
CITY WINDMILLS HOLDINGS PLC

Impact Report August 2015

PREPARED BY TRUCOST



City Windmills
Small Wind Turbines For Urban Use



CONTENTS

1. CEO Statement	3
2. Social Purpose & Context	5
3. Who benefits?	8
4. Activities & Operations	15
5. Stakeholders	17
6. Evidencing social value	19
7. Other sustainability and reputational issues	23
References	24

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ABOUT TRUCOST

Trucost helps investors to understand the economic consequences of natural capital dependency in order to identify risk and opportunity from growing natural resource pressures and environmental costs.

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Key to our approach is that we not only measure natural capital risk in physical quantities, we also apply a financial value to provide an overarching metric for risk and opportunity analysis.

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1. CEO STATEMENT

Wind is everywhere. From marine trading states and global exploration to windmills grinding flour, wind has been used as an economic propagator for millennia. This ever-present factor of production, however, has not played a prominent role in the global economy in the past century, beyond its use in recreational activities. More recently the challenges of global climate change and sustainable development, along with a desire to reduce dependence on fossil energy through development of renewable energy technologies, has re-focused attention on wind power as an abundant and environmentally sustainable form of energy.

After a slowdown in 2013, the wind power industry set a new record for growth in installed generating capacity, adding over 51 GW of new capacity in 2014 (GWEC, 2015). This growth represents a 44% increase in annual installed capacity with global total capacity reaching 370 GW at the end of 2014 (ibid). While the small-scale wind power sector currently holds a small share of the global wind power and renewable energy markets, it has enormous potential to deliver clean energy and greenhouse gas abatement. A report commissioned by the Carbon Trust reported that small wind power could generate up to 41.3 TWh of electricity and abate 17.8 million tons of CO₂ in the UK alone (Carbon Trust, 2008), representing almost 14% of the UK's final electricity consumption in 2014 (DECC, 2015). Small wind power also holds great potential to provide clean electricity to off-grid communities both in rural areas and in the developing world.

City Windmills is ideally positioned as a leader in this high growth potential sector with its innovative vertical axis small wind turbines and wind-powered lighting products. City Windmills is committed to driving the increased adoption of small-scale wind power to deliver clean, secure and renewable energy with minimal impact on biodiversity and the natural landscape.

Organizational Summary

City Windmills is a UK registered small wind turbine manufacturer and installer with operations in the US, UK and Switzerland, and currently produces generators for residential, commercial and industrial use. In contrast to the standard horizontal axis configuration that most are familiar with, the innovative and silent City Windmills generator is constructed around a vertical axis turbine. In addition to supplying wind turbine generators, the company has developed and is testing wind lighting products via a joint venture with Swiss company, Neulum SA.

City Windmills was admitted to the GXG Markets A/S First Quote section in 2013, and later in the year graduated to the Main Quote segment. As a Self Invested Personal Pension (SIPP) approved investment and with support from the UK financial community, City Windmills has grown organically and transitioned from research and conceptual design, to the current stage of commercial rollout. City Windmills has established strategic partnerships with leading Universities and research institutions to demonstrate and enhance its novel technology whilst contributing its own research to the scientific field.

The USA is City Windmills' initial primary market for turbine sales and the company has established a design and manufacturing affiliation with Dart Manufacturing on Long Island, NY, to facilitate expansion into this market. City Windmills recently won a contract to supply power via its industrial wind generators to Bimbo Bakeries, one of the largest bakery companies in the USA. This contract is a significant milestone for City Windmills as it provides a solid platform for growth, not only in North America, but worldwide. In addition to the Bimbo Bakeries contract, the City Windmills has a number of pilot projects in various States across the USA.

City Windmills's objective is to become a world leader in small wind turbines for commercial buildings and households. City Windmills believes that the economics of wind energy will encourage home and business owners to embrace small wind turbine technology, just as they have adopted solar power. City Windmills has design protection in North America, the European Union and Switzerland, and is investigating design protection in Asia ahead of a Japan/Asia joint venture.

Commitment to Social and Environmental Purpose

City Windmills' social and environmental contribution derives directly from the environmental performance of its innovative product offering. City Windmills' primary social and environmental objectives are to:

- **Reduce** greenhouse gas and air pollution emissions by displacing fossil fuel electricity generation;
- **Expand** access and improve security of supply of electricity by reducing dependence on centralized grid energy generation; and
- **Support** the development of the renewable energy sector whilst minimizing adverse impacts on biodiversity and the natural landscape.

City Windmills has an organization-wide commitment to each of these objectives, which are fully aligned with its core business and service offering. City Windmills is committed to measuring and regularly disclosing information on its social and environmental performance through the company's annual Impact Report and direct engagement with its partners, stakeholders and customers.

David Mapley, CEO, City Windmills Holdings Plc

2. SOCIAL PURPOSE & CONTEXT

Mission Statement

The Challenge

Carbon dioxide (CO₂) is the most significant contributor to global climate change. Energy production, including electricity generation, is a key source of global CO₂ emissions, accounting for 41% of global CO₂ emissions in 2010 (Foster and Bedroisan, 2014). The IPCC reports that climate change is already responsible for changes in human and natural systems on all continents and in the oceans, and if left unchecked will result in severe, pervasive and irreversible impacts on society and the environment (IPCC, 2014). This includes, but is not limited to, increased frequency of severe weather events, sea level rise, and changes to temperature and precipitation patterns with far reaching implications for agriculture, patterns of disease and biodiversity (ibid). In 2010, parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed to reduce greenhouse gas emissions such that climate change is limited to no more than two degrees Celsius (UNFCCC, 2014), however the path to achieving this goal is unclear. Scenario analysis by the International Energy Agency (IEA) suggests that if the world is to have an 80% chance of achieving this goal, the share of renewable energy in world electricity generation must grow to 57% by 2050 (IEA, 2013).

Wind power holds great potential to support the achievement of this goal, harnessing the wind to displace fossil fuel electricity generation with zero CO₂ and zero air pollution renewable energy. Global wind power installed capacity surpassed 50 GW for the first time in 2014, growing by 44% in that year (GWEC, 2015), but with this rapid growth has come increased criticism of large scale wind power for its aesthetic impacts on the landscape, dangers to local wildlife and the cost effectiveness of transporting electricity long distances to end users. Small-scale wind power (defined as generators with a capacity of less than 100kWh (AWEA, 2013) offers a potential solution to each of these challenges – capable of being deployed discretely and cost effectively in urban environments or in remote locations beyond the reach of national electricity grids.

City Windmills' Mission

City Windmills' mission is to “provide a renewable, scalable, and genuinely sustainable energy source as an independent, economic and competitive alternative to fossil fuels - thus ensuring energy security for the consumer and safeguarding the environment for future generations”. City Windmills will achieve this mission through the development, commercialization and deployment of the company's innovative suite of vertical axis small-scale wind generators. City Windmills' wind power solutions are modular, scalable and can be tailored to meet the requirements of customers ranging from large enterprises seeking to reduce their carbon footprint, to households seeking greater energy security, through to communities in the developing world seeking a low cost renewable lighting solution.

Context

City Windmills currently offers four main variants of its small-scale wind power generation system:

- **The CW 500** is designed for residential rooftop applications, offering energy security and reduced electricity costs for households.
- **The CW 1000** is designed for medium scale deployment on commercial building rooftops.
- **The CW 2000** is the largest capacity generator produced by CW and is designed for large-scale industrial electricity generation on rooftops or ground installations.
- **CW Lighting** is a stand alone self-sustaining LED lighting solution designed to provide low cost lighting in off-grid locations. City Windmills offers an alternative to solid or liquid fuel, or solar, based off-grid lighting solutions.

All of City Windmills' products can be purchased outright or installed under an electricity purchase agreement where the customer agrees to purchase electricity over a period of time at a set price.

The City Windmills system enables more effective deployment of wind generators. City Windmills' turbine does not incorporate the propeller or horizontal axis design common to large wind farms, but rather uses an innovative vertical axis chimney height design that can be mounted on rooftops. The design takes advantage of the compression or 'roof-top' effect, which results in accelerated wind over the roof of a building, leading to increased electricity generation in all conditions. This effect is enhanced in coastal environments (44% of the global population lives within 150km of the coast (UN Atlas of the Oceans, 2010)) and harnessing this phenomenon has tremendous potential for providing electricity at lower costs than rooftop photovoltaic systems.

City Windmills' generators are silent, can be deployed un-obtrusively on rooftops, and significantly reduce the risk to wildlife posed by conventional horizontal rotor wind power systems, which were estimated to kill 20,000 birds in the USA alone in 2009 (Sovacool, 2009). As a zero emission solution, City Windmills' generators offer advantages over small-scale electricity generators (such as diesel generators or cogenerators) in urban environments where air pollution remains a major challenge and is the subject of increasing regulation.

City Windmills' generators have great potential to provide secure access to electricity in areas beyond the reach of national electricity distribution networks. Small-scale wind generators can be deployed in rural and remote areas to provide a cost effective source of electricity that supports economic development in these regions. The technology also offers a solution to temporary interruption of electricity networks due to natural disasters or electricity network problems. For example, following Hurricane Sandy in the USA 2012, 8.5 million homes were left without electricity with re-connections in some areas taking more than a month (US Department of Energy, 2012). By placing the energy generator at source, it is possible to ensure energy security and independence for the consumer and mitigate risk of loss of access by distributing generation capacity.

Furthermore, City Windmills' technology has potential to extend access to electricity to 1.3 billion people living without electricity (IEA, 2014), and the company's innovative CW Lighting solution can displace the use of solid and liquid fueled lighting in developing countries, along with its associated environmental and health problems. An estimated 1.4 billion people worldwide rely on fuel (predominantly kerosene) based lighting, with a range of negative effects including increased exposure to toxic particulate matter air pollution, accidental burns and the release of black carbon, a potent short lived greenhouse gas (CCAC, 2014). Furthermore, fuel based lighting typically offers insufficient illumination to enable the provision of education for children (ibid). City Windmills is currently trialing a wind powered lighting solution in collaboration with Baylor University in the USA, and the company expects

to commence sales of the product in China and Africa in late 2015. City Windmills' established collaborations with the Red Cross and Lighting for Africa will aid in facilitating the dissemination of this technology where it is most needed.

Business Strategy

City Windmills' core business is focused on driving the adoption of small-scale wind technology as a cost-effective, distributed and environmentally sustainable source of electricity across multiple markets and geographies. City Windmills' core social and environmental contributions derive directly from the environmental performance of its products and thus its core business and social objectives are intertwined and entirely aligned. Thus as City Windmills grows and expands its operations, so too will the social and environmental benefits delivered by its products.

City Windmills is highly adaptable and capable of tailoring its wind power solutions to respond to the needs of its customers and to evolving regulatory landscapes and environmental and social concerns.

3. WHO BENEFITS?

Key beneficiaries of City Windmills' products and social purpose include the following groups.

City Windmills' Customers

Homeowners

In recent years, increased electricity outages due to storms, excess demand, and system failure have led many households to consider national electricity grids unreliable for continuous access to electricity. In the USA, where grid connections are typically above ground and hence susceptible to tree falls, the frequency of power interruptions in severe weather is significant. Large population densities in the East Coast and Mid-West regions of the USA coincide with severe storms and tornadoes respectively that can result in severe regional electricity interruptions exceeding two weeks duration in some cases. Since 2000, there have been 19 weather-related grid disruption events that affected more than one million customers (Wirfs-Brock, 2014).

In addition, the costs associated with generation capacity replacement and network maintenance are generally passed on to the consumer resulting in increases in electricity tariffs that outpace wage inflation in some countries. Small-scale wind power offers a cost effective solution to alleviate these problems. A typical City Windmills household installation can produce in excess of 3,600kWh/year, and can supply up to 50-70% of the annual electricity consumption of a household in the USA or Europe. Furthermore, City Windmills customers in the UK can benefit from a Feed in Tariff (FiT), a premium paid for excess electricity generated that is exported to the national grid, which both increases the cost effectiveness of small wind power and incentivizes household energy efficiency. In order for the customer to qualify for the FiT, a Micro Certification Scheme certified installer must install the wind turbine. In the USA, customers can also benefit from Investment Tax Credits (ITC).

City Windmills aims to deliver electricity to household scale customers at an average cost of £0.06 (US\$0.10) per kWh, representing a reduction of up to 57% and 20% compared to the average cost per kWh of grid electricity in the UK and USA respectively (USEIA, 2015; Eurostat, 2015). Target prices do not include Government incentives available in City Windmills' target markets that may influence the cost per kWh.

City Windmills generators can also be installed on multi-occupant buildings such as apartment blocks and office buildings with the energy generation benefits shared between the occupants. For example in Switzerland, electricity is commonly supplied to apartment buildings by communes that bill residents on the basis of square meterage and metering. Thus all occupants benefit from the renewable energy generated from their building.

Commercial/Industrial Property Owners

As is the case for homeowners, electricity price rises represent an important pressure on business. While City Windmills does not expect to fully displace grid connectivity in commercial and industrial applications, small wind power offers an opportunity to mitigate the impact of future electricity price growth whilst supporting green building initiatives in conjunction with other renewable energy technologies. The demand for small-scale renewable energy as part of new commercial buildings is expected to increase, with a 2012 survey by McGraw Hill Construction of construction and engineering firms in 62 countries finding that 83% of surveyed firms incorporate renewable energy in new building designs (McGraw Hill Construction, 2013). Furthermore, the report forecasts that the use of wind power by construction firms will triple from 14% to 42% of firms by 2017 (ibid). City Windmills' technology also offers advantages over increasingly popular cogeneration and tri-generation technologies in urban

environments as these technologies are generally powered by combustion resulting in the emission of harmful particulate and nitrogen oxide pollutants.

The modularity and scalability of its technology, along with flexibility in installation and financing arrangements, enables City Windmills to tailor wind power solutions to address the energy and financial needs of its customers.

City Windmills aims to deliver electricity to industrial scale customers at an average cost of £0.03 (US\$0.05) per kWh, representing a reduction of 68% and 29% compared to the average cost per kWh of grid electricity to industry in the UK and USA respectively (USEIA, 2015; Eurostat, 2015). Target prices do not include Government incentives available in City Windmills' target markets that may influence the cost per kWh. City Windmills recently established an electricity supply contract with USA bakery firm, Bimbo Bakeries, at this target price.

Remote/Rural Communities

Mountainous regions, plains and deserts give rise to remote, low-density populations in many parts of the world. The combination of long transmission distances and low customer density means that the extension of national electricity grids to remote locations may not be cost effective, and where provided, access may be less reliable than in urban locations. Self-generation capacity is growing in importance and affordability in these communities and City Windmills' technology can help to accelerate this transition. Furthermore, the repurposing of farm buildings and open spaces as renewable energy generators, can create opportunities for increased revenue, employment and economic development that can provide a counter to the trend of depopulation in rural communities.

Customers in Developing Countries

The International Energy Agency (2014) World Energy Outlook 2014 reports that almost 1.3 billion people worldwide do not have access to electricity. While extension of national electricity grids was the dominant approach to delivering access to electricity in the past, this approach is not economically feasible in remote locations with limited demand (Detchon and Van Leeuwen, 2014). In the 2011 Energy for All report, the International Energy Agency argues that in order to achieve universal access to electricity by 2030, 70% of the rural population currently without electricity will need to be connected via mini-grids and stand alone off-grid energy installations (IEA, 2011). City Windmills' small-scale wind power generators and wind powered lighting solutions are ideally positioned to contribute to achieving the goal of universal electricity access. City Windmills is currently trialing its novel wind powered lighting product and plans to begin sales into China and Africa in late 2015. City Windmills will leverage its established links with non-government organisations such as the Red Cross and Lighting for Africa to facilitate the dissemination of its technology into rural and urban communities in the developing world.

City Windmills' lighting solution is designed to provide up to ten hours of illumination per day and does not require any consumable inputs or directly emit CO₂ or air pollutants at the point of use. This technology has great potential to displace kerosene lamps that are commonly used in developing countries for illumination (Lam et al, 2012). A 2007 study by the Government of India found that 44% of surveyed rural households in India used kerosene as their primary fuel lighting in 2004-2005 (NSSO, 2007). Kerosene lanterns have been shown to produce substantial emissions of CO₂ and air pollutants including particulate matter, carbon monoxide, nitrogen oxides and sulphur dioxide, within confined household environments (Lam et al 2012). In addition to the well-documented risk of burns, poisoning and explosions, the use of kerosene lanterns may also be associated with reduced lung function and increased risk of asthma, infectious diseases (such as tuberculosis) and cancer (ibid). Replacement of kerosene lanterns with City Windmills' lighting solution can help to overcome all of these problems whilst providing higher quality illumination for longer periods of time.

Beyond these direct effects, bringing electricity to neglected populations will have a huge social and environmental impact that is difficult to quantify, spanning improvements in child education, healthcare care delivery, road safety, and reductions in crime.

Government

In 2010, parties to the UNFCCC agreed to reduce greenhouse gas emissions such that climate change is limited to no more than two degrees Celsius (UNFCCC, 2014). In many jurisdictions, greenhouse gas emissions abatement policies have included commitments to increase the proportion of electricity generated from renewable sources. This includes the target to generate 20% of final energy consumption in Europe from renewable sources by 2020 (European Commission, 2015), the Renewable Portfolio Standards implemented in 29 states in the USA (EPA, 2015), and the Renewable Energy Target in Australia (Australian Government, 2015). Increased deployment of distributed small-scale wind power in urban and rural areas will aid national governments in achieving these commitments. Furthermore, as noted above the cost to government of providing or subsidizing grid electricity to remote locations can be high, and small scale wind can offer a cost effective alternative.

A report commissioned by the Carbon trust reported that small wind power could generate up to 41.3 TWh of electricity and abate 17.8 million tons of CO₂ in the UK alone (Carbon Trust, 2008), representing almost 14% of the UK’s final electricity consumption in 2014 (DECC, 2015). City Windmills expects that small-scale wind power can deliver renewable electricity at a similar or greater scale in other markets where City Windmills operates, such as the USA and Switzerland.

Table 1 presents the estimated average renewable electricity output of City Windmills’ products per annum.

TABLE 1: ESTIMATED ANNUAL ELECTRICITY GENERATION PER CITY WINDMILLS PRODUCT INSTALLED BY MODEL (kWh)

CITY WINDMILLS PRODUCT	ANNUAL RENEWABLE ELECTRICITY GENERATION (kWh)
CW500	3,600
CW1000	8,400
CW2000	16,800

The Environment

The natural environment is a key beneficiary of the City Windmills’ business strategy. Each kWh of fossil fuel generated electricity that is displaced by clean and renewable wind power, contributes to reducing the far-reaching effects of climate change on ecosystems. Furthermore, the innovative design of City Windmills’ turbines reduces the threat to wildlife posed by conventional rotor wind power systems.

Table 2 presents estimates of the net greenhouse gas savings achievable through the installation of City Windmills’ turbines to displace grid electricity in its key markets of the UK, USA and Switzerland. As the full life cycle greenhouse gas footprint of City Windmills’ products has not yet been assessed, the results of a recent cradle to grave life cycle assessment of conventional small wind turbines installed in the UK (Greening and Azapagic, 2013), has been adopted as a proxy. As City Windmills’ products are comprised of many components that are common to conventional wind turbines, it is expected that this proxy represents a sound approximation of the life cycle greenhouse gas emissions

associated with a City Windmills' turbine that can be improved upon in the future. The net greenhouse gas emission reduction presented in Table 2 represents the difference between the greenhouse gas intensity of the national electricity grid in each country (Ecoinvent Database (Weidema et al, 2015)) and the estimated greenhouse gas footprint of City Windmills' devices per annum and over a conservative 10-year operational lifespan.

The estimates presented in Table 2 show that City Windmills' products can reduce greenhouse gas emissions compared to grid electricity by an average of 86% in the UK, 77% in the North Eastern USA and 25% in Switzerland. The total estimated lifetime greenhouse gas emissions abated per installed City Windmills turbine in the USA is equivalent to the annual CO₂ emissions of between 2.5 (CW500) and 11.2 (CW2000) passenger cars (EPA, 2015b).

TABLE 2: ESTIMATED POTENTIAL GREENHOUSE GAS EMISSIONS AVOIDED (CO₂e) PER CITY WINDMILLS PRODUCT INSTALLED TO DISPLACE GRID ELECTRICITY

CITY WINDMILLS PRODUCT	ANNUAL ELECTRICITY GENERATION (kWh)	ESTIMATED CO ₂ e FOOTPRINT (Kg / kWh)	NET CO ₂ e EMISSION REDUCTION RELATIVE TO NATIONAL GRID ELECTRICITY PER ANNUM (kg / kWh)						SOURCE
			UK		USA*		SWITZERLAND		
			ANNUAL	LIFETIME	ANNUAL	LIFETIME	ANNUAL	LIFETIME	
CW500	3,600	0.096	2,141	21,406	1,220	12,195	156	1,563	Greening and Azapagic, 2013 Ecoinvent Database (Weidema et al, 2013)
CW1000	8,400	0.096	4,776	47,762	2,727	27,270	292	2,919	
CW2000	16,800	0.096	9,436	94,361	5,341	53,406	324	3,242	

*Emissions factor for the North East Power Coordinating Council operating in the North Eastern states of the USA.

Key Assumptions

- Life cycle CO₂e emissions associated with City Windmills' products are assumed to be equivalent or less than estimates reported by Greening and Azapagic (2013) for micro wind turbines in the UK. Life cycle CO₂e emissions have been multiplied by two to account for the more conservative turbine lifespan assumed in this report compared to the Greening and Azapagic (2013) study.
- CO₂e emissions per kWh available on the market via the national grid in the UK, USA and Switzerland are based on life cycle assessment datasets published in the Ecoinvent database (Ecoinvent Database (Weidema et al, 2015)) applying the ReCiPe impact assessment methodology (Goedkoop et al, 2009).
- It is assumed that the CW500 displaces low voltage electricity supplied to households, the CW1000 displaces medium voltage electricity and the CW2000 displaces high voltage electricity supplied to industrial facilities (Ecoinvent Database (Weidema et al, 2015)).

Public Health

Air pollution presents a major environmental hazard to public health worldwide and is linked to reduced life expectancy and a wide range of health conditions. The World Health Organization estimates that outdoor air

pollution was responsible for 3.7 million deaths globally in 2012 (WHO, 2014). Many of these deaths occur in developing countries where outdoor concentrations of air pollutants such as particulate matter (PM) and nitrogen oxides (NO_x) are high, however the burden of disease caused by air pollution is also significant in developed countries, estimated at 430,000 premature deaths and 7 million Disability Adjusted Life Years (DALY) lost in 2010 (Lim et al., 2012).

City Windmills' generators emit zero air pollution at the point of use and therefore offer significant potential benefits over fuel-powered combined heat and power co-generators. Table 3 presents the estimated reduction in PM and NO_x emissions where City Windmills' products displace modern diesel powered co-generators in the UK. Table 3 also presents the estimated value of reduced health and environmental impacts associated with this reduction in emissions based on damage costs published by the UK Department of Environment, Food and Rural Affairs (DEFRA) (DEFRA, 2013). These damage costs represent the estimated economic cost of health and environmental impacts associated with the emission of air pollutants in different environments. While these damage costs are specific to the UK, they provide a useful approximation of the costs associated with air pollutant emissions in urban and rural areas in other countries.

It is important to note that these estimates do not take account of air pollutants emitted in the production, maintenance and disposal of City Windmills' turbines. While these emissions are expected to be small when averaged over the total quantity of electricity produced over the lifespan of the turbine, additional data will be collected in the future to improve the company's estimates of the air quality benefits provided by its wind turbines.

TABLE 3: ESTIMATED POTENTIAL PM AND NO_x EMISSIONS AVOIDED AND ASSOCIATED DAMAGE COSTS AVOIDED BY DISPLACEMENT OF DIESEL POWERED COGENERATORS WITH CITY WINDMILLS' PRODUCTS IN THE UK

CITY WINDMILLS PRODUCT	ANNUAL NO _x EMISSIONS AVOIDED (Kg)	ANNUAL PM EMISSIONS AVOIDED (Kg)	DAMAGE COSTS AVOIDED BY DISPLACEMENT OF ALTERNATIVE ELECTRICITY GENERATION (£ 2015)				SOURCE
			DIESEL COGENERATOR IN URBAN ENVIRONMENT		DIESEL COGENERATOR IN RURAL ENVIRONMENT		
			ANNUAL	LIFETIME	ANNUAL	LIFETIME	
CW500	3.4	2.0	£60	£548	£37	£340	Ecoinvent Database (Weidema et al, 2013)
CW1000	7.9	4.6	£140	£1,278	£87	£793	
CW2000	15.8	9.2	£280	£2,555	£174	£1,586	

The use of City Windmills' turbines to displace grid electricity also helps to avoid air pollutant emissions at the site of grid connected power plants. Estimated emissions potentially avoided in per product installed in the UK, and the associated damage costs avoided, are presented in Table 4.

TABLE 4 ESTIMATED POTENTIAL PM AND NO_x EMISSIONS AND ASSOCIATED DAMAGE COSTS AVOIDED BY DISPLACEMENT OF GRID ELECTRICITY IN THE UK WITH CITY WINDMILLS' PRODUCTS (SOURCE: ECOINVENT DATABASE (WEIDEMA ET AL, 2013))

CITY WINDMILLS PRODUCT	PM EMISSIONS AVOIDED AT UK GRID POWER PLANT SITES				NO _x EMISSIONS AVOIDED AT UK GRID POWER PLANT SITES			
	NET ANNUAL EMISSIONS AVOIDED (Kg)	ANNUAL DAMAGE COST AVOIDED (£GBP)	NET LIFETIME EMISSIONS AVOIDED (Kg)	LIFETIME DAMAGE COST AVOIDED (£GBP)	ANNUAL EMISSIONS AVOIDED (Kg)	ANNUAL DAMAGE COST AVOIDED (£GBP)	LIFETIME EMISSIONS AVOIDED (Kg)	LIFETIME DAMAGE COST AVOIDED (£GBP)
CW500	3	£8	30	£754	4	£4	398	£392
CW1000	7	£18	67	£1,663	9	£10	889	£875
CW2000	13	£36	131	£3,267	17	£19	1,742	£1,714

Key Assumptions

- DEFRA air pollution damage costs are published for the 2010 price year and have been inflated to future years based on the UK average inflation rate for 2010-2014 (World Bank, 2015).
- Damage costs avoided in future years over the lifespan of a City Windmills turbine are discounted at 2% per annum in line with UK Government recommendations (HM Treasury, 2011).
- Air pollutant emissions from grid electricity production are costed at the PM Electricity Supply Industries (ESI) damage cost, urban cogenerator emissions are costed at the PM Industry damage cost, and rural cogenerator emissions are costed at the PM Rural damage cost. NOx emissions are costed equally in all locations.
- Emission of PM and NOx from diesel powered cogenerators and grid connected power plants were estimated based on life cycle assessment data reported in the Ecoinvent Database (Weidema et al, 2015).
- It is assumed that the CW500 product displaces low voltage grid electricity supplied to households, the CW1000 displaces medium voltage grid electricity and the CW2000 displaces high voltage grid electricity supplied to industrial facilities (Ecoinvent Database (Weidema et al, 2015)).

Competitive Advantage

- City Windmills operates in a complex competitive environment, competing not only with other renewable energy technologies and providers, but also with traditional fossil fuel energy generators. However, City Windmills has a number of key strategic advantages over its competitors:
- Urban design: While traditional horizontal axis “propeller” designs are adequate for non-urban or coastal locations, these designs produce significant noise, disturb the aesthetics of the landscape, and pose a hazard to local wildlife. The City Windmills design is compact, silent and discrete, and the exterior barrel can be painted to blend into its surroundings.
- Cost Effective Renewable Energy: While the barrel design and shroud concept is unique and exclusive to City Windmills, standard wind turbine components are used for the rest of the product, which can be sourced locally and at low cost. City Windmills’ generators are also highly efficient, taking advantage of high velocity air currents generated on rooftops to increase electricity output, offering a low cost renewable energy solution.

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- **Patent Pending on Design:** City Windmills has applied for a patent on its turbine design in the US, EU and Switzerland, which will allow the company to maintain its lead in vertical axis wind technology. In contrast, most of City Windmills' competitors offer commoditized products.
 - **Experienced Management:** City Windmills has a highly experienced management team. The company's CEO has successfully run a number of technology firms, while its COO of the US operation has been involved with the renewable energy sector for thirteen years and founded CSG Inc in the US.
 - **On-Site Electricity Generation:** A major benefit of small wind turbines is that they can be installed much closer to or on peoples' homes. This feature will appeal to consumers that value independence from the grid system, particularly where power outages are a common occurrence.
 - **Early stage of industry:** Currently, there are no dominant players with economies of scale in this specialized sector of the market. This provides significant growth opportunities for small technology-savvy companies such as City Windmills.
 - **Environmental Concerns:** Consumers are increasingly conscious of the fragility of the natural environment and, as a result, eco-friendly products, such as those produced by City Windmills, have a competitive advantage. Where noisy conventional "propeller" turbines present a hazard to birds and bats, City Windmills' turbines are silent and bird-friendly.

4. ACTIVITIES & OPERATIONS

City Windmills undertakes a range of activities in the execution of its business model that are inextricably linked with the company’s social and environmental objective of delivering sustainable renewable wind power as an economically competitive alternative to fossil fuel based electricity. Key activities include:

- The development, trial, manufacture and installation of novel vertical axis wind turbines for application in the delivery of scalable renewable electricity generation capacity.
- Development of micro-scale wind powered lighting solutions for application in the developing world.
- Establishment of electricity supply contracts with residential and commercial scale customers that host City Windmills turbines on their property.
- Partnerships with Universities to further develop and refine the company’s product offering, whilst contributing to new scientific research in the wind power field.
- Engagement with partners to develop opportunities to deliver the company’s technology to new markets in the developed and developing world.

The table below outlines how City Windmills’ activities deliver outcomes for its beneficiaries.

ENGAGEMENT WITH BENEFICIARY	ACTIVITIES	OUTCOMES (OR CHANGES EXPECTED) FOR BENEFICIARIES
<p>Homeowners and Commercial/ Industrial Property Owners City Windmills directly engages with its residential and commercial customers to tailor its modular renewable energy solutions to meet their needs.</p>	<p>Design and installation of small scale wind power generators that meet customer’s energy and financial requirements.</p> <p>Ongoing development and refinement of the technology to improve the quality of the company’s products.</p>	<p>Increased energy security and resilience in periods of electricity grid service interruption.</p> <p>Relief from increases in grid electricity costs by supplying between 50-70% of typical household electricity requirements.</p> <p>Reducing corporate environmental footprints and supporting green building initiatives through the provision of cost effective and scalable on-site renewable electricity.</p>
<p>Remote/Rural Communities City Windmills directly engages with its customers in rural communities to tailor its modular renewable energy solutions to meet their needs.</p>	<p>Provision of scalable wind power solutions to meet the requirements of rural customers, ranging from household scale installations to larger installations to supply whole communities.</p> <p>Provision of self-contained lighting solutions for remote communities, developing country villages, and roads/ pathways in unsafe or remote areas</p>	<p>Increased energy security and resilience in periods of electricity grid service interruption.</p> <p>Reduced electricity costs relative to grid or other renewable energy technologies in certain conditions.</p> <p>Opportunities to re-purpose disused buildings in rural areas for electricity generation, providing an additional income stream for rural communities.</p>

ENGAGEMENT WITH BENEFICIARY	ACTIVITIES	OUTCOMES (OR CHANGES EXPECTED) FOR BENEFICIARIES
<p>Governments City Windmills seeks to support national governments in achieving their greenhouse gas abatement and renewable energy development commitments through provision of a cost effective and scalable renewable energy solution.</p>	<p>Installation of new renewable energy capacity. Facilitating the growth of micro-generation capacity in the UK through the FiT scheme. Providing an alternative to fuel driven cogenerators and trigenerators for on-site electricity supply, that reduces harmful air pollutant emissions.</p>	<p>Contributions to achieving national greenhouse gas abatement and renewable energy capacity development commitments. Alleviation of air pollution problems where City Windmills' products are used to displaced fuel powered small-scale electricity generation. Facilitating access to secure electricity supply in regions not adequately served by national electricity grids.</p>
<p>The Environment</p>	<p>Supply of consumer electricity demand with renewable energy resulting in reduced greenhouse gas and air pollutant emissions.</p>	<p>Helping to reduce the greenhouse gas intensity of electricity supply for residential and industrial customers. Helping to reduce emissions of air pollutants such as PM and NOx where City Windmills' products are used to displace grid or diesel generator produced electricity. Reduction in the aesthetic impact and potential hazard to wildlife compared to conventional wind power installations.</p>
<p>Customers in Developing Countries City Windmills is working with partners and potential customers to bring its small-scale wind power technology to the developing world.</p>	<p>Development of an innovative wind powered lighting solution, specifically designed for application in remote, off-grid locations. Collaboration with partners to deliver a wind lighting solution that meets the needs of customers in developing countries.</p>	<p>Access to secure and high quality household illumination. Reduction in CO₂e emissions and health hazards associated with air pollutant emissions from commonly used lighting alternatives (such as kerosene lanterns).</p>

5. STAKEHOLDERS

Identification and Engagement with Stakeholders

City Windmills’ business activities involve a range of stakeholders that use or are impacted by the use of its products and services. City Windmills’ interacts and engages with its stakeholders in the course of its business through formalized processes and more informal interactions.

The table below identified City Windmills’ main stakeholder groups, the company’s relationship with each stakeholder, and how the company engages with them and responds to their needs and expectations.

STAKEHOLDER	DESCRIPTION AND ENGAGEMENT
City Windmills’ Customers	<p>City Windmills’ customers are its most important stakeholder and a critical partner in achieving the company’s goal to increase the uptake of small-scale wind energy technology.</p> <p>City Windmills’ consumers benefit from reduced electricity costs, increased energy security and from the availability of a cost effective pathway to reduce their environmental footprint.</p> <p>City Windmills’ business model is highly responsive to the evolving needs of its customers, whether they are households, industrial facilities or remote communities. The company’s small-scale wind power installations are designed to be modular and scalable to meet the needs of its customers, and flexible arrangements are offered to finance the installation of new generation capacity.</p> <p>City Windmills places a high value on customer satisfaction and is in regular dialogue with its customers to resolve any issues they encounter, and to inform the future development and improvement of its products.</p>
The Renewable Energy Industry	<p>City Windmills aims to be an active member and advocate for the renewable energy sector, demonstrating that small scale renewable technologies can provide a genuine, secure and economically competitive alternative to fossil fuel based electricity generation.</p> <p>City Windmills is active at renewable energy sector events and conferences, and closely monitors developments in the sector.</p>
The Environment	<p>The environment is the ultimate beneficiary of the activities of City Windmills and its customers.</p> <p>City Windmills is committed to addressing the challenge of anthropogenic climate change and is a strong advocate for the crucial role that renewable energy can play in reducing greenhouse gas emissions.</p> <p>City Windmills is committed to measuring and monitoring the life cycle environmental impacts of its products as they are used in the market to ensure that its products deliver an environmental net benefit.</p>
Staff	<p>City Windmills’ staff are critical to the operation and future success of the business. City Windmills strives to cultivate a supportive environment for all staff that reinforces the company’s corporate values and commitment to its social and environmental objectives.</p>
Project Partners	<p>City Windmills works closely with a range of partners to deliver its products and services. This includes the company’s partnership with Neulum SA in Switzerland to develop its wind powered lighting product, and with Dart Manufacturing in the USA for the design and manufacture of the product range.</p> <p>City Windmills also works with universities to further develop its technology and actively pursues collaborative grant funding opportunities to support research studies and research departments with an interest in wind power. One such example is City Windmills’ partnership with Baylor University to trial the CW Lighting product.</p>

STAKEHOLDER	DESCRIPTION AND ENGAGEMENT
Investors and Shareholders	City Windmills has a range of investors and shareholders to which it reports regularly through its annual reports, website and shareholder meetings.
Government	<p>City Windmills actively monitors the developing government policy and legislative landscape in relation to climate change mitigation and renewable energy development in all of the jurisdictions in which the company operates.</p> <p>City Windmills also seeks to engage in the policy development process by participating in government inquiries on relevant subjects and by advocating for the benefits of small-scale wind power to address the social and environmental challenges faced by government.</p>

6. EVIDENCING SOCIAL VALUE

Evidencing social value

City Windmills is committed to disclosing information about its environmental and social impact through an annual impact report and ongoing communication with its stakeholders. As outlined previously, City Windmills' vision and business model is inextricably linked with its social, environmental and economic outcomes for a range of beneficiaries. The company's social and environmental goals are embedded within City Windmills business and strategic planning processes at all levels of the organization.

City Windmills' current environmental and social impact reporting framework is outlined in the evidence table below. As City Windmills is at an early stage of development, forward projections for the number and location of windmill installations are uncertain. As such, for the company's year one impact report, City Windmills has primarily set targets based on estimates of the quantified benefits expected per windmill installed by product type. City Windmills has also set a total greenhouse gas abatement target for the 2016 financial year. City Windmills is committed to measurement and monitoring of the environmental benefits realised as its products are used in the market and will set and measure progress against additional aggregate environmental benefit targets in future impact reports.

Evidence

BENEFICIARY	OUTCOME	INDICATOR	TARGET	DATA SOURCES	
City Windmills' Customers	Provision of cost effective renewable electricity	Annual average cost per kWh of electricity generated by City Windmills household and commercial scale installations	Household £0.06 / US\$0.10 per kWh ¹ Commercial £0.03 / US\$0.05 per kWh ¹	City Windmills Data	
The Environment	Reduced greenhouse gas emissions – contribution to meeting national emissions reduction commitments	Annual net CO ₂ e emissions avoided per windmill installed (tonnes) to displace electricity produced via national electricity grids Average per annum avoided in key markets: UK, USA and Switzerland	CW500	1 tonnes CO ₂ e	City Windmills Data Greening and Azapagic, 2013 Ecoinvent Database (Weidema et al, 2013)
			CW1000	3 tonnes CO ₂ e	
			CW2000	5 tonnes CO ₂ e	
		Annual net CO ₂ e emissions avoided per windmill installed (tonnes) to displace electricity produced via diesel powered combined heat and power generators	CW500	2 tonnes CO ₂ e	City Windmills Data Greening and Azapagic, 2013 Ecoinvent Database (Weidema et al, 2013)
			CW1000	5 tonnes CO ₂ e	
			CW2000	11 tonnes CO ₂ e	
Total net CO ₂ e emissions avoided (tonnes) due to the electricity produced by City Windmills' products installed in financial year 2016 ²	2,023 tonnes CO ₂ e avoided in financial year 2016	City Windmills Data Greening and Azapagic, 2013 Ecoinvent Database (Weidema et al, 2013)			
Government	Contribution to meeting national renewable energy generation targets	Annual electricity generated (kWh) per City Windmills product installed	CW500	3,600 kWh	City Windmills Data
			CW1000	8,400 kWh	
			CW2000	16,800 kWh	
Public Health	Reduced emission of particulate matter air pollution due to electricity generation	Annual particulate matter emissions (kg) avoided per windmill installed to displace electricity generated via national electricity grids. Average per annum avoided in key markets: UK, USA and Switzerland	CW500	2 kg PM ₁₀	City Windmills Data Ecoinvent Database (Weidema et al, 2013)
			CW1000	4 kg PM ₁₀	
			CW2000	7 kg PM ₁₀	
		Annual particulate matter emissions (kg) avoided per windmill installed to displace electricity generated via diesel powered combined heat and power generators	CW500	2 kg PM ₁₀	City Windmills Data Ecoinvent Database (Weidema et al, 2013)
			CW1000	5 kg PM ₁₀	
			CW2000	9 kg PM ₁₀	

1. Target prices do not include Government incentives available in City Windmills' target markets that may influence the cost per kWh.

2. Estimated based on City Windmills sales projections for financial year 2016 in the UK, USA and Switzerland.

Current Management

City Windmills was established to increase the uptake of small-scale wind power as a clean and economically competitive source of electricity, and much of the company's operations are dedicated to developing and delivering the technology required to achieve this goal. The management team owns around 30% of the company and is fully committed to the social and environmental objectives of City Windmills.

As City Windmills has not yet commenced full-scale commercial sales of its products, the potential benefits of the company's windmills over alternative electricity generation technologies and the company's environmental impact targets have been estimated based on robust published data as described in Section 3. As the company grows and develops, City Windmills will investigate strategies to better measure the life cycle environmental impacts of its products and the social and environmental impacts realised through the use of its products in practice. City Windmills is in the early stages of developing and implementing the monitoring systems necessary to achieve this goal and is working with leading consultancies to improve the company's capacity in social and environmental impact monitoring.

Future Commitments

City Windmills is a newly established company in the start-up phase of operations and in the process of commencing commercial scale sales of its wind turbine products. As the company develops, City Windmills commits to invest in more targeted, rigorous and verifiable impact monitoring and reporting strategies.

Specifically, City Windmills plans to invest and expand its capacity in the following key areas.

- 1. Understanding the Environmental Footprint of City Windmills' Products and Operations.** City Windmills' products enable the production of renewable electricity with zero carbon and air pollutant emissions during the operational phase, and minimal impacts on wildlife and environmental amenity. However, the production, distribution, maintenance and end of life disposal of City Windmills' products will undoubtedly produce adverse impacts on the environment. In order to accurately quantify the net environmental and social benefits delivered by the company, City Windmills must develop a more complete understanding of the environmental footprint of its products and operations. To this end, City Windmills commits to undertake the following activities:
 - Explore the feasibility of undertaking a full cradle to grave Life Cycle Assessment study of the company's products as implemented in their most common applications, including the production, operation, maintenance and end of life of the products. This will enable City Windmills to more accurately measure and report the net improvement in key environmental key performance indicators (such as emissions of CO₂e or air pollutants) realised by the use of its products.
 - Undertake on-site or remote monitoring of City Windmills' windmill products in operation at a sample of customer locations to gather more accurate data on the quantity of renewable energy produced under different installation conditions.
 - Survey customers to more accurately understand their motivation for adopting small scale wind power and the alternative energy sources that wind power displaces.
 - Survey customers to collect data on cost per kWh generated by the company's turbines under different installation conditions.

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- 2. Set Robust, Time-Bound and Quantified Targets for City Windmills' Future Impact.** City Windmills will develop robust forward projection scenarios for the installation of its products in its target markets and applications. These projections will inform the setting of a series of quantified targets for future years against the environmental key performance indicators detailed in Section 6 and other important indications as more data becomes available. The adoption of formalized targets will further enhance the monitoring and reporting of the company's environmental impacts and help to maintain the company's focus on delivering on its environmental objectives.
- 3. Determine the Feasibility and Effectiveness of Measuring a Broader Range of Benefits and Develop Methods to Achieve This Goal.** City Windmills will explore the feasibility and effectiveness of potential methods to quantitatively assess a broader range of the environmental and social benefits the company delivers. In particular, City Windmills will explore new methods to assess benefits in the following areas:
- Delivery of secure electricity supplies in periods of grid electricity supply interruption.
 - Reduction in wildlife hazards and impacts on amenities associated with conventional wind turbines and alternative small-scale wind generator designs.
 - Household level improvements in air quality and financial benefits realised by the adoption of the CW Lighting product and the real world adoption rate in developing countries.
 - Surveys of customers to better measure customer satisfaction and gain insights into their needs to better inform the future development and enhancement of the company's products.
- 4. More Effective Environmental Management and Reporting Systems.** City Windmills will investigate strategies to improve its environmental management systems and establish structured processes for regular data collection and analysis, matched with regular reporting processes. City Windmills will also investigate the feasibility of adopting a certified environmental management system such as ISO14001.

7. OTHER SUSTAINABILITY AND REPUTATIONAL ISSUES

City Windmills will soon launch its CW Lighting product to provide clean and secure lighting for customers in developing countries. This product provides an alternative to hazardous and polluting kerosene lanterns used in many parts of the world and can deliver enormous social benefits for communities spanning education, healthcare, community safety and economic development. Further updates will be made available on City Windmills' [website](#) and [facebook](#) page.

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City Windmills
Small Wind Turbines For Urban Use

