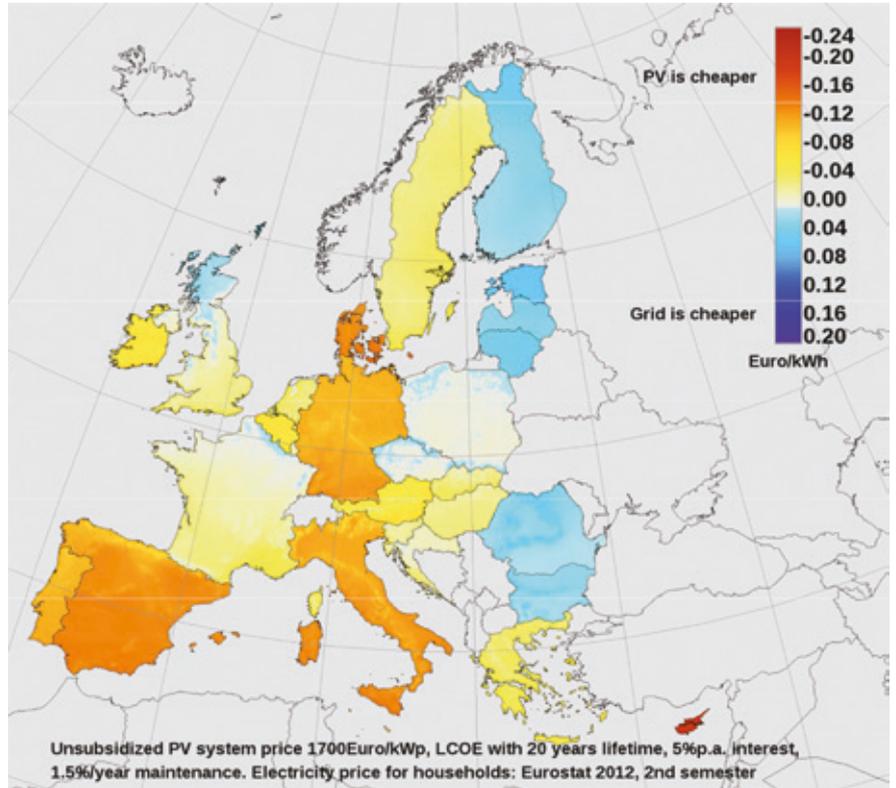


Figure 7: Europe photovoltaic electricity cost map comparing solar energy costs to the costs of electricity from the grid¹¹



Figure 8: Dublin City parks, gardens and reservoirs (Source: Irish Times, Built Dublin)

Recommendation 3: Push for a solar renewable energy feed-in tariff (REFIT)

At the next stage of consultations over the Green Paper on Energy Policy in Ireland, Dublin City Council should advance the proposal for implementing competitive solar tariffs.

Scope and expected outcomes

Scope

Although solar makes good sense when implemented as a standalone solution, the potential to expand and ensure that there is a significant contribution at a larger scale requires an incentive scheme to support distributed solar micro-generation.

Dublin City Council, along with Codema, Greenway, Tipperary Energy Agency and other partners, should strongly endorse a proposal to the Department of Communications, Energy and Natural Resources (DCENR) for implementing a REFIT scheme for distributed solar micro-generation.

The existing grid infrastructure could support a certain amount of distributed solar micro-generation. If solar energy is considered in the future for deployment at a utility scale, it is imperative that the grid infrastructure be reinforced and upgraded with the necessary capacity to support such production. EirGrid launched a strategy in 2008 to implement these upgrades by 2025.

Expected outcomes

- Set the foundation for accelerated investment in solar as a renewable energy source, as it will allow a more reasonable return on investment by granting economic incentives for renewable electricity exported to the grid
- Allow homeowners, businesses and the public sector to become energy self-sufficient while working towards achieving 2020 energy-efficiency targets.

Cost of inaction

- Limited grounds for distributed solar implementation, resulting in no capacity or incentives for sites generating solar energy to export energy back to the local grid
- A shortfall in solar energy’s contribution to achieving the target of 16% renewable energy in Ireland by 2020, established by the European Renewable Energy Directive (2009/28/EC)
- Increased reliance on wind and biomass energy generation

Proposed owner and stakeholders	Suggested resources needed
<p>Owner: Dublin City Council, in association with Greenway and Codema</p> <p>Stakeholders:</p> <ul style="list-style-type: none"> • DCENR — to include recommendations in the white paper on energy policy • Commission for Energy Regulation • (CER) — to create the grid conditions necessary for solar PV REFIT • Energy suppliers — to ensure smart meters are available to the community for measurement • Sustainable Energy Authority of Ireland (SEAI) — to communicate with communities once a solar REFIT is available 	<ul style="list-style-type: none"> • DCENR to assess current energy prices and REFIT for the various renewable sources in order to determine a solar PV tariff that is appealing and competitive • Dublin City Council and possibly other councils to push forward the proposal to the DCENR <p>Cost estimate: Low. REFIT will have a budget impact for central government and may affect consumer energy bills, but there is no direct cost to Dublin City Council.</p>

Recommendation 3: Push for a solar renewable energy feed-in tariff (REFIT) (continued)

Dependencies	Key milestones, activities and timeframe
<ul style="list-style-type: none"> National grid infrastructure that sufficiently supports micro-generation Installation of smart meters that allow more-precise measuring for energy import, export and consumption 	<ul style="list-style-type: none"> Consult with EirGrid prior to submitting proposal to DCENR for a solar REFIT to ensure grid infrastructure can support micro-generation imports from solar Dublin City Council partnership with Codema and other councils and entities, using their involvement with the Green Paper on Energy Policy in Ireland and consultation process to push forward the proposal for a solar REFIT to the DCENR Upon solar REFIT approval, DCENR amends the existing REFIT scheme or publishes a new one Communication strategy launched and supported by Dublin City Council, Codema and SEAI
Priority	
Medium	

In 2014, the Irish government published a Green Paper on Energy Policy in Ireland¹² with a subsequent white paper expected to arrive in 2015 following consultations. This may include measures for a REFIT for solar, depending on representations received and other inputs.

In the context of Dublin City Council, a REFIT for solar would enable business models that today are less attractive due to the lower price available for selling electricity to the grid without a REFIT. Specifically, these are models for which some or all of the electricity generated by a site’s PV installation is sold to the grid rather than used locally. Models include the following:

- Installation on rooftops of social housing complexes where individual tenants buy their own electricity, making communal supply difficult
- Installation on buildings with low power needs but relatively high amounts of roof space
- Floating PV arrays in reservoirs or fixed arrays in parks and fields
- Renting or licensing use of roof space to a third party that will pay rent, install its own PV equipment and sell power generated to the grid (as opposed to the building owner)

In the wider community, a solar REFIT would make the use of solar PV much more attractive and sustainable for individual households. Such households often are not able to use all the generated electricity during the day because household energy usage typically is highest in the evening and morning. Therefore, a viable means of selling electricity to the grid is required to make solar PV attractive to households. A REFIT addresses this issue while also providing confidence to the consumer that this programme will be in place for a long term.

Although the REFIT tariff is out of Dublin City Council control, Dublin City Council is in a strong position to influence government thinking on the subject and should use this influence effectively. The Smarter Cities Challenge team recommends that Dublin City Council direct its efforts towards encouraging REFIT tariffs that favour distributed, small-scale solar electricity generation rather than large solar farms, as this best suits the City and its residents.

With the consultation period for the green paper behind, DCENR is now moving on to conducting workshops over the next two months with some of those who responded to the consultation. Dublin City Council is one of the organisations that will be represented in the workshops, so they have a strong chance to directly affect white paper content. All parties involved must do everything possible to support them in this effort.

Recommendation 4: Incorporate smarter buildings and micro-generation into the Dublin City Development Plan

Dublin City Council is about to begin consultations on the next iteration of the Dublin City Development Plan for 2016 - 2022. The Plan is a prime opportunity for Dublin City Council to showcase its aims and provide clear leadership and direction for sustainable energy technology. It should be used as a springboard for enhancing Dublin's standing as a smart city.

Scope and expected outcomes

Scope

The current iteration of the Dublin City Development Plan runs from 2011 to 2017.¹³ Dublin City Council is already working on the next plan for 2016 - 2022.¹⁴ Public consultations began November 10, 2014, with the publication of the Dublin City Council Strategic Issues Paper.

As it stands, the current City Development Plan includes progressive aims for energy efficiency and renewables. Dublin City Council should seek to build on this momentum by making smarter buildings and renewable micro-generation part of the conversation.

Expected outcomes

- Adoption of solar PV and renewable micro-generation citywide, beyond Dublin City Council buildings alone
- Development of planning and building controls that leverage existing processes to further advance the cause of sustainability
- Solar energy made viable through smarter building technology for cases that would otherwise be marginal

Cost of inaction

- Loss of leadership position for Dublin City Council in areas of smarter technologies and distributed energy
- Missed opportunity to drive sustainability across the greater Dublin community

Proposed owner and stakeholders	Suggested resources needed
<p>Owners: Dublin City Council</p> <p>Stakeholders:</p> <ul style="list-style-type: none"> • Dublin City Council • Residents and businesses wishing to carry out development work in Dublin • An Taisce (The National Trust for Ireland) • Dublin City business associations • Other City Development Plan consultees • Dublin electorate 	<ul style="list-style-type: none"> • Dublin City Council • Codema • Smarter buildings and micro-generation technology/academic partners <p>Cost estimate: Low. The City is already committed to renewing the City Development Plan, and Dublin has a wealth of public and private sector expertise, which could provide input at little or no cost to the City.</p>

Recommendation 4: Incorporate smarter buildings and micro-generation into the Dublin City Development Plan (continued)

Dependencies	Key milestones, activities and timeframe
Existing City Development Plan processes	<p>Milestones are already defined for the 2016 - 2022 City Development Plan:</p> <ul style="list-style-type: none"> • Consultation and submission period*: November 2014 - January 2015 • Public display of first City Development Plan draft and consultation and submission period: October 2015 - December 2015 • Public display of second City Development Plan draft reflecting Councillors' revisions: Expected June 2016 - July 2016 • Plan goes into effect: Expected October 2016 <p>* The consultation process is a vital stage for identifying and resolving risks. One key risk for Dublin City Council involves the City Development Plan including a proposal that either cannot be implemented practically or would have negative side effects, such as significantly increasing development costs.</p>
Priority	
Medium	

The Dublin City Development Plan provides vision and an overall strategy for the proper planning and sustainable development of the city, covering a six-year period. The Council uses the City Development Plan to set out guiding policies and objectives for the development of the city in terms of physical growth and renewal, economic, social and cultural activity and environmental protection and enhancement. As such, it is a fitting platform for the Council not only to declare its leadership position on renewables and smarter buildings but also to drive future city development in this direction.

Smarter buildings would use technology to both reduce overall energy consumption and make best use of available micro-generation. For example, smart sensor-controlled lighting would reduce consumption, while the building as a whole takes full advantage of solar energy when it is available. This could include using peak solar energy production to charge electric vehicles or prime storage heating.

While the City Development Plan does not supersede Ireland's building regulations that are determined at the national level, it does provide the scope the Council needs to lead. Leadership can be demonstrated by providing a clear sense of direction, as well as by introducing tangible drivers for technology implementation through incentives for new developments or refurbishments that implement solar and/or smarter building technologies.

Recommendation 5: Develop leadership in solar funding

Dublin City Council should seize the potential of solar PV installations on social housing complexes, other municipally owned buildings and parks and open spaces by assigning a budget item that will make implementation feasible for the civic office.

Scope and expected outcomes

Scope

Feasible and affordable funding arrangements are essential to successful solar energy installations. This recommendation proposes the following combination of financial sources for Dublin City Council to get solar PV installed in its buildings:

1. Contribute funds directly
2. Apply for a loan or grant
3. Work with an ESCO to pay a fixed fee plus the REFIT price for solar energy
4. Receive full ESCO support by leasing rooftop space at a REFIT price lower than what Dublin City Council pays for energy from the utility provider
5. Innovative crowdfunding solutions to engage the local community

Expected outcomes

- Building utility expenses reduced by up to 15%
- Clarification of the steps required by stakeholders, third parties and City council procurement for future deployments
- Movement towards the 2020 renewable-energy target and PSO schemes to support renewable and indigenous generation and security of energy supply
- General solar energy buy-in and related funding from the greater Dublin community

Cost of inaction

- Dublin City Council will fall short in its commitment to drive change for renewables in municipal buildings.
- Dublin City Council will miss an opportunity to establish itself as a leader in smarter sustainability initiatives in Ireland and the EU.

Proposed owner and stakeholders	Suggested resources needed
<p>Owner: Dublin City Council</p> <p>Stakeholders: Dublin City Council</p>	<ul style="list-style-type: none"> • Technical consultant or Codema engineers to assess solar power generation potential • Project management and implementation resources to monitor and execute the work • Procurement team for purchasing PV systems and service
Dependencies	Key milestones, activities and timeframe
<p>Effective Dublin City Council rollout of its plan for renewable energy from PV installations</p>	<ul style="list-style-type: none"> • Approval in principle of the technical and financial scale of the project • Financing approaches chosen for the installations • Finalise appropriate size and scale with building managers, caretakers and planners • Procure upgrades based upon grant success and approval
Priority	
High	

Finance is a key component of any solar project, as capital requirements are relatively high and payback is over a period of multiple years. For larger projects in particular, it is important to have an effective funding strategy in place.

The team's interviews with key stakeholders revealed a widespread willingness among third-party contractors to invest in solar PV power generation. Dublin City Council has the capability and commitment to move forward with renewable energy, including having the available building assets to make it happen. However, some challenges need to be addressed. Although PV solar energy today requires a significant up-front investment that can be a barrier to entry, low prevailing costs typically produce reasonable payback periods. Each project implementation will require its own financial analysis based to the unique characteristics of the building being retrofitted.

Possible funding sources including the following:

Direct financing from Dublin City Council's own budget

Dublin City Council will require making a budget item for the first solar PV installation. This deployment will be fully owned by Dublin City Council, with cost savings achieved through reduced electricity bills. With each new installation, Dublin City Council will already have a budget item in place, with the cumulative cost savings from the other installations to help offset costs going forward.

Asset-based lending

A loan to Dublin City Council could result in no net cost of a solar PV system during the seven- to 10-year repayment period, followed by significant savings after the loan is paid in full. This reasonably assumes receiving a loan at a 5% interest rate, with energy cost savings that are roughly equivalent to monthly loan payments.

ESCO financing

Solar PV systems could be purchased through an ESCO-type financial arrangement. With such arrangements, the ESCO typically installs, owns and operates the system, and it sells energy at a tendered price below the cost of electricity from the grid as Dublin City Council makes loan payments. This ensures that there is no cost to the local authority, with the ESCO having access to a small portion of the energy at a fixed cost for a certain period of time, depending on the cost of the solar PV installation. Subject to summary approval, the arrangement could include a buyout option for Dublin City Council at a certain point in the payment period.

Full ESCO ownership

With this approach, Dublin City Council gives ESCO full ownership of the solar PV installation, tendering the project to receive fixed-price electricity for up to 25 years (typically the minimum guaranteed life of the solar PV panels), at a cost that is lower than the cost of electricity from the grid. This is an extremely low-risk way for Dublin City Council to power a public service building with renewable energy. It stays off the Dublin City Council balance sheet, but it also provides Dublin City Council with very limited financial returns.

Crowd and community funding

The term "crowdfunding" refers to raising funds through the collection of small contributions from the general public (the "crowd") using the Internet and social media. There are three models for raising funds through crowdfunding:

1. Donation model

With this model, individuals make a financial contribution to a project with no expectation of a financial return.

2. Lending model

This mirrors the typical lending scenario in which individuals lend money to a project with the expectation that it will be repaid. The lending model can take the following forms:

- **Traditional loan:** Standard terms are used, and there is an expectation for a monetary reimbursement in the form of interest. In this case, the loans may or may not be guaranteed, depending on the crowdfunding platform being used.
- **Forgivable loan:** Contributions are reimbursed to the lender only if and when the project begins to generate revenue or if and when the project begins to make a profit.
- **Pre-sale loan:** A finished product is promised in return for the contributor's pledge. Contribution amounts are determined according to an assessment of the fair market value of the product. Larger contribution amounts are typically accompanied by a promise of more "copies" of the product equivalent to the value of the amount of the contribution. Pre-sales are often combined with a rewards-based donation model, which enables people to pre-purchase special products or experiences with their donation. With this model, those who make donations are not investors or shareholders — they simply remain product owners and supporters.

3. Investment model

This model resembles a standard equity investment in which an individual receives equity in an entity in return for helping to finance it. Investment model crowdfunding includes these subcategories:

- **Securities investment model:** Investors buy shares in the company, giving contributors ownership in the parent company or rights in a project.
- **Profit- or revenue-sharing model:** A share of the revenue or profits of the project is paid out to investors, as opposed to additional shares in the underlying company. This is also known as a "collective investment scheme".

The local authority that purchases the system outright would have the highest net present value (NPV) and internal rate of return (IRR) that would result in the lowest overall cost. However, all the other options presented are financially and environmentally more favourable to doing nothing.

Recommendation 6: Build community awareness and engagement

Dublin City Council should create and launch a proactive awareness campaign touting the benefits of solar energy as part of a larger environmental sustainability discussion.

Scope and expected outcomes

Scope

We recommend that Dublin City Council organise a marketing and communications plan that targets the community and clearly outlines its solar initiative. Dublin City Council must take a visible leadership position and engage proactive dialogue with the community on this project. There are many economic, environmental and technological benefits that will resonate with Dublin area residents.

Given that Codema’s current mission includes energy-awareness campaigns in Dublin, this is a great opportunity for Dublin City Council to team with Codema and place a greater emphasis on solar power. Although the Dublin City Council initiative begins with a focus on government-occupied and municipally owned buildings, the long-term hope of the project is to encourage the use of solar PV on more public and private properties across Dublin.

For example, businesses in the Temple Bar area are eager to learn about this initiative. Many have expressed interest in considering solar power for their office buildings after Dublin City Council demonstrates success on a smaller set of government buildings.

Based on our interviews with stakeholders in the community, here are the key questions the campaign should clarify:

- What are the benefits of solar vs. other energy types?
- How does solar work?
- Why do we need to pursue solar when we already have energy production from wind and other sources?
- When and where will this technology be implemented?
- What does this technology cost the community, financial or otherwise?
- Are there any safety issues related to having solar panels installed nearby?

Expected outcomes

- Residents who are more educated on energy issues facing Dublin
- Residents who are more willing to play a role in energy solutions
- New funding sources and project experts
- Improved overall community perceptions of Dublin City Council

Cost of inaction

- Community pushback on the decision to invest in solar energy
- Untapped financial resources and expertise

Proposed owner and stakeholders	Suggested resources needed
<p>Owner: Dublin City Council</p> <p>Stakeholders:</p> <ul style="list-style-type: none"> • Codema • SEAI 	<ul style="list-style-type: none"> • Internal Dublin City Council team to initiate communications across traditional and social media and to pull the solar energy topic into the larger Dublin Smarter Cities initiative • Personnel at Codema and SEAI to expand their energy initiative communications to also cover solar • Active groups of young adults willing to play a role in expanding topic awareness
Dependencies	Key milestones, activities and timeframe
<p>Depth of communication plan depends on investment decision regarding how many properties will be included in the solar PV initiative.</p>	<ul style="list-style-type: none"> • Build a core set of materials and messages to share with the community • Determine the best vehicles for reaching the target audience
Priority	
<p>Medium</p>	

5. Conclusion

Distributed solar PV electricity is definitely an attractive and viable option for Dublin. The city offers sufficient solar irradiance, ample suitable space, several attractive financing options and the resident expertise necessary for deployment.

Dublin City Council is recognised as a leader for developing innovative solutions to resolve its civic challenges. The recommendations in this report are designed to equip Dublin City Council with a clear vision and fresh thinking for moving forward with distributed PV solar energy in municipal buildings. Based on the compelling findings of this investigation, the IBM Smarter Cities Challenge team believes it has found a winning course of action for Dublin City Council to show its commitment to achieving new energy-efficiency targets while also leading by example through its own sustainability initiatives.

Highlights

- Dublin is ready to move forward with solar PV energy
- Dublin City Council should push for local and national incentives that enable accelerated investment in solar, such as feed-in tariffs and building development guidelines
- Solar PV energy is a viable power strategy due to its scalability, its easy deployment and the abundant availability of solar radiation
- Dublin City Council should proactively engage the community through education and communication campaigns that promote solar energy and energise Dublin residents to get involved in sustainability efforts

6. Appendices

A. Additional context and background information

Energy usage in Ireland

Ireland currently imports 85% to 90% of its energy, mainly in the form of oil and gas — an annual expense totaling approximately €6.5 billion.⁴ Reducing this dependency will have a significant impact on both national energy security and the balance of trade.

The use of indigenous, inexhaustible and mostly import-independent resources would reduce Ireland's exposure to international fossil fuel price variations and supply disruptions.

According to SEAI statistics, energy from renewable sources in Ireland in 2012 accounted for 7.1% of the total energy mix. The main sources of renewable energy today are wind energy (46%) and biomass (43%). The existing energy policy considers renewable energy feed-in tariff (REFIT) schemes for wind and biomass, but not solar.

Wind power has been central to Ireland's drive to both reduce net energy imports and improve the contribution of renewable sources. Currently 216 wind farms across Ireland have an installed capacity of more than 2,800 MW. In 2013, 16.4% of Ireland's electricity came from wind sources.⁵

Wind is a highly variable power source. Although production in 2013 averaged 486 MW, this production level fluctuated during the year between 3 MW and 1,540 MW.⁶ In addition to this inherent variability of wind power, another issue is that the majority of wind production occurs on Ireland's west coast where the wind is stronger. This presents a transmission challenge. EirGrid, Ireland's electricity grid operator, is currently consulting on the Grid West project that will connect wind energy from the west to consumers in the east of Ireland. This project has proven controversial, however, with severe public reaction against the proposed installation of more transmission pylons.

Alternative renewable energy sources are needed to balance the variability of wind power, while offering a more distributed energy generation that is locally produced and consumed, reducing the need for long-distance grid capacity. Solar energy has excellent potential as a balancing source of energy. Solar has a different production profile than wind, and it can be highly localised, with energy harvested in the same urban areas it is used.

It is important to note that without significant investments to modernise the energy system and define a competitive REFIT, solar power is not an economically viable option for use at a larger scale for exporting back into the grid. However, it is viable in cases where the solar installation's maximum generation capacity does not exceed the minimum daytime energy consumption at its installation location, so that there is no or little surplus electricity that is not used locally.

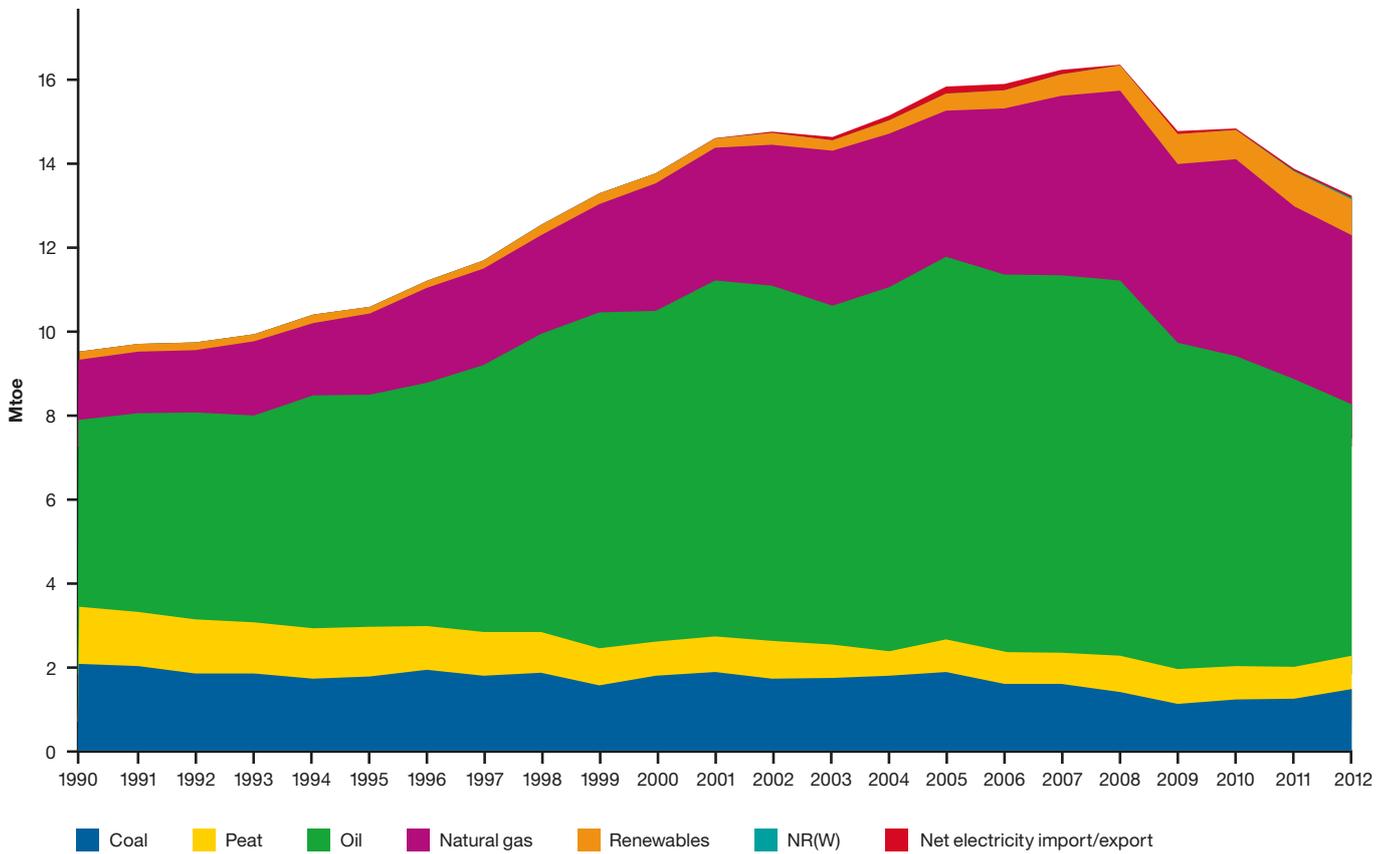


Figure 9: The total primary energy requirement in Ireland (Source: SEAI)

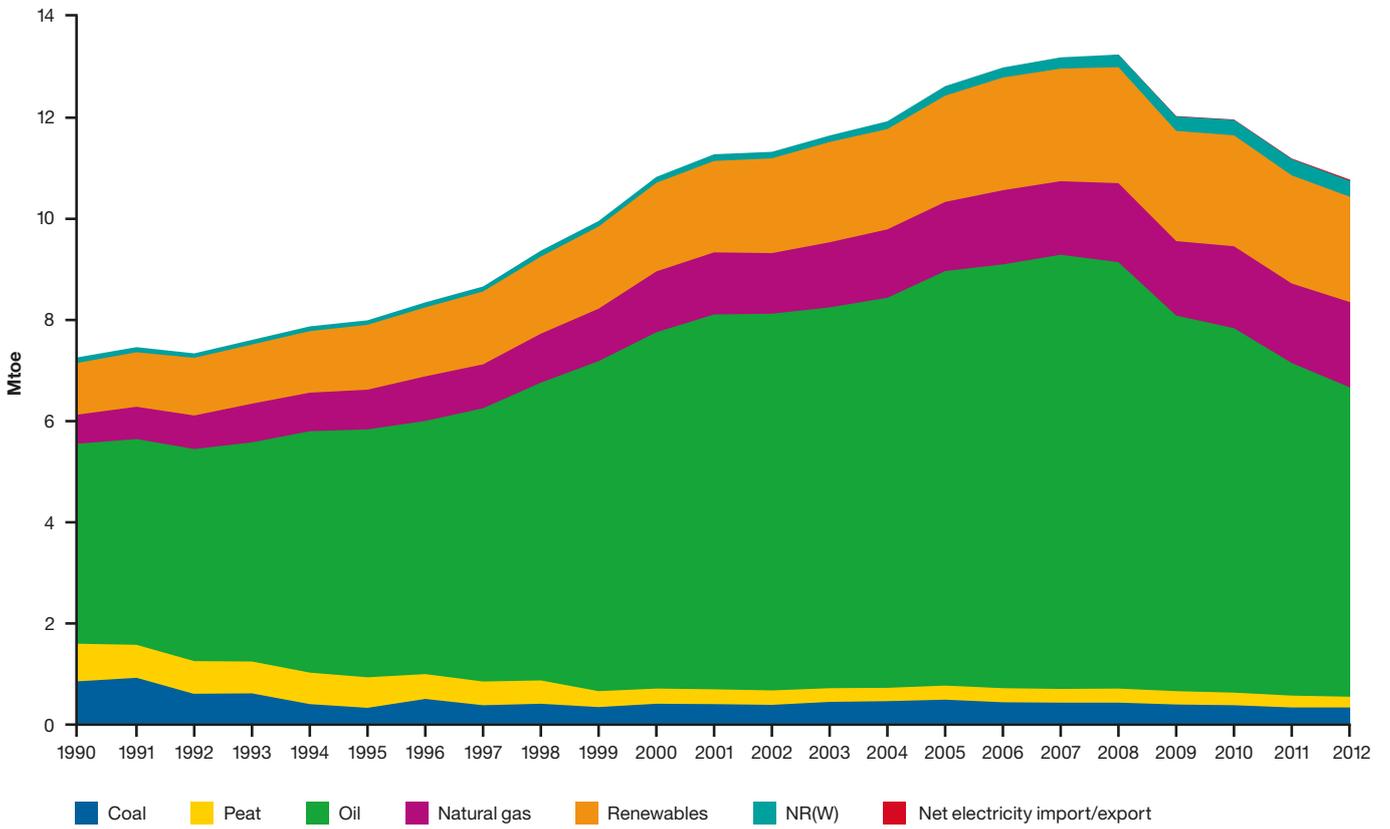


Figure 10: Total final consumption by fuels in Ireland (Source: SEAI)

Economic situation in Ireland

Having suffered the global financial crisis followed by the crisis in the Eurozone, the Irish economy is showing signs of recovery, but growth remains low. Growth in GDP was 0.4% in 2012, rising to 0.6% in 2013. Central bank forecasts put growth at up to 4.5% by the end of 2014, thanks to rises in consumption and investment.

Ireland exited its rescue plan in December 2013 and is again a financially sovereign country. The country followed to the letter the advice of the IMF, ECB and EC and implemented an austerity plan based on a tax hike, lower staff wages and budget cuts. International investors have regained confidence as evidenced by the success of the recent 10-year Treasury bond issuance, and the banking sector has stabilised. Increased competitiveness is attracting foreign companies, and public debt is expected to peak at 126% of GDP in 2014, with the budget deficit rising to 7.3% of GDP. However, the goal is to reduce the deficit to below 3% by 2015. The government will continue its policy of fiscal consolidation and structural reforms. Households are heavily indebted, and mortgage arrears persist.

Regulatory environment

The EU plays an important role as a driver for renewable energy strategies, as it is looking to decarbonise the energy system by 2050 through optimising energy usage and efficiency and leveraging low-carbon-emission energy. Ambitious targets have been established to ensure this goal is met, such as the 40% reduction of GHG emissions and increasing the share of renewables in the energy mix to 30% by 2030.

The Energy Efficiency Directive (2012/27/EU), adopted October 25, 2012, establishes a common framework of minimum measures and requirements for the promotion of energy efficiency within the EU as a means of ensuring that the 2020 target of 20% energy efficiency (20% reduction in greenhouse gas emission, 20% increase in renewables, 20% reduction in energy consumption) level is achieved. The directive includes the legal obligation to establish energy-efficiency schemes or policy measures in all member states. These measures do not prevent any member state from maintaining or implementing more stringent measures, but it does establish hefty penalties for not achieving the committed targets.

Under the terms of the European Renewable Energy Directive (2009/28/EC), Ireland committed to a legally binding target of 16% renewable energy by 2020.

Dublin City Council

Dublin City Council is a major energy consumer that uses 220 GWh of energy annually, 180 GWh of which is in the form of electricity. This consumption is spread across numerous buildings, ranging from small depots to the Main Civic Offices themselves (at 8.3 GWh). Energy consumption profiles and billing arrangements vary across different building types and usages. This diversity of demand means that no single energy solution will apply to all Dublin City Council buildings.

Dublin City Council has taken the initiative to produce a Sustainable Energy Action Plan, with the intent of reducing Dublin's carbon footprint by 20% by 2020 to become an energy-smart and energy-efficient city. More ambitiously, the Sustainable Energy Action Plan is a commitment from Dublin City Council to reduce carbon emissions by 33% from the energy it uses itself. Much of this reduction is to be achieved by introducing energy-efficiency measures, but distributed renewable energy also must play a significant role.

Overall, the Sustainable Energy Action Plan¹⁵ aims to achieve these goals:

- Reduce the economic expenditure on energy for citizens, Dublin City Council and business
- Reduce Dublin per capita CO₂ emissions
- Reduce Dublin's dependence on imported fuel
- Make Dublin a more competitive and attractive destination for business through modern and efficient energy infrastructure and pricing
- Increase Dublin's share of renewable and sustainable energy systems
- Encourage an environment that fosters and supports well-being for current and future citizens

Procurement

The procurement policy in Ireland is in line with EU Directives 2004/17/EC and 2004/18/EC. For some parties, it may seem like procurement is an inhibitor for innovation and rapid implementation. However, it is important to note that the purpose of the procurement process is to find the best solution for the City based on financial benefits, technological advancement and other criteria.

For solar to be implemented successfully, it would be beneficial to have a good understanding of Ireland's procurement policy and guidelines, as a means of ensuring the solar implementation is completed in the most efficient and effective manner. It is advisable to engage with a procurement representative for guidance at every project outset. On average, the procurement gestation period, beginning at the date of advertising and ending after contract evaluation, could take from six to nine months.

Depending on the type of tendering procedure, contract lifespan and contract thresholds and according to the Dublin City Council Procurement Policy and Procedures Manual, Dublin City Council can approach the procurement process through one of three procedures:

1. **Open:** All interested parties may submit tenders.
2. **Restricted:** Only parties invited by the authority following a short-listing process may submit tenders.
3. **Competitive dialogue:** Contract authorities advertise their requirements and enter into dialogue with interested parties.

Leadership

In support of the project, there is a wealth of expertise in Dublin that we recommend pulling in to help identify requirements and oversee implementation. The following key leaders and groups will be critical to success:

- **Dublin City Council architects:** The City architect and her team understand the specifications of the different building types across Dublin and possess extensive knowledge on the subject. She will be an important sponsor to ensure that all safety and technical requirements are closely followed with every solar PV installation.
- **SEAI:** Dublin City Council should apply for money from the SEAI Energy Community Fund to help offset upfront charges. Having been a key sponsor and partner in the successful Tipperary implementation of solar power, SEAI offers experience that can prove helpful to the Dublin City Council initiative.
- **Codema:** As Dublin's Energy Agency, Codema provides a vital bridge between local City authorities and private parties. Its mission is focused on improving the energy efficiency of public buildings in order to reduce Dublin CO₂ emissions and achieve ambitious climate and energy targets (20/20/20). The Dublin City Council solar PV project fits nicely into this larger Codema objective.

B. Project management and technical risk

Project management



Figure 11: The Dublin City Council solar PV project lifecycle

Managing technical risk

	Technical/project risk	Recommendations to mitigate risk
1	Lifespan of solar panels and inverters	Manufacturers generally guarantee at least 20 years for panels and five to 10 years for inverters. Technical specifications and performance contract typically include these warranties as part of the tender process.
2	Performance of each installation with respect to peak and average power generated	Bidders should survey installation sites before submitting quotes. Evaluation should be based on the number of KWh that each bidder's panel design can produce.
3	Drop in efficiency, inconsistent power supply output	During site selection and subsequent monitoring, care should be taken to ensure the roof is free of dust and debris and that the panels are not placed in a location where they will be covered by fallen tree leaves.
4	Breakage and theft of solar equipment from rooftop	Careful site selection and preventive measures should be employed to discourage damage and theft.
5	Implementation success	Strong project management and technical supervision expertise will keep stakeholders accountable and uphold timely approvals and completion dates
6	Continuous monitoring and usage of solar power	Usage targets and monitoring responsibilities should be clearly defined for each installation site.

Table 6: Project risks and recommended mitigation measures

Proposed project organisation

The following general project organisation structure is recommended to implement the IBM Smarter Cities Challenge team's recommendations, subject to integration and compliance with Dublin City Council structures and policies.

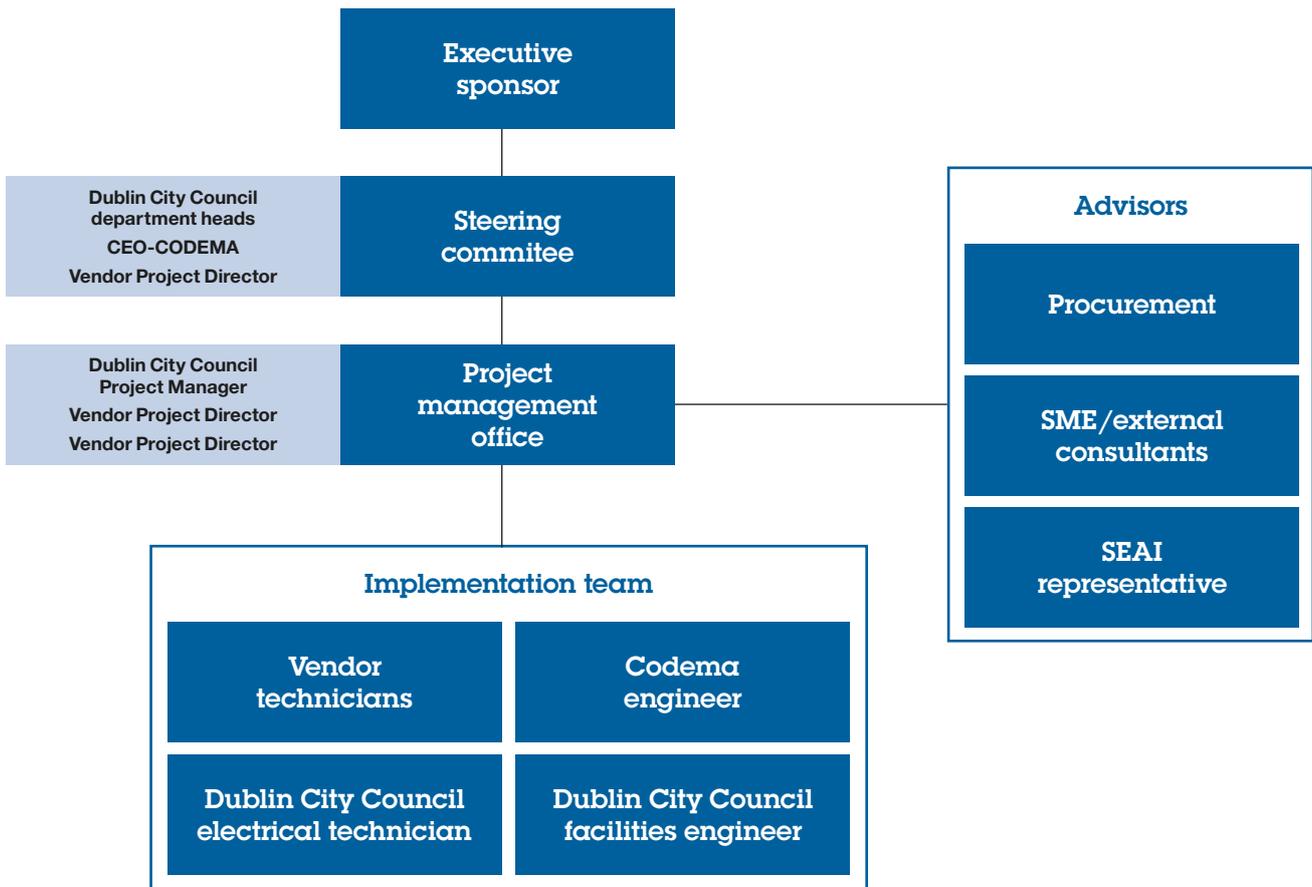


Figure 12: Dublin City Council solar PV project organisational structure

C. Overview of relevant assets

The following non-exhaustive list includes the main assets in Dublin that are relevant to the consideration of solar power. Not all of these assets are owned by Dublin City Council.

Dublin City Council civic offices

These buildings typically have a high roof area and high weekday energy usage. Many also have high 24/7 usage as they house server rooms and other continual-usage facilities. Energy generated from solar PV arrays on these roofs would generally be consumed exclusively by the building.

Social housing

There are generally two types of council-owned social housing in Dublin:

1. Individually rented flats — approximately 17,000 households
2. Sheltered flats for the elderly — approximately 3,000 households

The key difference with the latter is that energy is supplied centrally by Dublin City Council, which pays the bills. In contrast, with the majority of Dublin City Council-owned housing stock, the households have their own contract with energy suppliers and are responsible for payment.

Libraries

Libraries are owned by the Dublin City Council, many of which occupy older, often historic, buildings with relatively low power usage. Some smaller libraries may not be able to consume all solar PV-produced electricity on site.

Dublin City Council depots

There are a variety of depots for vehicles and parks, each with various energy usage profiles. Many of these sites have large areas available for solar PV generation, but they also have wide-ranging capacities for on-site energy usage. One potential use for solar PV in certain depots would be for charging council-owned electric vehicles, such as street sweepers. It is even possible that certain smaller depots would be more valuable to Dublin City Council if they were sold outright instead of being used to generate solar energy. Therefore, when considering such sites for solar energy generation, it is important to consider the site's long-term utility.

Parks and reservoirs

These locations have potentially large PV generation capacity but often very low on-site usage requirements. If an appropriate REFIT becomes available, these sites will be suited primarily for exporting electricity.

Leisure centres, community centres and recreational facilities

Dublin-area recreational stock varies in terms of roof space, energy usage profile and alternative energy sources. In many cases, other systems, such as combined heat and power (CHP), have been installed but are not always in use. It is generally difficult to apply a single rule to all buildings in this category.

Fire stations

Some of these City-owned properties offer strong potential for the installation of solar PV equipment.

Schools and hospitals

Dublin City Council does not own or control school or hospital premises, but these buildings are good candidates for solar energy generation. Therefore, Dublin City Council should explore potential partnerships, for which group purchase agreements of solar technology would help to achieve better unit prices.

Private buildings

A wide variety of privately owned and/or occupied commercial buildings exists across Dublin, many of which are historic. These buildings often have roof spaces and energy usage profiles that make them good potential candidates for solar energy generation.

D. Acknowledgments

The IBM Smarter Cities Challenge team would like to thank a long list of Dublin-area government members, business professionals and residents for their time and generosity in making this report possible. We feel honoured to have worked with every individual involved, and we look forward to watching the Dublin City Council solar PV programme thrive in the coming months and years.

Name	Role	Organisation
Lumley, Ian	Heritage Officer	An Taisce
McLean, Alex	Head of Projects and Energy Groups	Arthur Cox Law Firm
Maguire, David	Director	BNRG (BioNutritional Research Group)
Phelan, Bernadette	Consultant	Business in the Community Ireland
Roche, Tina	CEO	Business in the Community Ireland
Wardell, Gerry	Director	Codema
Hayden, Joe	Executive Engineer	Codema
Fuchs, Suzanne	Representative	Community Representative
Kelly, Marion	Representative	Community Representative
Brennan, David	CEO	DCBA (Dublin City Business Association)
Bennett, Mark	Green Business Officer	Dublin City Council
Burke, Christy	Lord Mayor	Dublin City Council
Caroll, Matthew	Senior Executive Architect	Dublin City Council
Cudden, Jamie	Smart City Programme Manager	Dublin City Council
Daniels, Stephen	Director	Dublin City Council
Finnegan, Peter	Director, Office of Economy and International Relations	Dublin City Council
Grehen, Ali	City Architect	Dublin City Council
Hester, Alan	Facilities Manager	Dublin City Council
Keegan, Owen	Chief Executive	Dublin City Council
Lannon, Anne	Head of Procurement	Dublin City Council
O'Hara, John	Planner	Dublin City Council
Quinn, Kathy	Assistant Chief Executive (Finance)	Dublin City Council
Daniels, Stephen	Academic Director, Sustainable Economies and Societies Research and Enterprise Hub	Dublin City University

Name	Role	Organisation
Furlong, Ronan	Executive Director, Innovation Campus	Dublin City University
McLoughlin, Fintan	Researcher	Dublin Institute of Technology
Norton, Brian	President	Dublin Institute of Technology
O'Farrell, Kevin	Researcher	Dublin Institute of Technology
Jennings, Jonathan		Glen Dimplex
Nolan, Stephen	Director	Green IFSC
Kavanagh, Peter	Director	Highfield Energy
Barry, Pat	Director	Irish Green Building Council
Brown, Justin	Director	Power Capital
Duff, Peter	Director	Power Capital
McCormack, Sarah	Director	Solar Energy Society of Ireland
Motherway, Brian	CEO	Sustainable Energy Authority of Ireland
Harte, Martin	Director	Temple Bar Traders
O'Hora, Aideen	Executive Director	The Green Way
Kenny, Paul	CEO	Tipperary Energy Authority
Thampi, K. Ravindranathan	Associate Professor	University College Dublin, Airtricity Professor of Solar Energy Engineering

E. Team biographies



Vijay Arya
 Researcher, Smarter Planet
 Solutions, IBM Research India,
 Bangalore India

Vijay Arya is a Research Staff Member on the Smarter Planet Solutions team at IBM Research India, with more than 10 years of combined experience in research and software development. He is currently working on analytics techniques to improve the reliability and efficiency of power distribution networks and renewable integration. His research spans smart grids, demand response, renewables, network measurements and modelling, wireless networks, algorithms and optimisation. He has received Invention Plateau Awards and the Outstanding Technical Achievement Award at IBM Research.

Before joining IBM in 2010, Arya worked as a researcher at National ICT Australia (NICTA). He received his PhD in computer science from INRIA (France) in 2005, after earning a master's degree from the Indian Institute of Technology (IIT) Delhi in 2000. He has served on the programme committees of networking conferences and has more than 20 conference and journal publications. Outside of work, Arya likes jogging and enjoys delicious food.



David Goddard
 Executive IT Specialist, Business
 Analytics, IBM Software
 London, United Kingdom

Based in the UK but part of a worldwide team of product and technology experts, David Goddard specialises in developing custom solutions, data visualisation and integrating technologies around the IBM Cognos® software platform. This varied work touches on cloud and big data technology, as well as more traditional databases and information systems. He is equally content writing code or modelling data but is happiest when working with customers. Goddard joined IBM in 2007 as part of the Cognos software company acquisition, where he previously spent several years in consulting and pre-sales technical roles.

Outside of work, Goddard enjoys running and cycling (a long-time mountain biker, he has relatively recently discovered the addictive joys of road cycling). He also greatly enjoys spending time with his wife and two young children, although he often finds it not nearly as relaxing as a nice bike ride. He holds an MSc in computing science and a BSc (Honours) in physics from Imperial College, London.



Lindsey Lurie
VP of Marketing, IBM Security Systems
Austin, Texas, United States

Lindsey Lurie is currently Vice President of Marketing for the IBM Security business in the software division. Her 14 years of experience with IBM spans several marketing and communication roles across many IBM software businesses, with responsibilities including demand generation, product marketing, advertising, PR, digital, social media and event execution. Lurie and her colleagues design the global strategy of IBM security-focused marketing campaigns and then work with geography teams around the world on campaign execution.

She holds a BA in journalism from the University of Texas in Austin and an MBA from Southern Methodist University in Dallas, Texas. In her spare time, Lurie enjoys tennis, hiking and baking delicious treats.



Ana Ocampo
Senior Op. Support and Development
Manager, HSBC Holdings
London, United Kingdom

Ana Ocampo provides direct strategic management support to the HSBC Group COO and Group COO's Chief Risk and Administration Officer on an ad hoc basis, specialising in the bank's business lines and functions. She has been with HSBC since 2008 in various roles based in Mexico, Uruguay, Dubai and the UK. Her responsibilities have included diverse areas, such as strategy execution, risk management, business management, corporate governance, financial management, internal communications and sustainability.

Ocampo holds a bachelor's degree in corporate finance and banking from Anahuac University in Mexico. She grew up in Mexico City and is currently based in London. She enjoys dancing, horse riding and travel.



Javier Reynoso
Head Ombudsman, HSBC Mexico
Mexico City, Mexico

Javier Reynoso has held various leadership roles with HSBC for more than four years. He is currently the Ombudsman and Head of Customer Service for HSBC Mexico, in charge of resolving high-level complaints from customers across the various bank businesses. The main challenge in his work rests in achieving the best solution for customers while operating in the bank's interest.

Reynoso manages a team focused on creating the best customer experiences possible. His work has always focused on taking good care of the bank's brand, strengthening relationships with regulators and building profitable long-term relationships with HSBC customers. He has served diverse customers, including large corporations, public sector organisations and premium and mass customers.

Reynoso has more than 20 years of regional and in-country banking experience, including tenures with several high-profile institutions. He holds a bachelor's degree in industrial engineering with a major in process and systems management from Instituto Tecnológico de Estudios Superiores de Monterrey. He also earned an MBA from Instituto Tecnológico Autónomo de México. Reynoso lives with his wife and three children in Mexico City. He enjoys cycling, mountain biking and running.



Sachin Seth
Partner, Executive Director/Partner
IBM Global Business Services
Mumbai, India

Sachin Seth manages IBM Global Business Services® clients for several IBM verticals across India and South Asia, including Smarter Cities, Energy, Communications, Manufacturing, Consumer Products and Financial Services.

He holds a bachelor's degree in electrical engineering and a post-graduate degree in management, both from India's premier institutes. His more than 20 years of professional experience spans various roles in engineering, IT and business consulting, working with global corporations in Japan and other Asia-Pacific regions.

In his current role, Seth is responsible for advising and executing business transformation and Smarter Planet initiatives for IBM clients. His work involves frequent participation in various technology and industry events as an IBM speaker or delegate.

In addition, Seth has worked on Corporate Services Corps (CSC), the globally acclaimed IBM corporate citizenship programme, since its inception in 2009. He was initially involved as a participant but currently serves as a review board member for CSC IBM India/South Asia.

F. References

- 1 Price Trend Crystalline Modules in EUR/Wp, Chinese Manufactures. Graph. Europe-Solar. www.europe-solar.de/catalog/images/solar/price-trend-modules-h.jpg
- 2 Price Trend PV Modules. A-E-S Europe. www.europe-solar.de/catalog/index.php?main_page=page_3
- 3 Photovoltaic Solar Electricity Potential in European Countries. European Commission, Joint Research Centre. 2012. http://re.jrc.ec.europa.eu/pvgis/cmmaps/eu_cmsaf_opt/PVGIS_EU_201204_publication.png
- 4 “Key World Energy Statistics 2013.” International Energy Agency (IEA). www.iea.org/publications/freepublications/publication/name-31287-en.html
- 5 Wind Energy Statistics. Irish Wind Energy Association (IWEA). www.iwea.com/windstatistics
- 6 Wind Generation. EirGrid. www.eirgrid.com/operations/systemperformancedata/windgeneration
- 7 Renewable Energy Feed-In Tariff (Refit). Sustainable Energy Authority of Ireland (SEAI). www.seai.ie/Renewables/Bioenergy/Policy_and_Funding/Renewable_Energy_Feed-In_Tariff_REFIT_
- 8 Photovoltaic Geographical Information System Calculator. European Commission, Joint Research Centre. <http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php>
- 9 PVWatts Calculator. NREL. <http://pvwatts.nrel.gov>
- 10 SEAI. “Comparison of energy costs.” www.seai.ie/Publications/Statistics_Publications/Fuel_Cost_Comparison/Domestic-Fuel-Cost-Comparisons.pdf
- 11 Ossenbrink, H., Huld, T., Jäger Waldau, A., and Taylor, N. “Photovoltaic Electricity Cost Maps.” European Commission, JRC Scientific and Policy Reports, 2013. http://iet.jrc.ec.europa.eu/remea/sites/remea/files/reqno_jrc83366_jrc_83366_2013_pv_electricity_cost_maps.pdf
- 12 “Summary of Green Paper on Energy Policy in Ireland.” Department of Communications, Energy and Natural Resources. May 2014. [www.dcenr.gov.ie/NR/rdonlyres/ED7Dublin City Council31-9FOA-4350-8E2D-979DBEAE4034/0/DCENRSummaryofGreenPaperonEnergyIreland.pdf](http://www.dcenr.gov.ie/NR/rdonlyres/ED7Dublin%20City%20Council31-9FOA-4350-8E2D-979DBEAE4034/0/DCENRSummaryofGreenPaperonEnergyIreland.pdf)
- 13 Dublin City Development Plan 2011-2017. Dublin City Council. www.dublincity.ie/main-menu-services-planning/city-development-pan
- 14 Dublin City Development Plan 2016-2022. www.dublincitydevelopmentplan.ie
- 15 Dublin City Sustainable Energy Action Plan. Dublin City Council. www.dublincity.ie/main-menu-services-water-waste-and-environment-sustainability-and-climate-change-dublin-city/dublin

G. Abbreviations

Abbreviation	Definition	Reference
CER	Commission for Energy Regulation	www.cer.ie
CHP	Combined heat and power	
CO ₂	Carbon dioxide	
Codema	City of Dublin Energy Management Agency	www.codema.ie
DCENR	Department of Communications, Energy and Natural Resources	www.dcenr.gov.ie
DSO	Distribution system operator	
EPA	Environmental Protection Agency	www.epa.ie/irelandsenvironment
ESB	Electricity Supply Board	www.esb.ie/main/home/index.jsp
ESCO	Energy service company	
EU	European Union	
GHG	Greenhouse gas emissions	
GWh	Gigawatt hour	
kWh	Kilowatt hour	
MWh	Megawatt hour	
kWp	Kilowatt peak	http://en.wikipedia.org/wiki/Nominal_power_(photovoltaic)
NREAP	National Renewable Energy Action Plan	
PV	Photovoltaic (solar cell that converts light into electric current using the photoelectric effect)	
REFIT	Renewable energy feed-in tariff (REFIT). REFIT is a feed-in tariff support scheme that operates by guaranteeing new renewable generation a minimum price for electricity exported to the grid.	www.dcenr.gov.ie/Energy/Sustainable+and+Renewable+Energy+Division/REFIT.htm
ROI	Return on investment	
SCC	Smarter Cities Challenge	http://smartercitieschallenge.org
SEAI	Sustainable Energy Authority of Ireland	www.seai.ie
TSO	Transmission system operator	



© Copyright IBM Corporation 2015

IBM Corporate Citizenship & Corporate Affairs
1 New Orchard Road
Armonk
NY 10504

Produced in the United States of America
January 2015
All Rights Reserved

IBM, the IBM logo, ibm.com, Cognos, IBM Global Business Services, Smarter Cities, Smarter Cities Challenge and Smarter Planet are trademarks or registered trademarks of International Business Machines Corporation in the United States, other countries, or both. If these and other IBM trademarked terms are marked on their first occurrence in this information with a trademark symbol (® or ™), these symbols indicate U.S. registered or common law trademarks owned by IBM at the time this information was published. Such trademarks may also be registered or common law trademarks in other countries. A current list of IBM trademarks is available on the Web at "Copyright and trademark information" at: ibm.com/legal/copytrade.shtml

Other product, company or service names may be trademarks or service marks of others.

References in this publication to IBM products or services do not imply that IBM intends to make them available in all countries in which IBM operates.

Map data ©2015 Google



Please Recycle

