UKWA
The Voice of The UK Logistics Industry

INVESTMENT CASE FOR ROOFTOP SOLAR POWER IN WAREHOUSING

August 2022

Introduction & scope of work

SYNOPSIS

This research project, commissioned by UKWA, investigated the overall case for installing rooftop solar photovoltaic (PV) systems in the warehousing sector. Warehousing has steadily been increasing its energy efficiency over the last 10 years, through improved lighting, electrification of material handling and system efficiency; however, rooftop solar projects have expanded more slowly. As the warehousing sector possesses approximately a third of all commercial roof space it has a large potential role to support the rollout of solar PV generation.

This report summarises the potential benefits for rooftop solar PV in warehousing for the sector's key players and the overall national and local benefits. The key barriers are described, future opportunities for increased deployment have been explored. Finally three priority areas addressing key barriers have been identified.

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Executive summary

What are the key benefits of rooftop solar on the UK's warehouses?

Warehousing is in a unique position for solar power, providing an unparalleled amount accessible roof space close to industrial and residential centres.

Rooftop solar PV provides, lower and secure electricity costs, reduced environmental impact, no additional land use and increased asset value and efficiency.

National and local benefits

UK warehousing has the roof space for up to 15GW of new solar, which would **double the UK's solar PV capacity.** This could meet National Grid's minimum requirements for solar expansion by 2030 according to their 2022 future energy scenarios (FES), producing up to 13.8 TWh of electricity per year enabling the warehouse sector to become a **net producer of green electricity.**

Rooftop solar PV in warehousing can play a significant role in delivering **local renewable energy**, particularly in urban areas where limited alternative options are available due to land and planning constraints.

The UK's 20% largest warehouses can provide 75million square metres of roof space, avoiding the need to develop new land **equivalent to the footprint of 500,000 houses.**

Industry benefits

Commercial electricity prices have doubled since the start of 2022 and are set to continue to rise into 2023. Solar PV can **reduce annual electricity costs by 40-80%** and protect occupiers against future electricity price rises while preparing for increased demand from electrification of heat and transportation.

In aggregate rooftop solar PV has the potential to save the industry **£3 billon per year.**

Rooftop solar PV presents the sector with a unique opportunity to significantly **reduce environmental impact,** potentially reducing CO_2 emissions by **2 million tonnes/year** while also providing a good financial investment.

For owners and landlords solar PV has a major role in **levelling up the UK's warehouses** increasing the value and desirability of the warehouse assets. It also supports the drive for increased efficiency and meeting energy performance regulations.

Executive summary

What are the barriers and future opportunities?

Investment costs, low electricity demand and grid connections are the main barriers to systems, and a culture shift is required to develop larger installations.

Electrification of heat and transportation will increase the need for low-cost electricity and improve solar PV economics in warehousing.

Improved aggregation and energy storage will enable larger solar PV arrays.

Key barriers

The low warehousing typical **electricity demand** limits the economically viable installation size and therefore the viability of using the full roof area. However up-front investment costs can remain high.

Electricity **grid network connections availability** can limit the maximum system size, incur costly upgrades and even prevent projects where grid constraints are very high.

Larger installations require adopting different market risk as a power producer, either through outsourcing or a **culture shift** in the sector to see warehouses as **solar power plants** and maximise installation size**.**

Legal **agreements on repair and maintenance** to manage landlords and occupiers liability may delay and complicate installations. This can make some smaller projects uneconomic.

Future opportunities

Electrification of **heat**, new automation systems and critically electric **transportation** could significantly increase electricity demand in warehousing. This will **improve the economics** of rooftop solar through increased self-consumption.

Increasing initiatives to **streamline the aggregation** and resale of excess renewable energy from smaller facilities in local communities will enable **higher incomes** from exported power, allowing larger systems to operate more economically.

Reduction in the costs of **local energy storage** could allow **greater flexibility**, improving self-consumption and reducing impact on local network infrastructure.

Warehousing, net zero and rooftop solar PV

Why is now the time to investigate rooftop solar for warehousing?

Warehousing, net zero and rooftop solar PV

A range of drivers are improving the attractiveness of solar PV

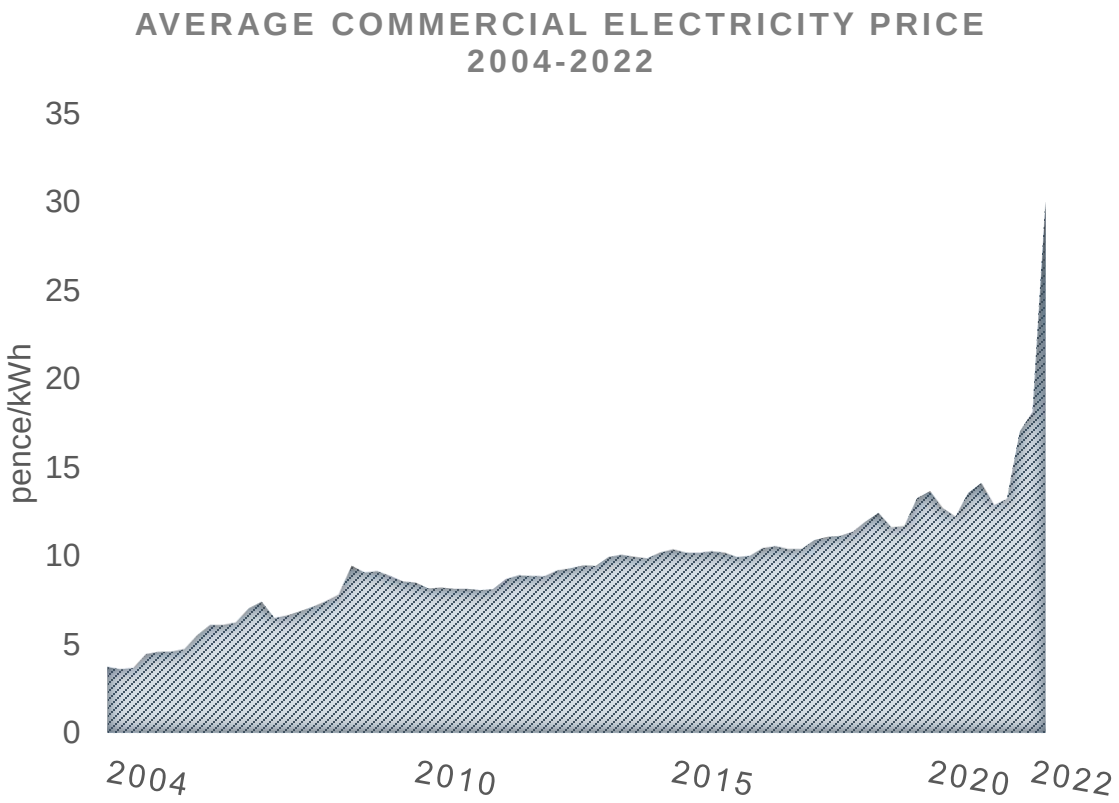
Solar is expected to expand greatly through the 2020's to support the transition to net zero. Warehousing has a unique asset to support the rollout.

In the UK, following the end of the Feed-in Tariff (FiT), and the subsequent market drop in 2018/19, installations are increasing again and are forecast to rise through to 2025 at least.

A combination of increasing energy prices, the drive to net zero and the prospect of heat and transport electrification means there is a strong need for low cost, low carbon and reliable electricity in the warehouse and logistics industry.

Solar PV UK rollout expanded significantly in the early 2010's due to generous feed-in tariff support. However, as this subsidy was reduced and ultimately removed in 2019, there has been a significant downturn in solar installations.

Solar panel cost reduction combined with energy price increases is improving the economics making solar PV more attractive to business, resulting in installations rising in 2021 and 2022.



Source: BEIS, 2022 Q2 price through consultation

Warehousing, net zero and rooftop solar PV

Why is now the time to invest in rooftop solar?

UK solar capacity is expected to increase two or threefold over the next 10-15 years to support the UK's net zero ambitions.

Solar installations are expected to rise to meet the UK's net zero ambitions. Analysis from National Grid[1], the Climate Change Committee[2] and National Infrastructure Commission[3] model a **doubling of solar capacity by 2030**, with some scenarios requiring much higher deployment. The UK Government published its Energy security strategy in April 2022[4], **proposed a five times in increase** in solar by 2035.

A major question is **where all this new solar capacity will be built;** over the last decade the majority of solar installations have been utility-scale ground-based systems, usually on farmland. With growing pressure on food security and housing there is an increasing need consider commercial rooftops as a priority for locating PV capacity.

While regulatory ambitions and the market conditions for solar are improving, there **remain barriers to unlocking the full potential** opportunity of the UK's commercial rooftops and, in particular, the unique position in the warehousing logistics sector which has the largest combined commercial rooftop space.

This report summarises the potential **benefits** of rooftop solar in warehousing sectors key players and the overall national and local benefits. The key **barriers** to solar deployment are described and **future opportunities** for increased deployment are explored.

Benefits of solar PV

An overview of the key benefits of solar PV at the national and local level and the misaligned benefits for warehousing occupiers and landlords

National benefits for rooftop solar in warehousing

What is the potential across the UK?

Warehousing provides a unique opportunity for large scale rooftop solar deployment, with approximately one third of the UK's total non-domestic buildings' roof space.

Rooftop solar power could transform the UK warehouse sector into a net producer of renewable electricity

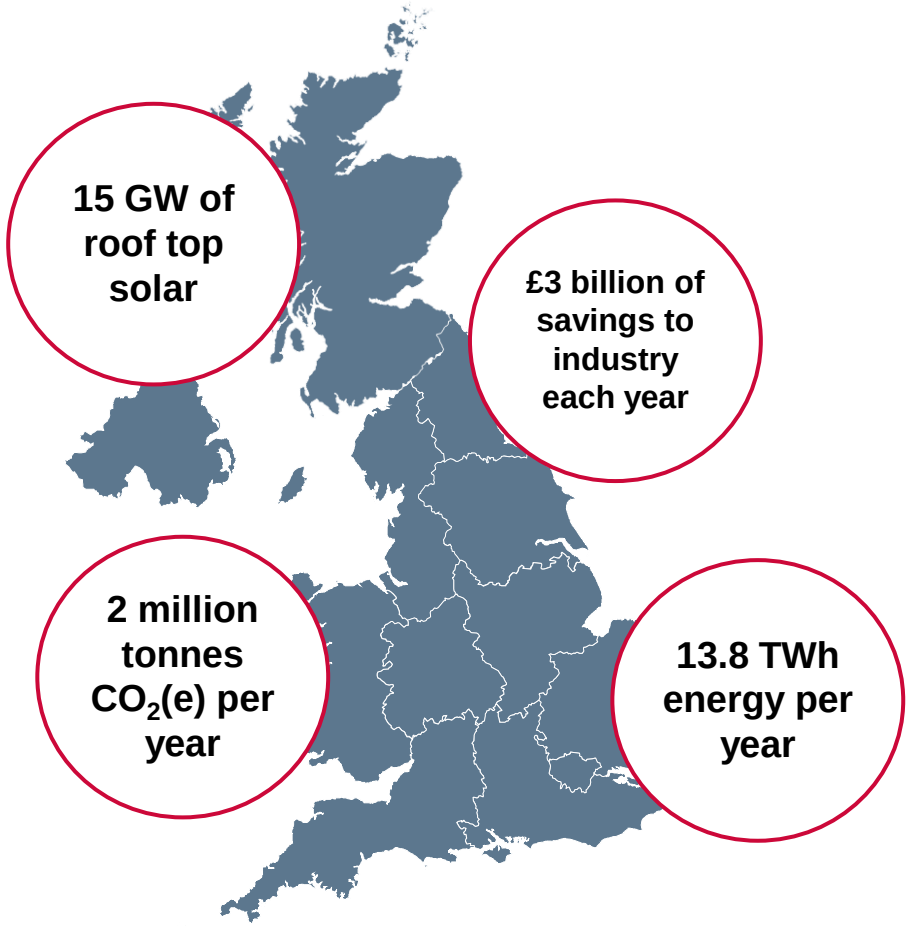
With **only the largest 20%** of warehouses there is enough roof space to **double the UK's solar generation capacity** from 14 to 28 GW

National Grid's future energy scenarios[1] consider 12-29 GW of additional solar is required by 2030; warehousing could play a major role in the next decade.

With 15 GW of solar fitted, the warehouse sector could **generate ~13.8 TWh** of renewable electricity per year – transforming the sector from **net consumers to net producers.**

This could save the logistics business **£3 billon per year**, through energy savings and additional income from energy sales.

This could avoid emissions for up to **2 million tonnes of CO_2(e) per year** by reducing reliance on grid electricity, which is still heavily supported by natural gas.



National potential of rooftop solar on UK's warehousing
Calculations in annex

Benefits for occupiers

Why should tenants be pursuing rooftop solar on their sites?

Rooftop solar is one of the most cost-effective CO_2 reduction measures for warehouses.

Payback times for solar PV have been falling due to increased electricity costs.

Third party financing options enable installations without initial capital investment.

Environmental, social and governance
Meet environmental impact and corporate social responsibility targets. Solar PV is a direct solution to decarbonisation compared to outsourcing or offsetting.

Immediate and future cost reduction
Payback for upfront cost can be as low as 4 to 6 years.[5] Driven by currently high energy prices. Third party financing options can provide immediate annual cost savings without investment

Market and regulatory risk management
Meet customer requirements for reduced supply chain carbon footprints. Ensure operations are not disrupted later to upgrade facilities to meet upcoming efficiency regulations.

*A 500 kW solar PV system (suitable for 100,000 sq. ft. warehouses) can **reduce CO_2** emission by around **65 tonnes per year**, equivalent to driving an HGV approximately 87,000 km

Benefits for landlords

Why should landlords invest?

Solar PV is a complementary investment to commercial property in its own right, while providing additional benefits.

Increased asset returns, value, customer attractiveness and meeting environmental obligations.

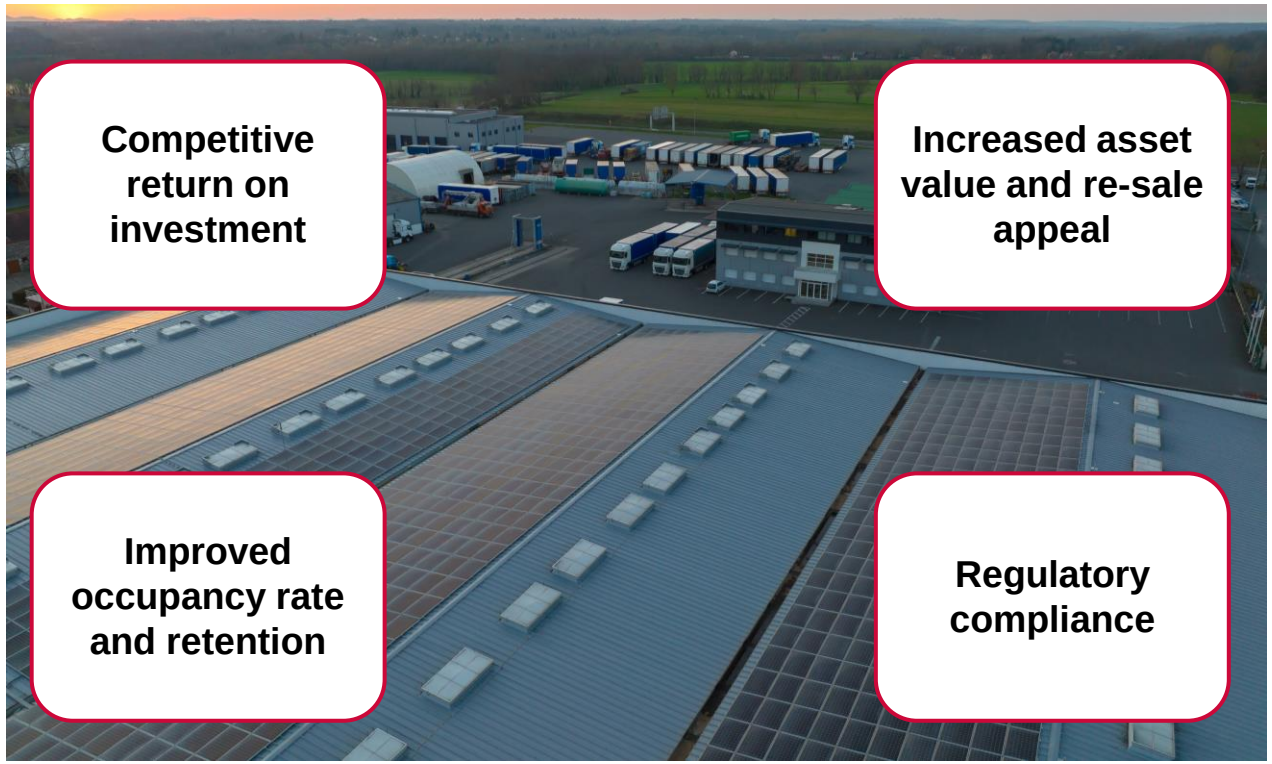
Rooftop solar PV de-risks meeting future regulations and prepares assets for electrification.

Return on investment
Rooftop solar PV is a good investment opportunity in its own right, providing an internal rate of return of 10-15%* on self financed projects.

Asset value and desirability
Solar PV systems have lifetime of 25 years adding to the total warehouse asset value. Increased ESG interest by institutional investors is leading to CO_2 emission-based investment criteria.

Lower energy costs are more attractive, increasing occupancy rate

Regulation compliance and investor attractiveness
By 2030, non-domestic minimum expected energy standards (MEES) is planned to be EPC B, with EPC C rating required by 2027. Solar PV can help meet this obligation while providing good financial return.



- The IRR is dependent on location, building size, orientation, onsite energy demand and through life electricity prices.

Benefits for local areas

Why should local communities support rooftop commercial solar?

Warehousing is unique in providing extensive commercial rooftop space in urban and sub-urban areas, where other renewable energy options are limited.

Rooftop solar on warehousing could be a significant element in local energy system planning.

It is ideally placed to meet the local net zero targets for 2030 as a ready to deploy technology.

Local area net zero planning targets
Local Government must play a major role in meeting UK's net zero targets.[6] In England, 91% of principal local authorities have commitments to decarbonise.

Warehousing rooftop solar PV provides large footprints in urban and sub-urban areas. The UK's 20% largest warehouses can provide 75million m^2, avoiding the need for additional land, equivalent to the footprint of 500,000* houses.

Attractiveness for businesses
Encouraging solar PV will reduce energy costs for business, providing greater business competitiveness and resilience in the local area. Local businesses will benefit from lower CO_2 emissions, increasing their attractiveness to customers through lower impact on the supply chain.

*Assuming average house plot area of 150m^2

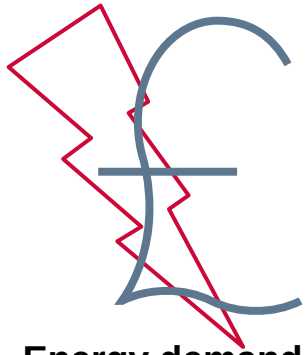
Barriers

Examination of the key elements preventing or slowing the rollout of solar PV in the warehousing sector

Barriers to scale-up

Four key barriers that slow commercial solar PV roll out

Most barriers reduce the size and potential uptake speed of solar PV in warehousing, rather than preventing installations.



Energy demand and economics

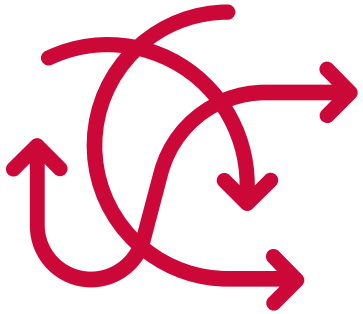
Energy demand in warehousing is relatively low per unit floor area and does not match solar PV generation profiles.

Optimum economics are linked to higher on-site energy demand, therefore limit the economic optimum installation capacity.

Business model and contractual barriers

As the logistics market becomes more specialised and segmented it is harder for many operators and owners to justify investing.

Timing for installations with leases limits the window for installations being conducted.



Project complexity and commercial risks

The complexity of the process and design options can be challenging and require specialist input.

Full repairing and insuring leases create commercial barriers on liability for both tenants and landlords.

Local energy coordination and planning

Grid connection constraints are a major barrier to larger scale deployments and require local and national support.

Local energy planning to support installations and help achieve higher uptake is currently lacking.

Economics of solar power

What are the main costs, incomes and complexities?

Solar power economics are driven primarily by upfront cost and the degree of self-consumption.

Solar variability adds further challenges in size optimisation.

The typically lower value of exported power means smaller systems are favoured to maximise on-site consumption.

The principal economics of solar project are straight forward:
Costs included:

- Upfront planning and development
- Upfront equipment and installation
- Through life maintenance

Upfront costs are typically around 70-80% of the overall project costs.

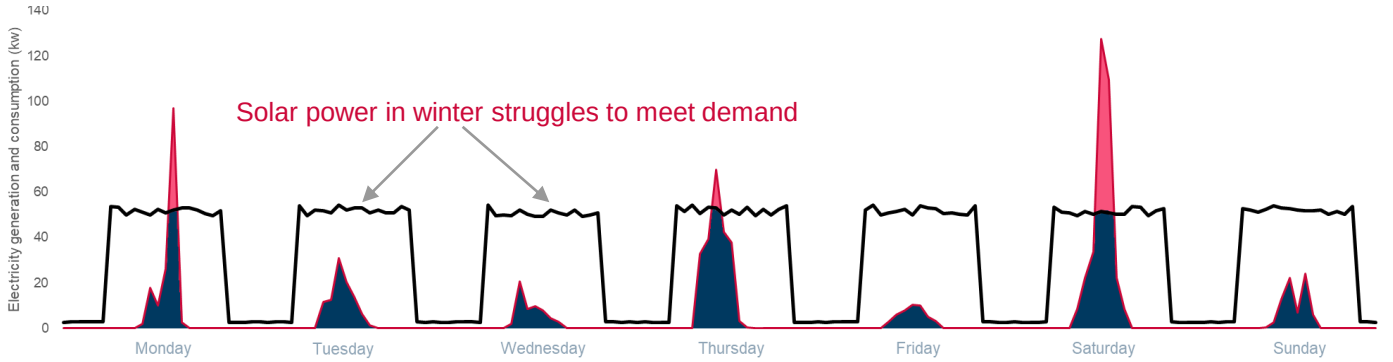
Income streams include:

- Self-consumption to avoid retail electricity costs
- Income from exported power.

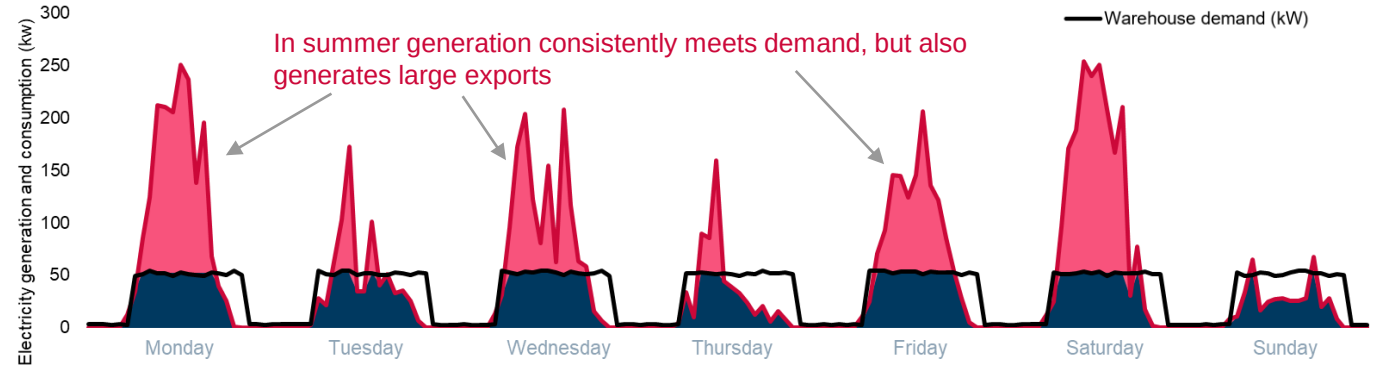
Avoided electricity costs are typically 2-3 times more valuable than exported power.

The complexity that comes with solar is due to its temporal and seasonal nature; it is challenging to match generation accurately with demand to maximise self-consumption. In winter there is low generation and in summer very high generation.

January week: example solar generation and consumption



June week: example solar generation and consumption



Illustrative examples – demand profiles simplified

Solar sizing and optimisation options

What is the impact on payback, profitability and emissions?

Understanding the primary aim of the project is important in determining the sizing approach.

Smaller installations with high self-consumption provide low risk returns, while larger systems can provide higher overall payback.

Optimise payback and return on investment

In this approach the solar system is sized to optimise the profitability of the solar system to balance payback time and system size.

This can generally be achieved by optimising for self-consumption and therefore the optimum PV array size is constrained by energy demand characteristics.

- Size(kWp): 150
- Payback (years) : 6
- IRR(%): 15%
- Energy (GWh): 3
- Carbon savings(tonnes): 500
- Net present value(25yrs):£303k

Maximise financial impact

A focus can be to maximise the net present return – this may reduce the profitability, but increase the overall return. While this increases the investment risk, the potential benefits are also increased.

This is typically constrained by grid connection and the potential for electricity exports and their value.

- Size(kWp): 400
- Payback (years) : 8
- IRR(%): 9%
- Energy (GWh): 9
- Carbon savings(tonnes): 1300
- Net present value(25yrs):£357k

Maximise environmental impact

Prioritising environmental impact aims to maximise generation to reduce CO_2 emissions as far as possible and therefore businesses' environmental impact.

This is primarily constrained by roof size and structure and the maximum allowable installation for the grid connection.

- Size(kWp): 1000
- Payback (years) : 12
- IRR(%): 3%
- Energy (GWh): 22
- Carbon savings(tonnes): 3300
- Net present value(25yrs):£317k

This is an illustrative example calculation, specific costs and payback is highly dependant on circumstances, assumptions in annex.

Business model and contractual barriers

How do existing warehousing business approaches deter investment?

Market segmentation, deters investment in solar generation due to the benefit being split by multiple parties.

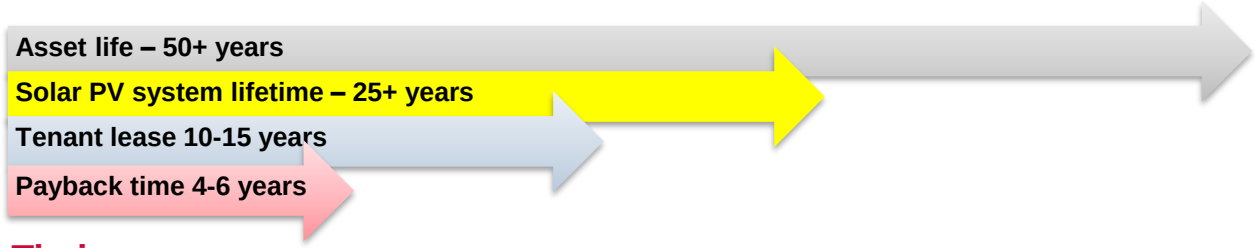
Long leases provide a short window for low friction contractual negotiations.

Business model and market segmentation

The warehousing market is increasingly segmented, in particular with the rise of third party logistic models requiring agile operations to manage short term customer contract risks (1-3 years) and shorter leases.

Solar PV projects are longer term investment 10-25 years and linked to the warehouse, this mismatch in timescales deters investment from occupiers.

Extracting the full benefits is challenging when ownership and delivery are separated. There is a need for standardisation to reduce interface frictions.



Timing

Some occupiers are keen to invest to reduce costs and environmental impact. However, justifying investment in property you don't own is challenging unless there is sufficient time to make a return.

- Lease durations are typically 10-15 years while the payback time for rooftop solar - typically 4-6 years - means at the start of most leases there is sufficient time to realise financial benefit, however this diminishes quickly over time
- When remaining lease duration approaches payback time, the perceived project risk is higher for tenants to invest.
- The ideal solar PV installation time is at the start of a new lease every 10-15 years to simplify the contractual negotiations.
- Older buildings with asset life of <25 years may not receive full benefit from solar and may also have higher cost installations.

Complexity and risk

What are the main risks that prevent, delay, or reduce installations?

There are a range of risks in installing a solar PV system, but as with any construction project careful planning and the use of experienced professionals can help minimise the impact.

Feasibility

In the feasibility phase, the key expenditures are feasibility assessment and surveys, design, legal costs. The key elements to address in this stage are:

- Structural: a professional survey is necessary to ensure chosen roof(s) can accommodate PV systems.
- Contractual: clear alignment between tenant, landlord or other parties either allowing rights for installation and roof access or commitment to resolve any issues identified.
- Energy audit: good understanding of the daily and seasonal energy demand of your building is critical for economic assessments.
- Engage solar company(s) to initiate early consultancy on solar design – key due diligence to select company to collaborate on detailed design and planning and permit applications.

Design and consenting

After establishing feasibility, a detailed site survey and financial modelling will be required to support a detailed system design. The next stages are:

- Application for grid connection permits: this critical stage can delay and limit the installation and therefore should be made as early as possible.
- Planning permission: this is rarely an issue for rooftop solar, as small scale solar is permitted development. However for installations >1MW there is specific requirement to apply for full planning permission this can take several months.
- Finalisation of legal agreements, including power purchasing agreements.
- Finalisation of financing options and internal project approval for the investment.

Installation, operation and end of life

With all consents in place installation of the system can begin. The following factors are key risks:

- Quality of installation: critical to the long-term performance of the solar PV system.
- Disruption during installation: careful planning can enable installers to minimise or eliminate installation disruption as much as possible.
- Damage during installation: agreements with the installers to ensure any damage during installations is repaired.

System operation requires:

- Through- life performance monitoring and maintenance.
- Financial monitoring and management of export agreement and contracts.

End of life:

- Decommissioning, dismantling and recycling costs.

Local energy coordination and planning

How is lack of local energy planning obstructing installations?

Local energy planning does not currently coordinate grid upgrades or facilitate local energy generation and consumption.

Grid connection permits are a major barrier to rooftop solar installations, increasing costs and constraining project size.

In some cases, these additions can prevent projects from being developed.

Grid connection permitting

When building any solar project over 16A per phase (3.68kWp for a single phase or 11.04kWp three phase) the local distribution network operator (DNO) must be informed and provide prior permission. In response to an application, DNO's typically respond in 4 ways:

- Proceed with no constraints or charges
- Constraints on maximum system size and export limitation, without requiring grid upgrade costs. (Verification costs are required)
- Requirement to upgrade grid connection infrastructure, some cost must be born by the solar project owner.
- In some cases constraints can be so tight as to prevent a project from being developed.

For smaller commercial systems (<100-250kWp), there is infrequently an issue with grid connections, but for sizes over 250kWp there is increasing likelihood that constraints and significant costs will be required, which diminishes project returns and increases installation time and complexity.

Local area energy planning

Deficit of local energy planning is acting as a barrier to commercial solar installations in warehousing.

As electricity usage and local renewable generation is increasing grid infrastructure needs to be upgraded to support the local community and businesses. These costs are typically shared through distribution use of system charges.

However when building solar generation projects, there is a currently a first come basis on access to the available capacity for free. Later project required to pay for upgrades that would typically be shared.

Solar PV has the potential to provide low-cost energy locally, increasing the value to the project owners, while also sharing benefits to local business/community energy costs. The matching of generation and customers is not currently coordinated and acts as a barrier.

Future opportunities

An overview of potential opportunities that will mitigate some barriers and enable increased benefits

Technology drivers

What technology changes will increase the attractiveness of Solar PV?

Increasing local demand and self-consumption could enable significantly larger installations.

Energy storage has the potential to offset grid connection limitations and improve economics as costs reduce.

Electrification of transport

Decarbonisation of light and heavy goods vehicles is likely to cause be the biggest increase in energy demand in the logistics sector in the near future.

Whether through direct electrification or hydrogen conversion, decarbonisation of 25% of the UK's HGVs alone would require between 60-100%(8-14TWh) of the current annual electricity consumption of the whole warehouse sector.

HGV electric charging or hydrogen generation on-site at warehouses could double the electricity demand, increasing the attractiveness of on-site solar PV generation through higher self-consumption and larger capacity systems.

Energy storage

On-site battery storage can improve solar PV financial viability by:

- Increasing the % of energy self-consumption and therefore increasing the economic value.
- Reducing the peak exports, therefore reducing the necessary grid connections or enabling larger installations.
- Opening up the opportunities for providing flexibility services and accessing new forms of revenue from the energy system.

Currently the capital cost of battery systems is typically too high to be justified for most installations.

However, as costs further decrease and the second life battery market grows, battery storage systems could enable significantly larger solar installations on a wider range of warehouses.

Automation and light manufacturing

The warehousing and logistics industry is already estimated to have the highest proportion of automation of any industry[7] and is forecast to grow dramatically in the next 5-10 years to meet the high and growing penetration of e-commerce in the UK retail industry. This trend is likely to further increase the energy demand in some warehousing.

However, the overall energy demand picture for automation and manufacturing is complex as some solutions can reduce demand for the same throughput while others increase demand but significantly increase the warehouse efficiency.

Economics and business models

Improving the value of exported energy

Self-consumption dominates the economics of solar power, which is challenging for low demand warehousing.

Increasing the value of export power, greatly increase the optimum size of solar installation.

Power purchasing agreements for export

Larger installations can take advantage of power purchasing agreements (PPA) to significantly increase the value and decrease the risk of energy exports.

Sleeved PPA allows the user to have little knowledge of the electricity market, working with energy suppliers to manage the purchasing and sale of the electricity over the network. A number of specialist PPA companies provide this service.

Aggregation and virtual power plants (VPP)

An emerging opportunity for smaller installations is the increasing capabilities of aggregators to combine smaller generators into virtual power plants.

In this approach partnering with third party aggregator allows the solar PV owner to achieve higher value export. The aggregator is able to achieve a higher value by combining several solar PV systems (and potentially other assets) into a single VPP that can either bid directly into the electricity market, can secure contract for difference contracts or can be sold through long term PPA.

Community energy

New business models and approaches for local energy markets such as peer-to-peer trading can allow significant improvements in export price. These approaches are new and could bring more risk and complexity.

More sophisticated options, such as collective self-consumption can allow local communities to work together, maximising use of local energy and minimising the impact on the local grid. The current regulation in the UK makes these approaches difficult to implement but this is likely to evolve.

Priority areas

What are the key priorities areas to alleviate barriers and enable widespread solar deployment

Priority areas

Identified priorities areas to enable widespread solar PV

Government can support solar PV deployment through tax incentives and electricity market reform and reduce barriers in accessing grid connections.

The industry must develop best practice approaches.

Investment costs

Whilst high energy prices are helping to improve solar PV economic performance, the investment costs are also increasing as solar panels installation is influenced by global inflation and supply chain pressure.

As 70%+ of costs involved in solar projects are upfront and interest rates are rising, financing these projects is increasingly challenging. In particular for small and medium businesses where cash flow is tight.

In April 2021 the UK government extended a super deduction on capital investment including solar panels, which will end in 2023. This could be extended to 2030 to support continued investment.

Grid connection permits

The UK grid is becoming more constrained with growing electricity demand and increased residential and commercial generation. This will increase costs when securing connection permits for rooftop solar and limit their viable size, therefore limiting the national, local and business benefits.

The department of business, energy and industrial strategy is currently reviewing the electricity market arrangements and Ofgem is consulting on the future of DNO/DSO structures.

These activities should address how new arrangements will improve planning and reduce grid connection barriers for deployment of commercial rooftop solar.

Industry perception, knowledge and best practice

The knowledge and perception for solar PV projects is fractured with challenges regarding risks, costs, legal issues and business models.

There is a need to provide best practice guidance to the industry for solar projects, especially in regards to contractual arrangements between tenants and landlords, and the opportunities for third party financing.

UKWA is providing a step-by-step guide for UKWA members outlining the overall process of developing a solar project, the key design options, economics financing and legal considerations.

Annex

References, calculations and acknowledgements

References

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3. Renewables, Recovery and Reaching Net Zero, national infrastructure commission 11 August 2020
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5. Solar Energy UK: Corporate buyers' guide (2022)
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7. THE ECONOMIC IMPACT OF ROBOTICS & AUTONOMOUS SYSTEMS ACROSS UK SECTORS, BEIS Research Paper Number: 2021/043

Calculations (1/2)

Installation and energy generation capacity

BEIS Non-Domestic National Energy Efficiency Data Framework has been used to estimate total warehouse floor area. This data shows 35000 warehouses over 1000 sq. m (~10000 sq. ft) in size, with a total floor area of 150 million sq. m and average energy use of 11.2 TWh (75% of 14.4 TWh total electricity use)

Assumptions:

- Roof area = floor area
- Solar peak capacity = 200kW/m^2 = 5000m^2/MW
- Roof space fitted = 50%
- Average load factor = 11%

Total peak capacity = (150,000,000/5000)×50% = 15000MW = **15 GW**

Annual generation = 11% × 8760 × 15GW = 13797 GWh = **13.797 TWh**

Carbon and cost savings

Carbon savings
The UK average grid carbon intensity is currently between 150-250g/kWh, mid point of 200g/kwh has been used. Solar PV carbon intensity is typically quoted at 50g/kWh.

- Carbon saving of 150g/kWh has been calculated

13,800,000,000 kWh × 150g = **2.07 million tonnes**

Cost savings
New commercial contracts for electricity supply are starting at 33 pence/kWh (June 2022). Minimum export rates are around 5-7.5p/kWh. Export contracts at the time of writing are 10-15p/kWh.
Assumptions:

- 50% average self-consumption
- 33p/kWh average self-consumption savings
- 10p/kWh average export income

7,900,000,000 kWh × 0.33 +7,900,000,000 kWh × 0.1 = £2,966,355,000 = **£3 billion**

Calculations (2/2)

Opportunity for occupiers

Grid electricity carbon intensity in the UK is typically around 150-250g/kWh in 2021 – 200g/kWh was used.

Solar electricity carbon intensity is around 50g/kWh, including construction, installation and decommissioning.

500kWp solar plant is estimated to make 433,000kWh/year.

433,000 x150 = 65.0 tonnes.

HGV truck emission around 750 gCO2/km: https://theicct.org/publication/co2-emissions-from-trucks-in-the-eu-an-analysis-of-the-heavy-duty-co2-standards-baseline-data/

Solar sizing optimisation

Scenario – ambient warehousing looking to invest in solar power with following characteristics:

- 100,000 sq. ft
- Location: UK Midlands
- Electricity usage: 30kWh/m^2/year
- Operating 7 days/week (6am-8pm)
- Flat roof, all panels south facing

Solar techno-economic assumptions

- Equipment and Installation costs - £1000-1500/kW (including site, electrical and grid connection costs)
- Inverter cost and lifetime -10% installation cost, 11 year life time.
- Solar irradiance data – PVGIS-SARAH 2
- Slope, Azimuth - 41/-11 degrees,south facing
- System losses - 21%
- Performance degradation - 0.5%/year
- O&M costs -10 £/kWp/year
- Maximum solar - 200W/m^2
- Maximum roof space coverage- 60%
- Discount factor - 5%

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- Solar Energy UK – *an established trade association working for and representing the entire solar and energy storage value chain representing a member-led community of over 300 businesses and associates.*
- ABP – *Associated British Ports operate 21 ports across the UK, supporting around 120,000 jobs. In 2021,17 of 21 ports have renewable energy generation projects, including 6.5MW of solar energy installed and new installations planned for 2022 and beyond.*
- Conrad Energy – *Conrad Energy's generation portfolio powers the equivalent of over a million homes from embedded, flexible generation projects, solar and battery storage. Conrad Energy has over 150 experts dedicated to supporting critical national infrastructure, enabling the UK's energy transition to net zero by 2050*
- Potter Space – *SME warehouse and industrial space developer, with five locations across the UK covering over 250 acres. Potter Space has completed five solar installation projects since 2011, with over 3000 sqm of PV panels installed.*

Please note the contents and conclusions of this report do not necessarily represent the views of any of these organisations.

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