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Solar Energy in Ireland – A Position Paper

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Solar energy has the potential to become a significant energy source in the Republic of Ireland. This paper presents arguments against and for solar energy with focus on planning, community benefits, environmental impacts and intermittency.
Ireland's 2020 greenhouse gas (GHG) emissions reduction target is a 20% reduction in non-emission trading scheme (ETS) emissions compared to 2005 levels. However the deployment of solar energy will require citizens' engagement and the government needs to play greater role in the transition to a low carbon future.
The paper presents a position regarding solar energy development in the Republic of Ireland, supported with several study cases.

Keywords: Republic of Ireland; renewable energy; solar energy; solar electricity; solar heat; photovoltaic.

ABBREVIATIONS

BfN : German federal agency for nature conservation
CO_2 : Carbon dioxide
CSP : Concentrating solar power
ESB : Electricity supply board

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ETS : Emission trading scheme
GHG : Greenhouse gas
IPCC : Intergovernmental panel on climate change
NREAP : National renewable energy action plan
PV : Solar photovoltaics
RES : Renewable energy sources
RES-E : Renewable electricity
RES-H : Renewable energy for heat and cooling
RES-T : Renewable energy in transport
RFC : Renewable solar power systems with regenerative fuel cell systems
TPER : Total primary energy requirements

EXECUTIVE SUMMARY

Solar energy can be used as a power source in order to reduce consumption of primary energy, achieve Ireland's 2020 targets and minimise carbon footprint.

The two main ways that solar energy is used are: photovoltaics (Solar PV) and solar thermal for heating. Solar PV converts the sun's radiation into electricity and solar thermal converts the sun's radiation into heat, to use for residential and commercial space heating and hot water.

Solar energy could account for 10% of renewable energy generation capacity in Ireland, by 2020, representing 500 MW of installed generation capacity.

The main arguments against solar energy are related with planning (criteria used for the site selection and the process of planning permission), implementation of solar projects without the inclusion of community benefits, intermittency and storage (grid operators have to run decisions in response to intermittent renewable output, requiring sometimes storage solutions).

The main arguments for solar energy refer to environment, such as agricultural activity and wildlife (small livestock can graze around the solar panels); biodiversity (helps to promote and conserve biological diversity); health (it help to reduce the carbon dioxide emissions and other pollutants in the atmosphere); jobs (more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels) and 2020 targets (solar energy can be used as a pathway to achieve these targets).

The largest PV project in Ireland is located at County Tipperary. It is a 45 kWp project in the public buildings in Tipperary. In the United Kingdom the Westmill Solar Cooperative is the first large scale solar farm with community benefits.

To conclude, Ireland has potential for both solar PV and solar heat production. Ireland's energy policy should focus more on promoting and implementing solar energy in Ireland. Benefits should accrue to local communities. Awareness campaigns and guidelines for planning are needed to ensure an efficient implementation of solar energy in Ireland.

1. INTRODUCTION

Nowadays, besides fossil fuels (gasoline, oils, coal and natural gas) that release carbon dioxide, human activities, such as burning fossil fuels for heat and energy, clearing forests, fertilizing crops and raising livestock, contribute to global warming. The effects of climate change are evident on all continents, causing irreversible impacts for people and ecosystems, such as storms, sea-level rise, coastal flooding, inland flooding, and extreme weather events.

There is an international commitment to limit the mean global temperature rise to 2°C above pre-industrial levels, through the reduction of greenhouse gases emissions' (GHGs) and the implementation of renewable energy. The Europe 2020 strategy aims to turn the EU into a 'low carbon' economy based on renewable energy sources and energy efficiency.

Ireland's 2020 GHG emissions reduction target is a 20% reduction in non-emission trading scheme (ETS) emissions compared to 2005 levels. Renewable energy targets are to increase the share of final energy consumption that is made up by renewable energy sources (RES) to 16%. [1].

Ireland's environment remains in a good condition, although there are some areas of concern. The recent economic recession has

lowered greenhouse gas emissions. However, the main challenge for Ireland is, as its economy recovers, it must do so in a sustainable way. In this context, the four key environmental challenges for the country are (Fig. 1) [2]:

Fig. 1. Ireland's main environmental challenges [2]

The environmental challenges presented in Fig. 1 refers to valuing and protecting natural environment, building a resource-efficient, low-carbon economy, implementing environmental legislation and putting the environment at the centre of decision making. This means, a commitment not only for the climate change and greenhouse gases, but also for water, biodiversity, air, rural development and waste.

The objective of this paper is to review the status of solar energy in the Republic of Ireland and present a position regarding its development.

2. BACKGROUND

2.1 Global Energy Profile

The global energy scenario is changing quickly as a result of economic and population growth and technological advancements.

Fig. 2 shows the growth of global primary energy consumption, between 1970- 2010, from different sources.

Fig. 9 (Annex 1) shows the growth of global energy consumption aligned with population growth The two curves follow a very similar path, leading us to the conclusion that population growth is one of the most important factors in the rise in energy consumption [3].

2.2 Irish Energy Profile

Fig. 3 illustrates total primary energy requirements in Ireland (conversion of primary sources of energy into forms that are useful for the final consumer, for example electricity generation) emphasizing changes in the fuel mix. Over the period 1990 – 2014 Ireland's annual total primary energy requirements (TPER) grew in absolute terms by 40% (1.4% per annum on average). Between 2005 and 2014 it fell by 16%, showing the impact of recession on energy production [5].

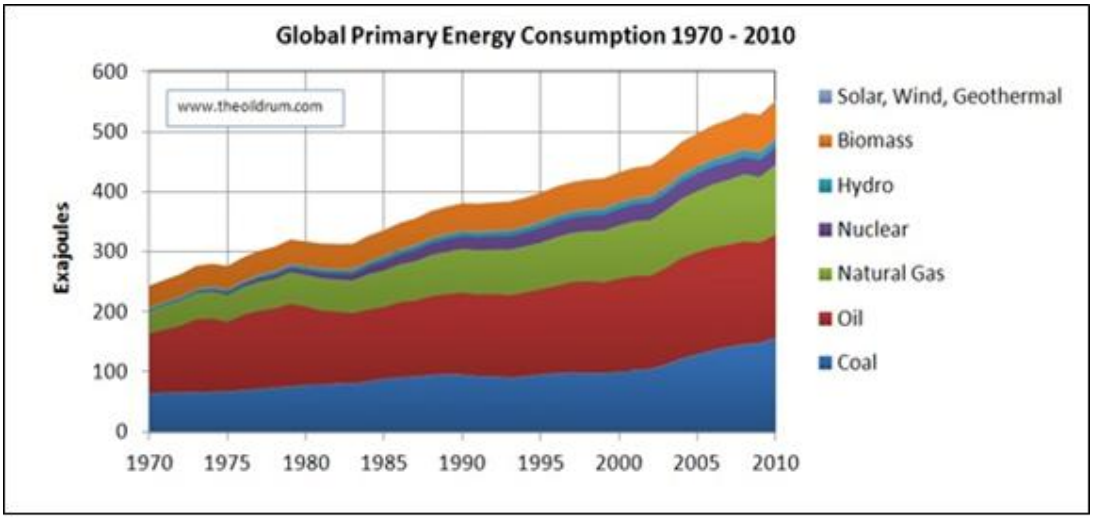

Fig. 2. Global energy consumption [3]

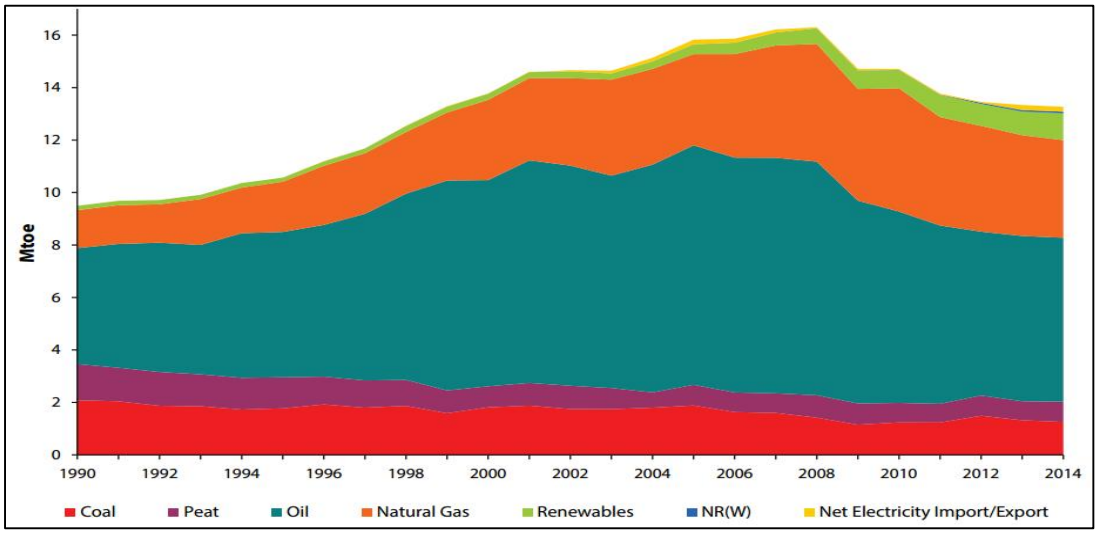

Fig. 3. Energy supply-The total primary energy requirements in Ireland [5]

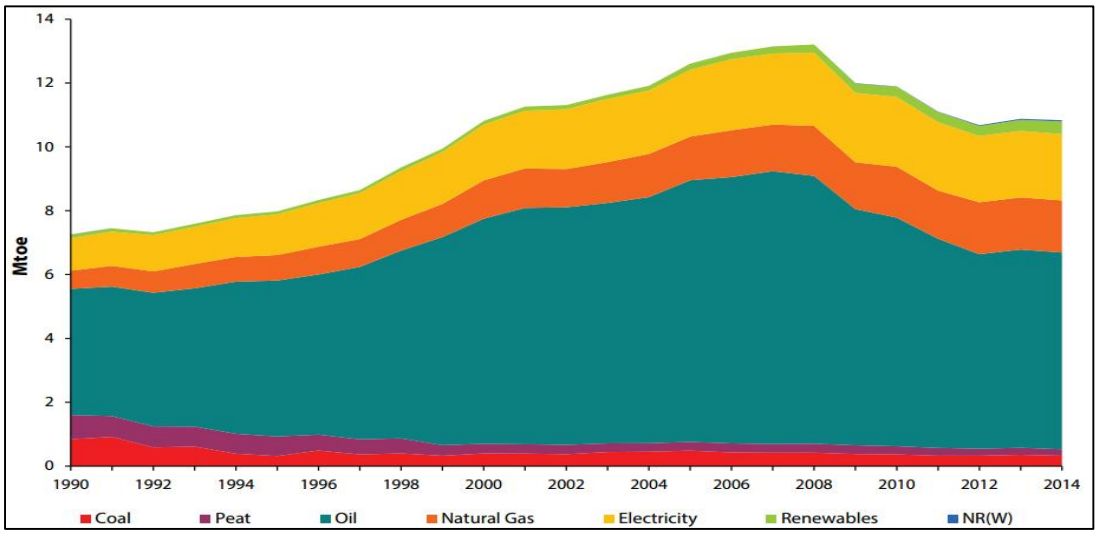

Fig. 4. Energy demand-Total final consumption by fuels in Ireland [5]

Fig. 4 above allocates the total final consumption by fuels in Ireland over the period 1990-2014.

2.3 Can Solar Energy be a Significant Source of Power in Ireland?

The most commonly encountered systems for solar electricity production are Concentrating Solar Power (CSP), Solar Thermal Electric Power Plants Photovoltaics, Solar Heating Systems, Passive Solar Energy, Solar Lighting, Solar Cars, Solar Power Satellite and Renewable Solar Power Systems with Regenerative Fuel Cell Systems (RFC).

Solar PV is used for energy production (large scale) or water heating (small scale) while concentrated solar power is on a commercial scale.

In recent years photovoltaic solar energy has grown faster than other renewable energy sources internationally, with an average annual growth of 58% demonstrating the potential of this technology.

Fig. 5 illustrates the evolution of European PV cumulative installed capacity between 2000-2013 [6].

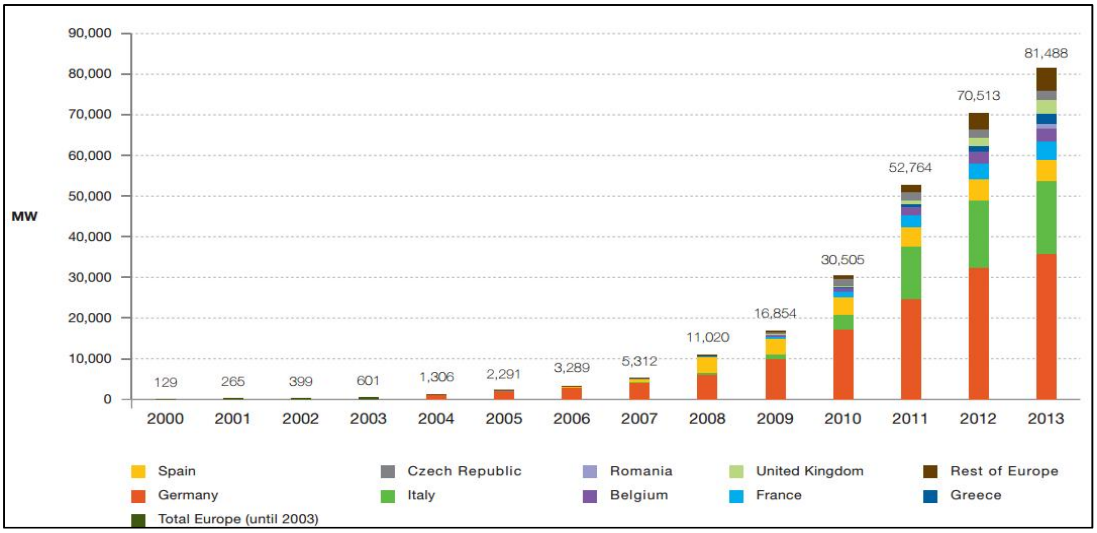

Fig. 5. Evolution of European PV cumulative installed capacity 2000-2013 [6]

Is commonly believed that the solar radiation in Ireland is very poor, however solar radiation in Wexford is 78% of the level enjoyed in Madrid and France and is equivalent to the levels found in most of the UK [7].

Figs. 6 and 7 illustrates the yearly sum of global irradiation on horizontal and optimally inclined surface, during the period 1998-2011. On horizontal surfaces the potential the potential for solar electricity is between 600-900 kWh/kWp and the sum of global radiation between 800-1200 kWh/m2. On optimally inclined surfaces the potential the potential for solar electricity is between 750-1050 kWh/kWp and the sum of global radiation between 1000-1400 kWh/m2.

Solar energy therefore has the potential for significant power generation in Ireland.

2.4 Solar Heat

The sun is a source of free heat that, with the use of solar systems, can be used in buildings for space heating (normally heating a liquid or a gas) and hot water.

The required temperatures will define the type of solar system to be used.

3. ARGUMENTS AGAINST

3.1 Solar Electricity

3.1.1 Planning

In Ireland some sites are more suitable for solar farms than others.

Solar radiation is one of the most important requirements and initially it is important to undertake desktop assessments to determine if the site has sufficient solar potential.

The criteria used for the site selection are [8]:

- Flooding (must be outside recognised flood zones),
- Land use (must be outside of built up areas or woodland areas),
- Land type (agricultural, ex-industrial landfill, or brownfield),
- Designation (must be outside of protected areas),
- Public access (not crossed by a public footpath, right or way or bridal way),
- Aspect (level or sloping South/SE/SW, not overlooked by housing),
- Shading (not shaded by trees, buildings or terrain),
- Solar radiation (must receive at least 1050 kWh/m^2 of solar radiation),
- Grid connection (must be within 1km of existing power distribution lines),
- Access (access for vehicles for construction) and
- Site size.

Another problem is the length of time it takes to get planning permission for a solar farm project creating discontentment among investors.

3.1.2 Community benefits

Currently solar energy in Ireland is taking the same track as wind farms some time ago in not

ensuring buy-in from local communities. Local communities should have a stake (either ownership, part ownership or shares) in solar energy projects.

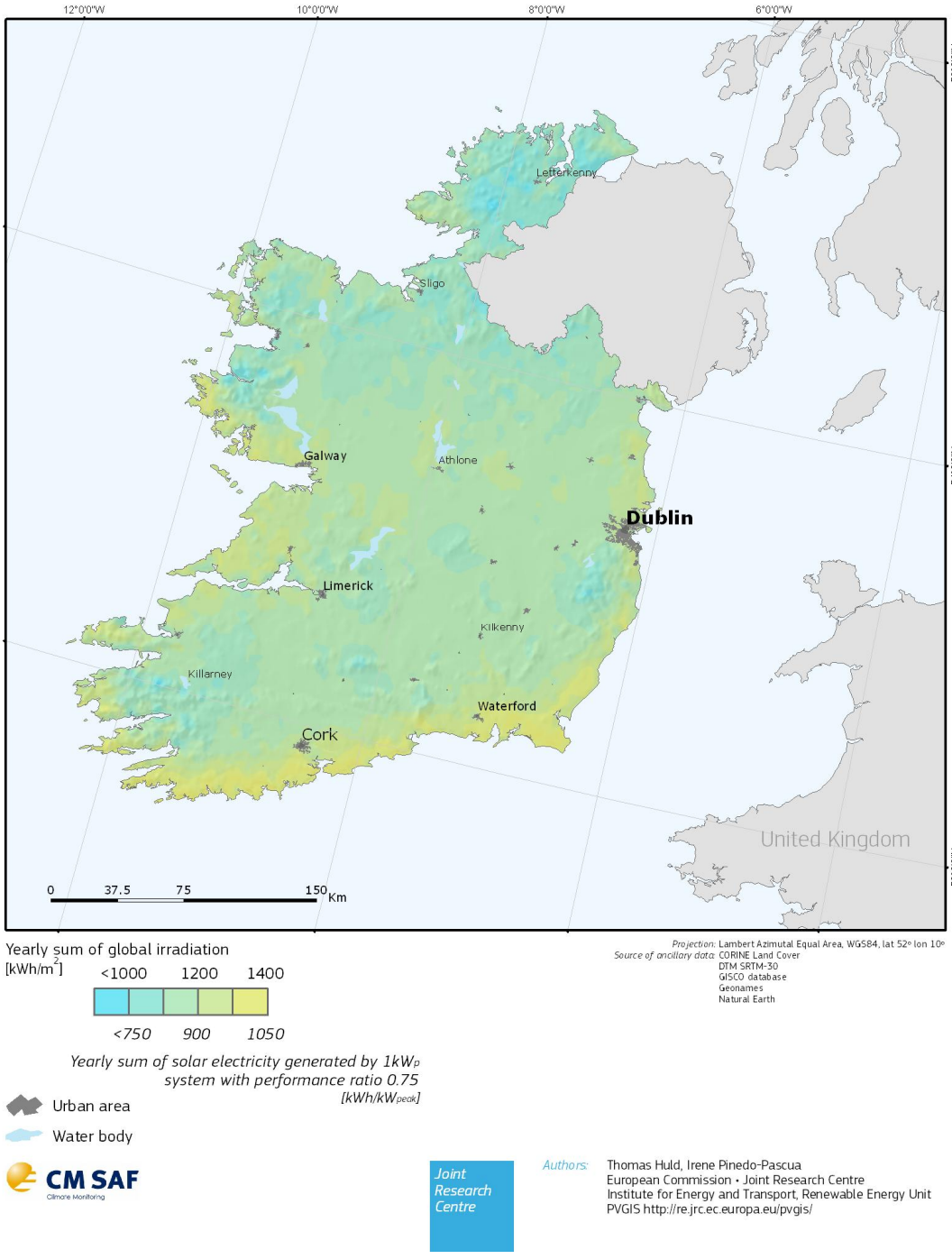

Fig. 6. Ireland global irradiation and solar electricity potential – optimally-inclined photovoltaic modules [9]

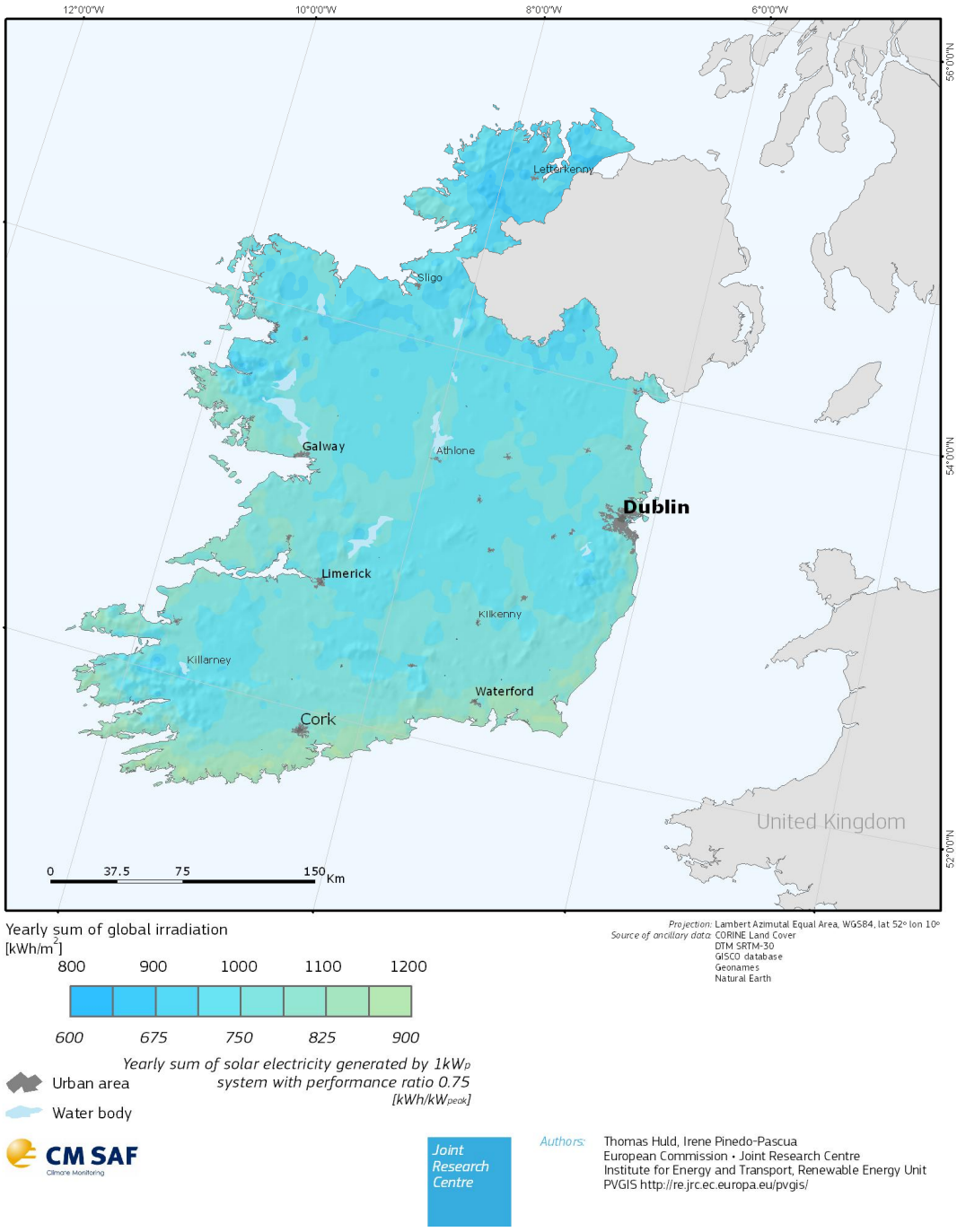

Fig. 7. Ireland global irradiation and solar electricity potential - horizontally mounted photovoltaic modules [9]

Payments/benefits are not being shared with local communities, e.g. solar PV on public buildings and the current constraints on community investment and shared ownership of renewable energy in Ireland may include [10]:

- access to the national electricity grid,
- get paid for the electricity they export,
- access to finance,
- financial and economic incentives such as tax incentives, VAT exemptions and investment schemes,

- lack of economically affordable access to the electricity grid,
- restricted choice of legal structures to facilitate community investment,
- lack of clarity in the planning process, and
- the restricted powers of local authorities to invest directly in wind energy projects.

3.1.3 Visual impact

Ground-mounted solar panels may require large areas for solar radiation collection, causing some visual impacts (however being visible doesn't mean necessarily being intrusive, e.g. the farm may be screened with trees or otherwise not overlooked).

In solar power plants producing electricity, the main visual impacts can come from the central receiver systems and grid connection.

In Ireland solar needs 5.5 acres of land per Megawatt of capacity. 1 MW of solar on 5.5 acres can produce 876 MWh of electricity per annum, enough to power 300 homes for a year.

3.1.4 Ecological impact

The use of large areas of land for power facilities can affect vegetation and wildlife as in loss of habitat and affect species classified as sensitive [11]. Central concentrator power systems could be a danger to birds and flying insects can also be burnt when flying close to the reflector's area.

There is some evidence to suggest that concentrated solar power installations can cause bird fatalities through collisions and burns [12].

3.1.5 Costs

In Ireland, solar PV is the only renewable energy technology that does not qualify for State subsidy, which will limit the investment and the evolution of the industry [13].

3.1.6 Intermittency and storage

The availability of sunlight is not consistent and solar power has a low capacity factor (measurement that compares produced energy with the energy that it would produce if operating at full capacity for the same amount of time) comparing with other sources of energy Table 1.

Photovoltaic and concentrated solar power have some of the lowest capacity factors of any major energy source.

Table 1. Capacity factor of different energy sources [14]

Energy source	%
Photovoltaic	20%
Onshore wind power	37%
Concentrated solar power	38%
Hydropower	45%
Combined cycle gas plant	87%
Nuclear	90%
Geothermal system	90%
Large coal plants	93%

Intermittency of solar energy may have a significant impact on electric grid reliability. When solar provides less power than was forecasted, grid operators have to run decisions in response to intermittent renewable output.

Intermittency will require storage solutions in the Irish electricity system (as with other intermittent energy sources). Currently a variety of technologies can be used such as pumped storage hydroelectricity, compressed air storage, battery storage and thermal storage devices. However EU's Energy Roadmap 2050 confirms that storage technologies remain critical, and that future integration of Renewable Electricity (RES-E) will depend on increased storage capacity. Finally, the costs still too high and lifetimes need to increase [15].

3.2 Solar Heat

3.2.1 Market awareness

Solar heat is still considered as a new technology. Consumers and investors do not realize the benefits, such as cost effectiveness, benefits for society, energy bills and fiscal incentives.

4. ARGUMENTS FOR

4.1 Solar Electricity

The supporting structures of solar PV occupies less than 1% of the land area used and the remainder of the infrastructure occupies less than 5%. Therefore around 95% of the land is available for vegetation growth and can support agricultural activity as well as wildlife. So it is possible to have both economic and ecological benefits [16].

4.1.1 Agriculture

Solar farms occupy less than 30% of leased area and allow land-use like grazing small livestock such as geese, chicken and sheep, accommodating a livestock density that supports rural business [16].

With regard to geese and chicken, they can graze and take shelter around the solar panels and live safely in the area. Solar farms allow energy production with no emissions, no moving parts and no noise.

Similarly solar farms do not reduce the number of sheep that can graze in the area.

The solar panels provide shelter from adverse weather and airborne predators.

At the end of the solar farm's life the steel frames can be pulled out of the ground easily and the land will be as it was - the construction is 100% reversible.

4.1.2 Biodiversity

Biodiversity is the variety of plant and animal life including ecosystems, and life communities and genetic diversity [17].

A solar farm can help to promote and conserve biological diversity. First, through careful use of environmentally sensitive, species-rich habitats, it can reduce or avoid detrimental effects on biological diversity. Secondly, by changing the use of intensively farmed land, it can in some circumstances improve a site's ecological value considerably. This is true also in the context of agricultural land and peat-land regeneration [17].

The land on which the panels are installed can also be used for bee keeping, wild flowers increasing the available habitat vital to the lifecycle of bees.

Further, wildflowers provide valuable sites for endangered bird's species. Lastly, increased biodiversity brings opportunities for recreation leading to improved health and well-being.

The German Federal Agency for Nature Conservation (BfN) commissioned a study on the impacts of solar farms on nature and the landscape. Research carried out at six solar parks analysed the impacts on vegetation, landscape and selected groups of animals. The study found that the negative impacts of solar parks on nature and landscapes are small. It highlighted the fact that solar parks built on intensively farmed land in particular can improve the environmental value of a site [17].

4.1.3 Planning

With a good planning solar energy can be deployed with minimal disturbance and be fully reversible, after the project life of 25 to 30 years. Planned sensitively, solar can deliver a net planning and biodiversity gain [18].

4.1.4 Community benefits

Solar energy can play in important role in the energy transition to a low carbon future and it can be used especially in rural communities as a way of ensure energetic independence through the implementation of energy co-operatives.
A strong community energy industry, will [19]:

- Reduce carbon emissions from the energy sector,
- Provide local investment opportunities,
- Ensure local investment money stays in local communities,
- Generate local jobs,
- Build strong and resilient community networks, and
- Help Ireland to meet renewable energy targets.

4.1.5 Costs

Ireland is the fourth most expensive country in Europe to buy electricity [7] and while energy costs are raising, renewable energy costs are falling including solar energy costs. The costs fell more than 80% in the last 5 years and more reductions are expected. In the future, solar energy is expected to become the cheapest electricity source.

Therefore falling costs are increasing deployment, and accelerating technological progress. With this the financial attractiveness of installing solar PV panels is increasing, allowing a reduction on consumer's electricity bill [20]. Fig. 8 illustrates cumulative global solar photovoltaic deployment and solar photovoltaic module prices between 2010-2014. While solar PV cumulative installed capacity is increasing, global average module selling prices are decreasing.

Finally, from the investor point of view, this technology presents a very low risk of investment

and a short payback time. Also, as it is a reliable source of energy it attracts investments.

4.1.6 Environment and footprint

Solar energy technologies have low GHG emissions in comparison to fossil energy sources, so solar power can be used instead of fossil fuels and can dramatically reduce greenhouse gas emissions.

Solar PV has a minimal impact on the environment, since land can be used for agricultural uses. It does not produce any pollutants and is one of the cleanest sources of energy worldwide [21]. At the same time it can contribute to the 2020 targets and reduce Ireland's carbon footprint.

4.1.7 Health

The air and water pollution emitted by coal and natural gas plants is linked to breathing problems, neurological damage, heart attacks and cancer [22]. According to U.S. Department of Energy [23] burning fossil fuels for energy adds pollutants into air contributing to childhood asthma and other health and environmental problems.

Generating electricity from renewable energy rather than fossil fuels offers significant public health benefits. It helps to reduce carbon dioxide emissions and other pollutants in the atmosphere and the overall healthcare costs [22].

4.1.8 Energy security

85% of Ireland's energy was imported in 2014, costing €5.7 bn, 97% of which were fossil fuels. Ireland's overall energy use and related CO_2 emissions increased by approximately 5% in 2015 [21].

With the volatility of oil prices energy costs are forecasted to rise, creating multiple threats to energy and economic security [24].

On the other hand, solar energy is predictable and can be used as a reliable energy source, providing energy independence especially to remote areas. It has the potential to contribute between 10% and 20% of Ireland's renewable energy generation by 2020 and contribute to security of supply by providing predictable and reliable electricity generation [24].

4.1.9 Energy bills

Solar power can create energy citizens, helping householders and businesses pro-actively manage their energy costs and cut household electricity bills by 50% [21].

4.1.10 Jobs

On average, more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels [26].

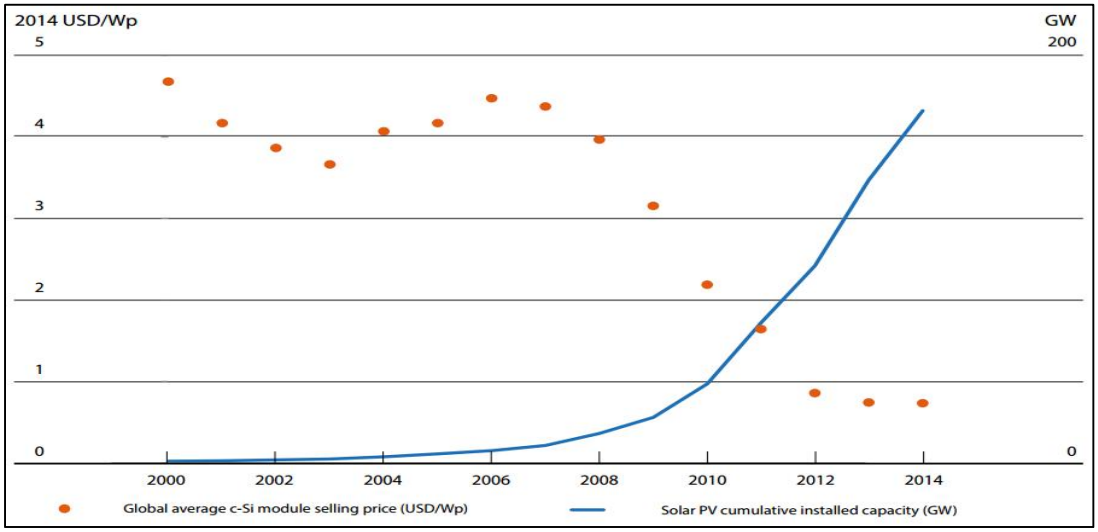

Fig. 8. Cumulative global solar photovoltaic deployment and solar photovoltaic module prices between 2010-2014 [25]

The International Renewable Energy Agency estimates that 11.3 direct jobs are created for every MW of solar capacity installed, 11 in construction and 0.3 in operations and management [24]. Up to 7,300 direct jobs would be created and sustained with the rollout of a supported solar sector in Ireland [21].

4.1.11 Meet 2020 targets

Ireland's 2020 renewable energy target is to increase the final energy consumption from renewable energy sources to 16%. This target will be made up of contributions from renewable energy in electricity (RES-E), renewable energy in transport (RES-T) and renewable energy for heat and cooling (RES-H) [15].

Renewable energy sources such as wind, hydro and solar energy can be used as a pathway to achieve these targets.

4.1.12 Noise and emissions

Ground-mount solar panels do not have moving parts and do not generate noise or emissions. Even during the construction activity the noise is not significant.

4.2 Solar Heat

4.2.1 Auto – generation

Solar heat is suitable for domestic consumption. Some citizens have a strong desire for supplier independence and have their own green agenda. Micro-generation can be seen as a safe and independent way of producing electricity, especially in remote locations and as a power backup.

4.2.2 Visual impact, noise and emissions

Solar panels do not have moving parts, do not generate noise or emissions and can also be integrated in buildings. According with Department of the Environment, Heritage and Local Government [27] solar panels create a low visual impact making them particularly suitable in urban areas and can be integrated in all type of buildings – residential, industrial, commercial and public.

4.2.3 Costs

In 2014 Electricity Supply Board (ESB) closed the pilot scheme to support customers to install domestic micro-generators (solar PV). However the scheme was extended until 31st December 2016, and it has a payment rate of 9.0 cent per kWh. Solar heat costs presents low investment costs for users and those who produce most of their heating from solar will get payback within 7.5 years. Solar heat currently is supported in Ireland with up to €1,200 grant [27].

4.2.4 Energy bills

With a contribution from solar energy, bills are reduced. Self-production also allows export of energy to the grid, depending on the size of the solar system (though at present there is no tariff for micro-generation, therefore no payment to the producer).

5. TWO IRISH CASE STUDIES

In Ireland, 40% of energy generation must come from renewables by 2020. An established solar sector could easily generate 20% of the country's overall renewable electricity. However, solar PV is the only renewable energy that does not qualify for a State subsidy [18].

5.1 Nenagh Town Park (45 kWp)

The largest PV project in Ireland, completed in October 2014 is located in County Tipperary. Nine public buildings in Tipperary have benefited from the installation.

> *Tipperary County Council is very pleased with the results that are now emerging after only one year into this project. We are proud that we can run our public buildings using clean sustainable energy. This photovoltaic project has delivered more than we had anticipated, not only in electricity and cost savings, but also influencing others to take on similar projects. We would recommend to others that they should actively consider PV as part of their cost, efficiency and sustainability goals [28].*
>
> *We're delighted to have been involved in the first large PV project in the state. The increase in the number of organisations that are now installing PV has demonstrated that this Tipperary County Council project has been a catalyst for change [28].*

5.2 The National Heritage Park (25 kWp)

The Irish National Heritage Park at Ferrycarrig (Wexford) is in the process of installing 102

ground and roof-mounted solar panels which will significantly reduce its energy footprint and bills [29]:

> *The heritage park currently has an ESB bill of around €36,000 which will hopefully be halved once the whole solar array and other work comes on stream.*

6. INTERNATIONAL CASE STUDIES

6.1 Solar Farm with Community Benefits

6.1.1 Westmill solar (5 MW)

Westmill Solar Cooperative is the first large scale community-owned solar farm in United Kingdom and it has 1,658 members. It has over 20,000 PV panels on 30 acres and generates 4.8 GWhr/year of clean electricity, enough to power 1,400 homes and to prevent 2,000 tonnes of carbon dioxide emissions annually [30].

The solar farm is rated at 5MW and it offers to local people the opportunity to share in the direct rewards of the project. It provides benefits for the area such as boosting the local economy by making sure that profits stay in the area, encouraging visitors and raising the local area's profile [30].

6.2 Belfast International Airport

6.2.1Crookedstone solar farm (4.83 MW)

The first solar farm connected in Ireland was completed in February 2016 in Co. Antrim, Northern Ireland and connects to Belfast International Airport. This is the largest UK airport solar project.

The project is a 4.83 (MWp) solar farm, connected directly into the private network of Belfast International Airport, providing 27% of the airport's annual electricity demand. The energy provided will allow savings of 2,100 tonnes of carbon emissions each year – equivalent to taking 469 cars off the road [16].

> *As a business we are committed towards sustainability, and being able to procure solar electricity is a huge benefit, not only towards lowering our carbon footprint but reducing our operating costs and providing pricing certainty for the future. We need certainty of supply, capability of supply but it also has to be the right price and Lightsource demonstrates they are the right long-term partner for us. We were delighted that even on the first day of connection, the solar farm generated more power than we needed, and the airport ran for 9 hours on just solar power alone [16].*

6.3 Solar Farm with Land and Agricultural Benefits

6.3.1 Crinacott solar park (6.8 MW)

Crinacott Solar Park is a 6.8 Megawatt plant with 28,608 solar panels which provide energy to 1,800 households and is located on a working farm. It was commissioned in 2013 and took just six weeks to construct. Sheep on the farm are able to graze around the installation. This keeps the land around the panels maintained and the farmer does not lose valuable grazing acreage. It also acts as a shelter for the sheep during adverse weather conditions [16].

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

1- Ireland has a huge potential for solar PV production. Solar radiation in Wexford is 78% of the level enjoyed in Madrid and France.
2- Solar energy can contribute to 2020 greenhouse gas emission targets and play an important role in Ireland's overall energy mix providing a reliable and secure source of energy when combined with a non- intermittent source of energy.
3- The falling costs of solar modules make it more viable and affordable.
4- Irish Energy Policy should focus more on solar energy in Ireland to promote and implement it.
5- Benefits are raising from solar farms and should be shared with local communities.
6- Awareness campaigns and guidelines for planning are needed to ensure an efficient implementation of solar energy in Ireland.

7.2 Recommendations

- **Ireland's targets-** The government should decide targets for solar power and heat for domestic and industrial use. Solar energy could account for 10% of renewable energy generation capacity by 2020, in Ireland.

- **Planning-** Consultative planning process involving local communities and the stakeholders should be developed to make sure that mistakes made with planning for wind farms will not be replicated with solar farms.
- **Financial support-** The government should encourage and support the development of solar PV in Ireland and support the development of solar energy through financial schemes.
- **Facilitate connection to the grid and agree tariffs-** ensure community energy groups have grid access, can connect their project and get paid for the electricity they export.
- **Energy citizens-** Engaging citizens and investors is fundamental for the transition to a low carbon future and for the development of solar energy in Ireland. The Government needs to play a role in this transition and should focus on the priorities of social acceptance of renewable energy sources and citizens education, particularly as a way of reducing demand.
- **Community ownership-** The development of local energy co-operatives it's a way of domestic and industrial auto-production and at a grid-scale, but with direct benefits for the local communities.

Solar energy is an essential part of the decarbonisation of energy production in Ireland and fundamental for the transition to a low carbon future.

Solar energy is an important renewable heat and power energy source. Ireland's energy policy should focus on stimulation of the use of solar energy to accelerate the transition to a low carbon energy future while ensuring buy-in from communities in the implementation of such policies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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ANNEX 1

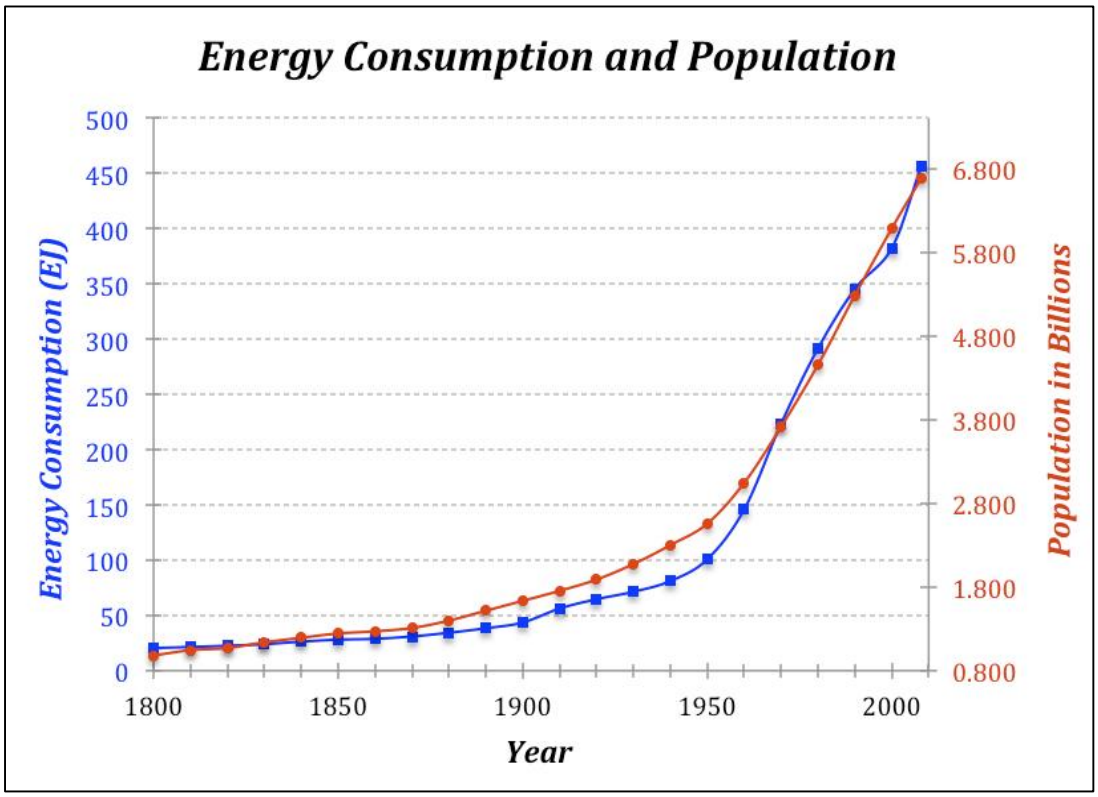

Fig. 9. Energy consumption and population [4]

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