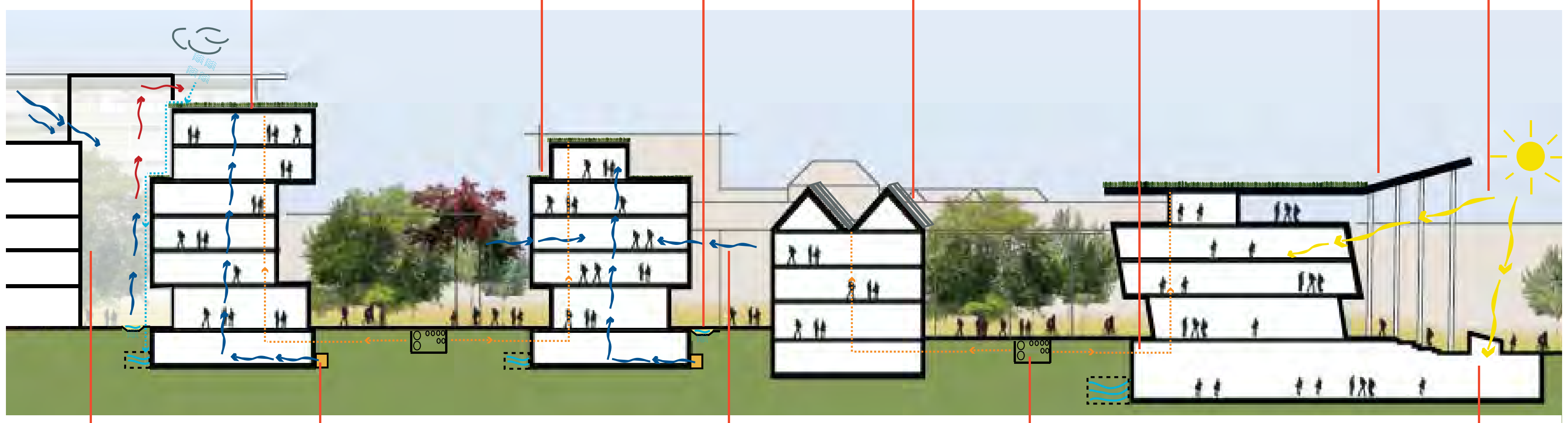
D_environmental sustainability



environmental sustainability overview: flexible fabric and visible systems

The development of the Grangegorman Quarter is based on the international best practices of environmental sustainability. Early, sustainable masterplanning decisions will be augmented by the requisite governmental requirements and best practices and decisions of the designers of the individual buildings.

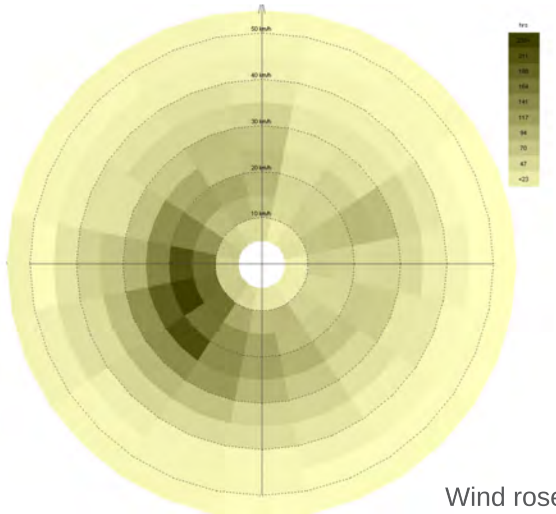
At the masterplanning level, buildings have been located and oriented to take advantage of natural daylight, reducing the need for artificial light. Building widths vary but narrow widths have been chosen wherever possible to further insure the penetration of natural light into the interior spaces. Courtyards generally open to the south to prevent the overshadowing of exterior landscaped space by buildings. The buildings have been located densely on the northern portion of the site, allowing the existing open space to the south to remain a naturally landscaped space. The open playfields have been linked to a more regional chain of open spaces allowing people and wildlife to find a natural system of pathways through the urban density of the city.

One of the major goals of the environmental sustainability strategy is to minimise energy demand and carbon emissions by creating an energy plan that allows the Grangegorman development to become a zero carbon development by 2050. Therefore the energy plan for the Grangegorman development prepares for an eventual 100% renewable energy supply.

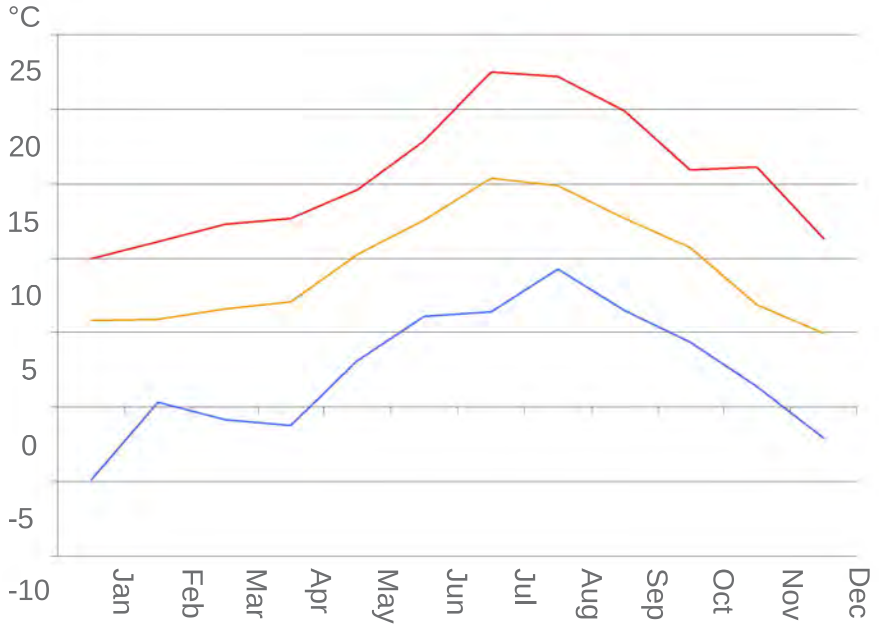
The basis of the initial energy plan is subdivided into two components: a site wide energy plant as well as an individual renewable energy plant for each building block. All heating, and a portion of the electricity, will be generated from a centralised combined heat and power (CHP) plant using biofuels and distributed to individual buildings. In addition, each of the individual buildings will provide hot water from hot water solar collectors located on the roofs of each building.

Additional energy producing and energy saving principles, standards and requirements have been introduced through this narrative. But while technology dependent concepts such as power generation from biofuel use and high visibility strategies such as wind turbines and photovoltaics have been considered for the plan, there are also other important energy and water saving principles that are based in sensible and sensitive early planning in the Masterplan.

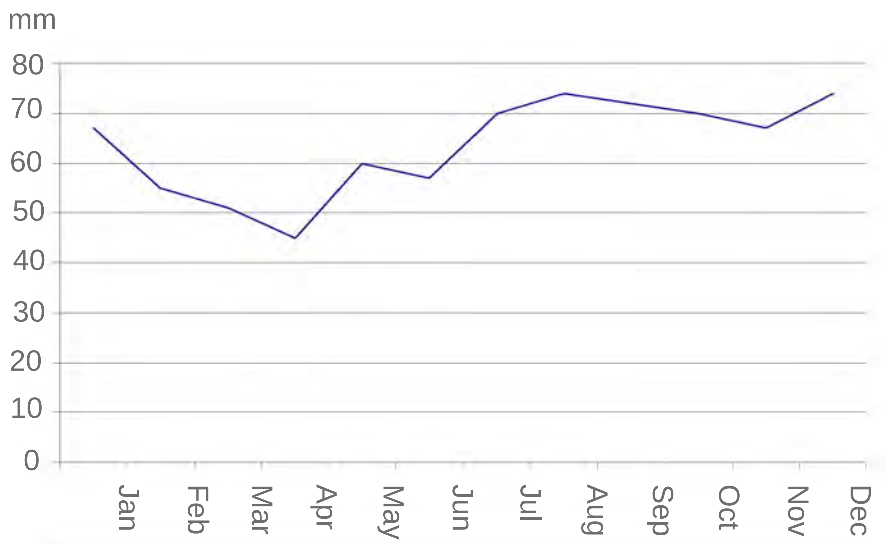
There are also environmental sustainability principles that relate to the quality of life the building inhabitants and neighbors should enjoy, such as indoor air quality, view corridors, noise reduction, pollution reduction, traffic reduction, and conservation of natural and cultural heritage resources. Some of these issues have been addressed in detail throughout the Grangegorman Masterplan and Masterplan Design Guidelines and the remainder have been detailed within this section. In addition to the energy supply goal, several key environmental sustainability principles have been developed for the project at the masterplanning stage:



Wind rose for Dublin



Monthly maximum average (red), average (yellow) and minimum average (blue) temperatures for Dublin



Average monthly rainfall for Dublin

- **sensible urban density and linking natural pathways**

The 73 acres site has been walled off from the city since the nineteenth century and is one of the largest undisturbed pieces of land in Dublin. It was important to maintain the existing healthy landscape elements, especially the large open fields to the south of the site by planning most of the new construction to the north of the site and creating an urban but sensibly dense design.

The River Liffey, Phoenix Park and the Canal are all important natural resources for the city. Linking these currently unconnected landscape pathways with the new Grangegorman Quarter strengthens the entire infrastructure, providing landscaped pathways for pedestrians and wildlife through the dense urban fabric of Dublin.

- **natural daylight, ventilation and wind protection**

The design of the building footprints, heights and layouts have been developed to allow maximum daylight to enter buildings, minimise overshadowing of each other and of landscaped areas and to minimise excessive wind.

- **preservation of existing natural and cultural heritage**

There are currently twelve buildings on the site that have been listed on the Dublin Record of Protected Structures. The re-use and re-purposing of all but one of these existing buildings not only conserves the embodied energy used in their initial construction and saves the energy that would be used to replace them, but helps create a connection to the past history of the site. Wildlife habitats and existing mature healthy landscaping have been studied and steps undertaken for conservation.

- **transportation strategies**

The Masterplan design encourages pedestrian movement over vehicular use. The concept prevents the general public from traversing the site in automobiles and allowing other vehicles to enter the quarter only via "shared surface" pavement where vehicles are subservient to pedestrians. The design has been oriented to promote strong connections to public transportation such as existing bus routes and the proposed LUAS line at the Broadstone Gate.

- **water management**

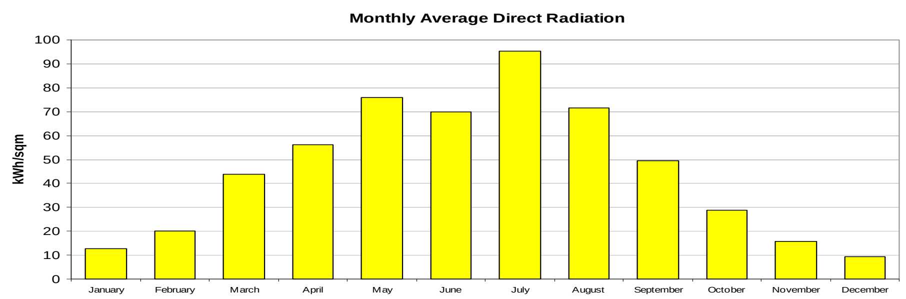
Water retention strategies such as swales and holding ponds have been designed to reduce runoff into the city system. This runoff has been incorporated into landscape features such as the water rill located in front of the Sports Centre. In addition, permeable surfaces have been incorporated in the outdoor public areas to allow water to return naturally to the aquifer below.

- **Renewable, long-lasting and environmentally safe building materials**

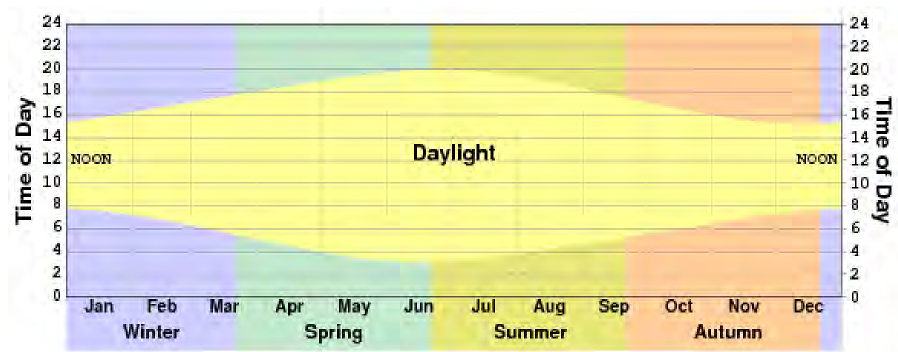
The Masterplan encourages the use of recycled and renewable building materials through the various energy efficiency and environmental sustainability standards that it is under the authority of. Using renewable construction materials prevents pollution and waste generation, creates new recycling industries and reduces landfill disposal and expansion. Using low VOC paints, formaldehyde free adhesives, and other safe building materials creates high indoor air quality and promotes greater health and efficiency for the occupants.

- **energy efficiency and sustainability standards**

Each individual building shall achieve a Building Energy Rating (BER) of A3 or better based on 2008 asset rating system, which corresponds to an Energy Performance Coefficient (EPC) of not greater than 0.50 compared to 2008 Building Regulations. This BER shall be calculated using a permitted Irish National calculation methodology for Commercial buildings, being NEAP/iSBEM, or approved Building Simulation software.

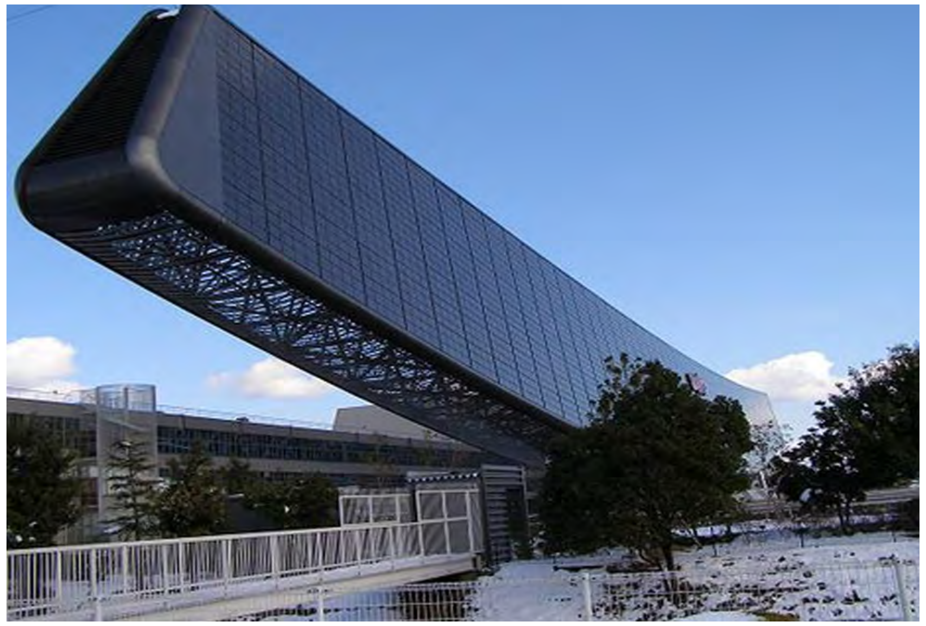


Monthly average direct solar radiation



Dublin daylight hours

polycrystalline PV panel



the solar ark, part of the 2005 world exhibition in gifu prefective, japan utilizing monocrystalline PV panels

renewable resource energy generation and the combined heating and power plant (CHP)

The Sustainable Energy Strategy is to reduce the energy demand and to optimise the use of renewable energies so that the Grangegorman Urban Quarter may eventually become a Zero Carbon Development. In accordance with the client's brief, the target aspiration is that at least 30% of energy will be from zero net carbon emissions from energy generated on site on an annual basis. The energy strategy has been developed as a flexible framework which is designed for change over time as and when new affordable technologies become available.

Renewable Energy Supply Strategy

A complete range of on site renewable energy strategies for the Grangegorman Quarter have been considered including: Sun, Wind, Geothermal and Biofuels. The preliminary profile for the energy demand of the new development is as follows:

Heating (inc. Hot Water)	=	65.9%
Electricity	=	30.7%
Cooling	=	3.4%

Heating and Hot Water

The primary strategy is to provide all the heating from a centralised CHP and biomass boiler plant. The plant consists of a series of boilers burning bio fuels to produce heated water. The type of bio fuel will depend upon the ease of source and price. However, the Masterplan has been designed to accommodate wood chips, as these require more storage space than other fuels, thus allowing for all other possible fuel storage eventualities.

The medium temperature water from the boilers is distributed across the site along an arrangement of district heating pipes. During the winter and mid seasons the building solar hot water supply is supplemented with hot water from the district heating system. During the summer, if required, the hot water supply may be used to provide cooling for individual buildings via heat absorption chillers located on the roof of individual buildings as required. The bio fuel heating system will provide in excess of 55% of the energy demand for the development.

It will be feasible to locate solar hot water collectors on the roof of individual buildings to provide hot water requirements during peak summer period. The hot water will be supplemented from other sources during the cooler periods of the year.

A feasibility study into the potential use of geothermal heating is currently being undertaken. Technical feasibility depends upon:

- Access for the ground pipe system
- Availability of geothermal heating source
- Access to drill for vertical pipes
- Ground conditions will affect ease of construction and system performance

Electricity Power Supply

The early stages of development will be predominantly supplied with electricity from the on site electrical substation supplying power from the local electrical grid. At present only 7.5% of the electricity generated in Ireland is generated from renewable sources with the remaining 92.5% from fossil fuels.

However, the Energy Supply Board (ESB) announced on 25 March 2008 that their Energy Strategic Framework 2020 is to invest over 22 Billion Euro to halving carbon emissions by 2020 and achieving a carbon net zero by 2035. 50% of the 22 Billion Euro investment package is geared towards investment in renewable future. By 2020, the ESB will increase renewables from 7.5% to at least 30%. This will include 1,400 megawatts of wind power generation in addition to wave, tidal and biomass.

Short Term Strategy for On Site Electrical Power Generation

Careful consideration will be given to emergency lighting, street lighting and sports flood lighting being powered by proprietary wind/photovoltaic stand-alone lighting systems.

A considerable portion (23%) of annual energy would be provided by the CHP power generated on site.

Long Term On Site Zero Carbon Electricity Supply by 2035

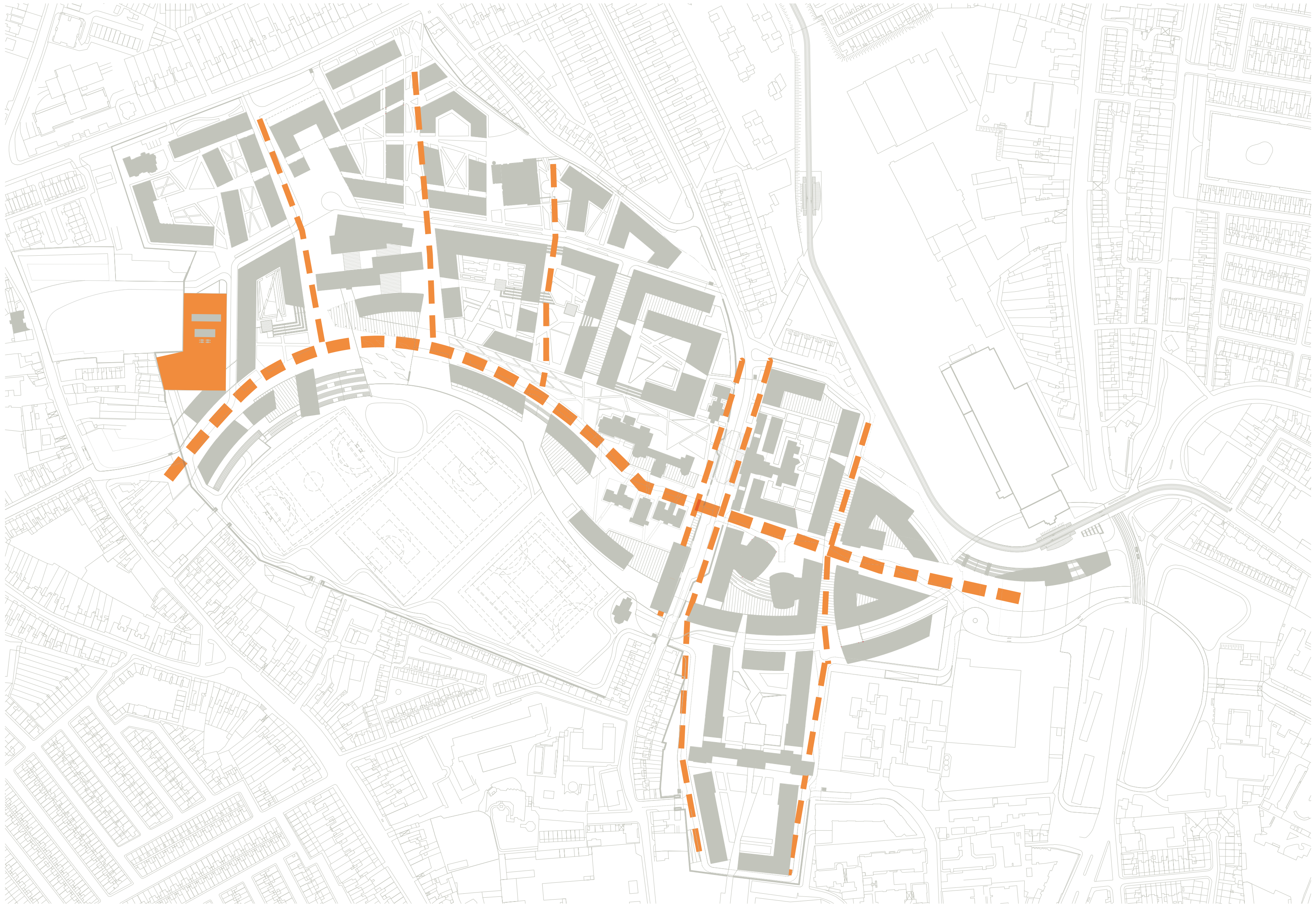
By 2035 either the off site electricity supplied to the site will be from a zero carbon source and/or more on site electricity will be generated from on site wind, solar and bio fuels. The Masterplan has been future proofed for either eventuality. Therefore the development has the potential to become a zero carbon development.

Optional Large Scale On Site Renewable Energy Electrical Power Generation

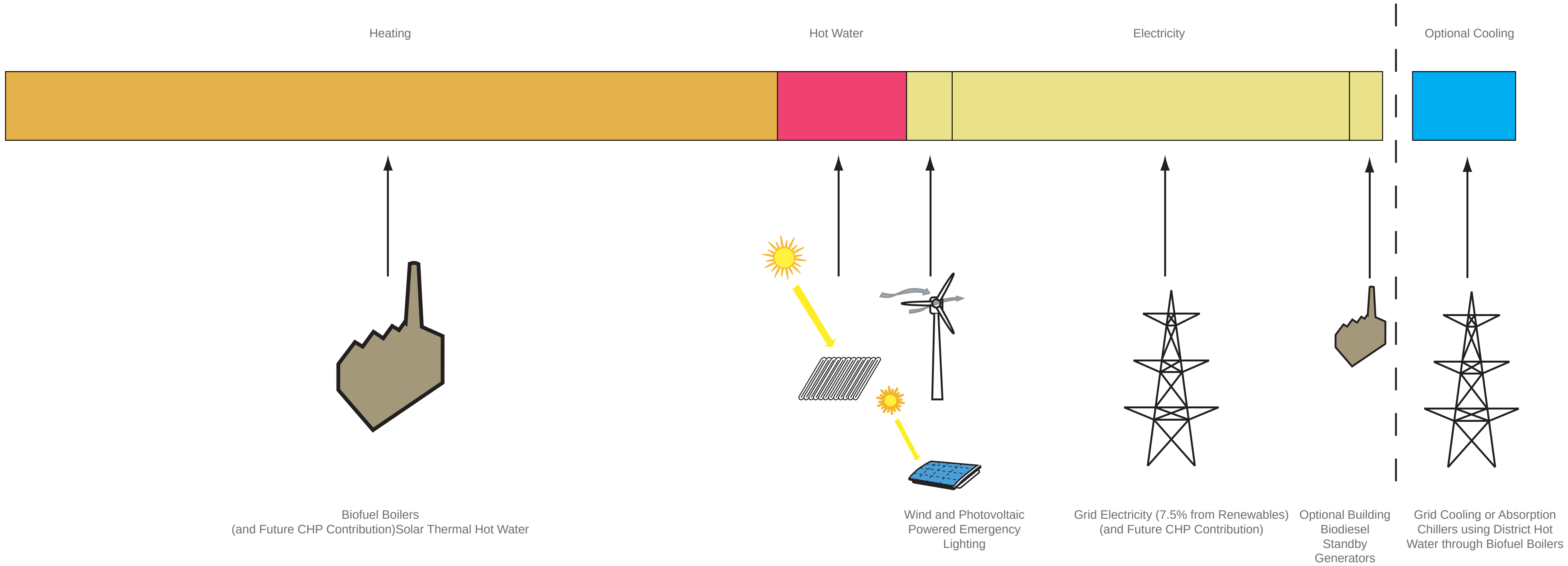
As well as traditional placement on rooftop locations, there is the possibility of including large scale PV arrays throughout the Grangegorman Quarter, such as potential walkways around campus, on building elevations etc.

Technical and Planning Issues that need to be considered:

- Systems should ideally face between south-east and south-west and pitched at 30 to 45 degrees from horizontal to maximise the amount of light on the PV's
- Unshaded at all times of day if possible
- Consider loading capacity of roof/structure
- Ensure the building's metering system allows export of energy if needed
- Birds may need to be discouraged from perching near the systems



Conceptual diagram showing utilities routing concept from the electrical substation and combined heat and power plant.



Combined Heat and Power Plant

Combined heat and power (CHP) is the simultaneous on-site generation of electricity and heat. Types of CHP available range from the sterling engines Micro CHP's of about 5 kWe to large scale reciprocating engines or large gas turbines with a production of greater than 2 MWe.

The significant benefit of CHP installations is that they can convert up to 90% of the energy available in the fuel into electrical power and useful heat which compares very favorably with conventional power generation with a delivered energy efficiency of only 30-45 %. Other benefits of CHP installations include reduced running costs, reduced environmental global emissions and improved security of electrical supply.

However the capital investment on CHP plant can be substantial, so it is important to run the plant to achieve maximum returns. Also electricity generation produces heat which in summer periods, requires cooling energy as it cannot be utilized in heating buildings. So it is important that any CHP plant operates to a development that provides a significant base load for the CHP to meet. Conventional boilers and grid supply or on-site renewables can then provide the peak demand.

Analysis of annual heating and power hourly load schedules has been undertaken. This identified that the optimum CHP unit size for the development to be 2MWe total, operating September through to June.

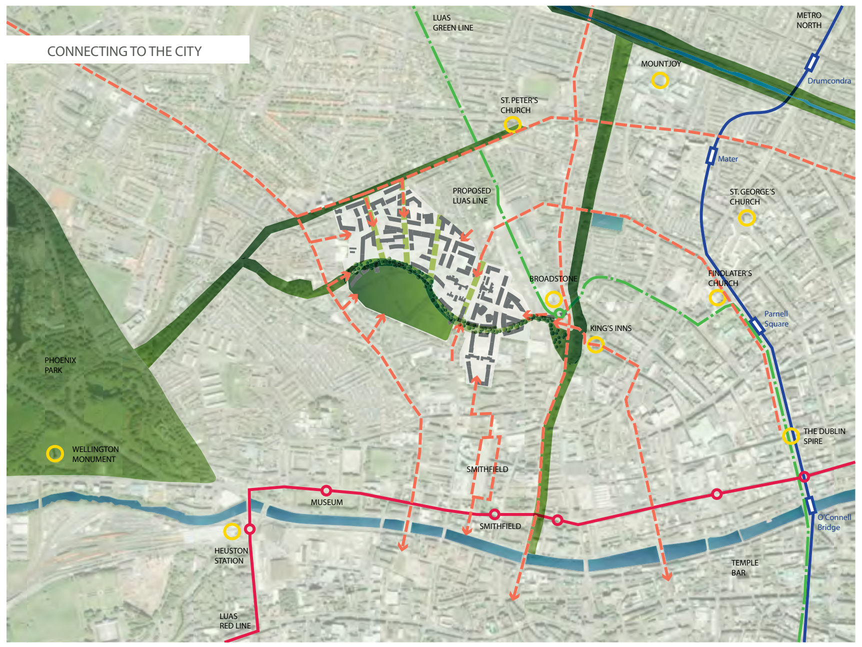
Space has been allocated at the CHP to replace one or more of the district heat boilers with bio diesel CHP generator, increasing the electrical power produced from renewable means and the on-site electrical production.

Allowance for Building Spot Cooling

Building spot cooling is to be determined on a building-by-building basis. However, in the future if spot building cooling is required across the whole quarter due to building use or/and climate change then district cooling may be considered from the centralised plant.

Building Height diagram

Area plan prior to the new development.



The Grangegorman Masterplan links currently unconnected landscape pathways for pedestrians and wildlife.

sensible urban density and linking natural pathways

The Programming Brief for the Grangegorman Quarter requires near 400,000 square meters of development within the 73 acre / 29.5 hectare site. This indicates a general Floor Area Ratio of about 1.4, indicating that if the program area were distributed evenly across the site it would cover the entire site 1.4 times.

To introduce roads, pathways and courtyards and maintain healthy portions of the existing landscaping and open space, the plot ratio increases a certain percentage and building designs increase in height. Portions of higher building density offset portions of open space. The key to designing is the sensible and sensitive location of building density based on specific site criteria (such as site topography, latitude and solar orientation, existing site features to retain, wind characteristics and macro / micro climate information) and community factors (such as noise, traffic, overshadowing, views, etc...).

The major existing site conditions that were determined important to retain were many of the mature healthy trees on the site and the open fields to the south. Building footprints were then located north of the existing open fields and the footprint locations were adjusted to accommodate some of the trees and landscaping to remain. Some of the Grangegorman program such as the Sports Centre, large classroom blocks and some of the Craft Training Facilities were located partially underground to further conserve existing open space. A well designed urban layout design can have the following benefits:

- Attractive and usable external spaces
- A sufficient amount of solar heat gain or solar shading
- A sufficient amount of daylighting and minimum overshadowing
- Passive cooling or shelter from strong winds
- Dispersion of pollutants and reduction in carbon dioxide emissions
- Reduction in energy consumption

Heating and lighting energy can be reduced by the climate-sensitive masterplanning for passive solar gain and daylighting and UK studies of passive solar housing suggest that improved site layout can save 5% or more in domestic energy consumption In non-domestic buildings, the effective use of daylight can lead to savings of 40% or more in lighting energy use.

While the building density is to the north of the site, it was important not to over densify or plan buildings with heights that would be uncharacteristic or overshadow the community around the edges of the site. The building heights have been reduced as the planning of buildings reaches the edges of the site to prevent encroachment on, block the views of, or overshadow residents of the surrounding community.

The Grangegorman development was also an opportunity to link together several disparate natural landscape paths in the areas near the site. With the retention of The Fields and the introduction of the Serpentine Walk, the new development links together a pedestrian landscape and wildlife corridor from the Canal and Mountjoy area in the north, through the site and out to Dublin's Phoenix park.

Exterior space daylighting analysis showing the majority of external spaces achieve more than 60% daylight factors (shown in yellow and orange).

natural daylight, ventilation and wind protection

A naturally daylit building provides contact with the outside world either directly through a view out, or indirectly as the changing daylight reflects the time of day or weather conditions. Daylight can reduce, and in some situations eliminate, the need for artificial lighting during the day. In non-domestic buildings, the effective use of daylight can lead to savings of 40% or more in lighting energy use. The quantity and quality of daylight depends on (in addition to the external environment and obstructing buildings):

- Building depth
- Windows
- Internal reflectance
- Type of glass
- Internal use and space layout

In general, the volumes shown in the Masterplan have been designed with a shallow or narrow plan between 14 and 16 meters in width to allow natural light to penetrate into the interior spaces. At the building design level, other techniques such as light shelves and light tubes can be employed to further increase the penetration of natural daylight.

Solar Access

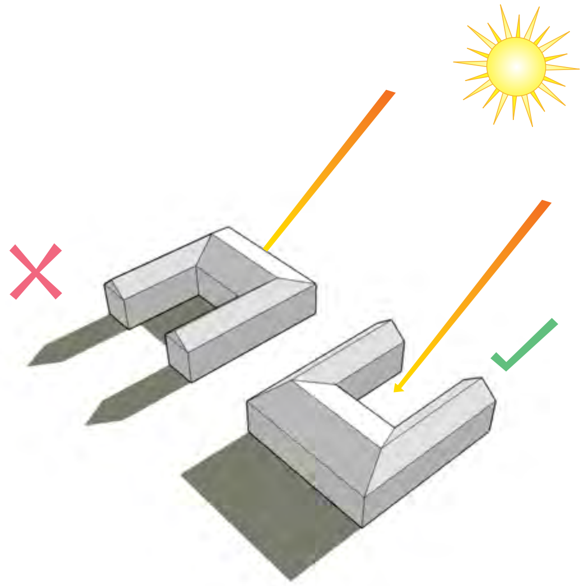
Sunlight is highly valued as an amenity. In housing, the main requirement for sunlight is in living rooms, especially in the afternoon. It's less valued in bedrooms and kitchens, where it's preferred in the morning. The BRE guidance document 'Site Layout Planning for Daylight and Sunlight: A Guide to Good Practice' states that:

"In general, a dwelling or non-domestic building which has a particular requirement for sunlight, will appear reasonably sunlit provided that: At least one main window wall faces within 90° of due south and; On this window wall, all points on a line 2 meter above ground level (floor level) are within 4 meters (measured sideways) of a point which receives at least a quarter of annual probable sunlight hours, including at least 5% of annual probable sunlight hours during winter months, between 21st September and 21st March."

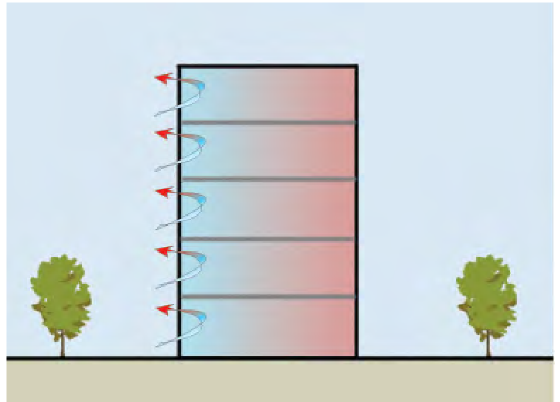
In a dwelling the room in which the main window wall is situated must be the main living space in that dwelling. For the student accommodation however this would be the shared living space proposed within each apartment. This has been incorporated into the Masterplan with notional internal floor layouts specifying that the shared living space is within 90° of due south.

Building Form

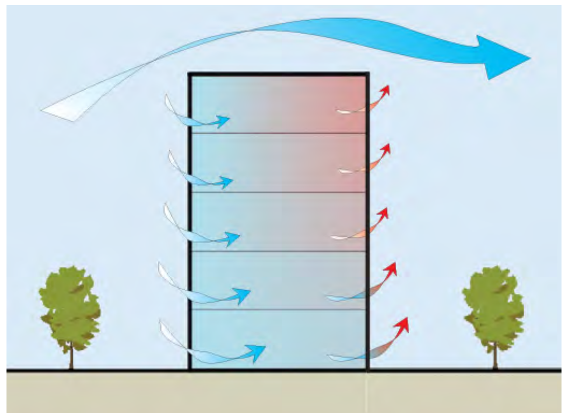
The majority of buildings within the DIT development fall into the shallow plan category, the result of which is that there is the potential for natural ventilation to be incorporated into the design depending upon individual building orientation and proximity, and greater daylight penetration reducing the need for artificial lighting throughout the development.



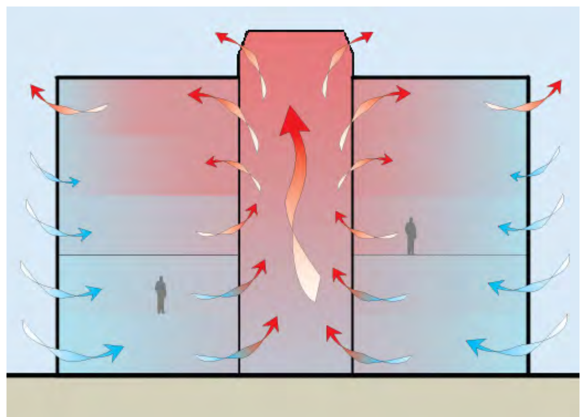
Idealized preferred courtyard orientation



Single sided ventilation



Cross ventilation



Stack driven ventilation

Exterior Daylight Availability

The Masterplan strategy is to minimise to a large extent the east-west oriented building volumes in favor of north-south oriented building volumes to reduce the amount of north facing building facade. In addition, the Masterplan design stacks higher building volumes in the north-south oriented directions as opposed to the east-west oriented directions to minimise the amount of overshadowing of adjacent buildings and landscape space. Where feasible, the courtyards open to the south to allow maximum daylight to penetrate onto the exterior spaces.

Several solar access studies were undertaken during the Masterplan process. One study was based on a modified Daylighting Factor. The Daylight Factor is traditionally a ratio between the amount of light received at a point inside a building from an overcast sky, to the amount of light that would be received at the same point from an unobstructed overcast sky. In the case of the Exterior Daylight Study undertaken, the definition of Daylight Factor has been modified to be the ratio between the amount of light received at a point outside a building from an obstructed overcast sky, to the amount of light that would be received at the same point from an unobstructed overcast sky.

Daylight factor ranges and descriptions:

0% - 20%	Very poor daylight access
21% - 40%	Poor daylight access
41% - 60%	Minimum daylight access
61% - 80%	Good daylight access
81% -100%	Excellent daylight access

The majority of external spaces should receive daylight factors greater than 50%. This indicates minimum through to excellent access to daylight. Unshaded external spaces receiving less than 40% daylight factors should be minimised. These areas can form intermediate zones between well daylit exterior spaces and covered or interior spaces and should be found close to buildings where the shading by the building is predominant.

The predicted distribution of external daylight availability is displayed on the colored Masterplan analysis diagram on the preceding page. The diagram illustrates daylight availability in terms of daylight factors using five colour bands as indicated on the key to the right of the figure. Orange areas achieve more than 80% daylight factors, while dark blue areas achieve less than 20% daylight factors. The greyed areas indicate buildings, atria or other covered areas.

The diagram shows that the majority of external spaces achieve more than 60% daylight factors (areas shown yellow and orange). This includes the sports fields, the open urban spaces and the open spaces around the buildings. Some areas on the site achieve between 20 and 60% daylight factors (areas shown light blue and green). This includes streetscapes between opposite medium-rise buildings, smaller courtyards within blocks and areas immediately adjacent to building facades. Very few areas receive less than 20% daylight factors (areas shown dark blue). These areas are all in small corners or near to the entrances of buildings. These are appropriate locations for lower levels of daylight as they assist in visual adaptation between bright exteriors and less bright interiors or covered spaces

Natural Ventilation Strategies

The benefits for allowing areas of the building to be naturally ventilated, or to benefit from outside conditioning, when the conditions allow, are a reduction in energy consumption and an increase in environmental connectivity

It is clear however that correct satisfactory comfort conditions must be maintained throughout the year, and that comfort conditions must not be compromised solely by the desire for natural ventilation. In this respect air conditioning and heating will be needed in certain spaces, however periods of natural ventilation or free cooling may be maximised through bio-climatic design.

There are three varying methods of natural ventilation:

- Single sided ventilation
- Cross ventilation
- Stack driven ventilation

Single sided ventilation relies on openings at one end of the room and natural buoyancy to effectively ventilate the internal space. High and low level openings can be adopted to maximise efficacy; with cooler air entering at the bottom, hot air out at the top. To further increase the efficiency of this process, it is opportune to increase the distance between the openings.

Cross ventilation is a more powerful mechanism that relies on the natural pressure differences established across the building by the interaction of the built form with the prevailing wind system. As wind forces are so much larger than those of stack effect, wind powered cross-ventilation is most effective for ventilation in summer.

Cross-ventilation is feasible in unobstructed open-plan offices (for example, those with low partitions) that have window openings at both ends. It will also work, though less effectively, in cellular offices, provided doors onto corridors are opened in hot weather - a condition that cannot be guaranteed if the occupants prefer privacy. But cellular offices with heavy partitions have the advantage that their higher thermal mass will dissipate heat.

Stack ventilation utilizes a combination of wind and thermal effects to maximise ventilation effectiveness. Generally, increasing the height difference between the stack exhaust and the inlet areas maximizes ventilation rates. Under still conditions, buoyancy forces will cause a constant movement of air through the space. When windy, the exhaust located at high level will typically remain depressurized with respect to the inlet location and good levels of ventilation are experienced.

For multi-storey buildings, raising the outlets of the atrium above the top of the building will prevent hot destratified air from convecting heat into the upper levels.

Night Time Cooling

During the night, outdoor temperatures are lower than indoor ones. Consequently, it is possible to ventilate the building by allowing the outdoor air to enter the spaces and remove the stored heat that has been trapped in the buildings thermal mass during the day. This means that occupants enter into a cooler environment in the morning resulting in a substantial energy saving from the reduced operation of the buildings mechanical ventilation system.

June 21, 9 am

June 21, 12 pm

June 21, 3 pm

SUMMER SOLSTICE

September 21, 9 am

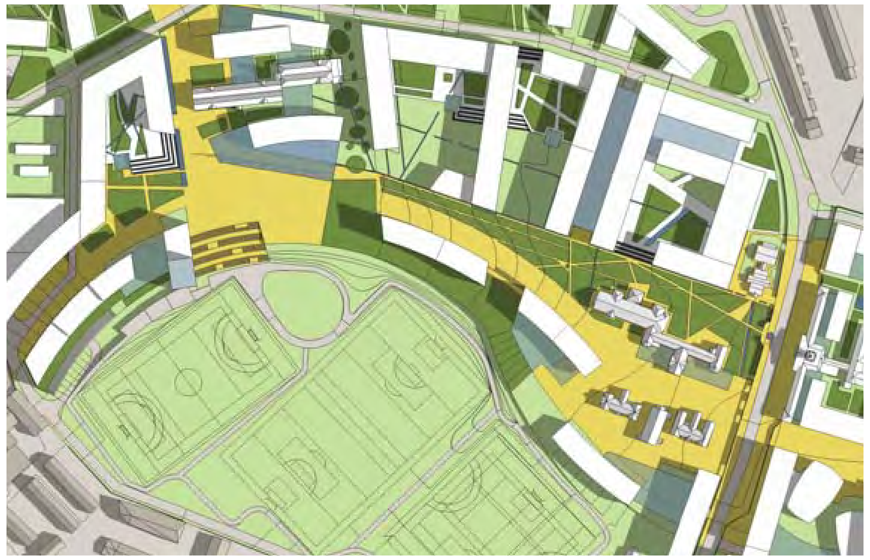
September 21, 12 pm

September 21, 3 pm

FALL EQUINOX

Daylight and Shadow Study, overall view

Overall daylight and shadow study showing the effects of the building massing and heights for certain periods of the year at the latitude for Dublin, Ireland.

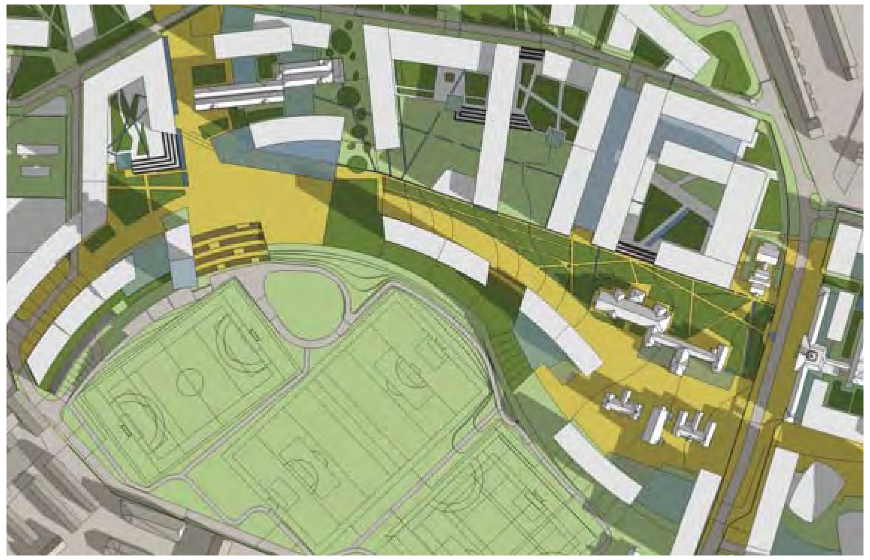


June 21, 9 am

June 21, 12 pm

June 21, 3 pm

SUMMER SOLSTICE



September 21, 9 am

September 21, 12 pm

September 21, 3 pm

FALL EQUINOX

Daylight and Shadow Study, DIT view

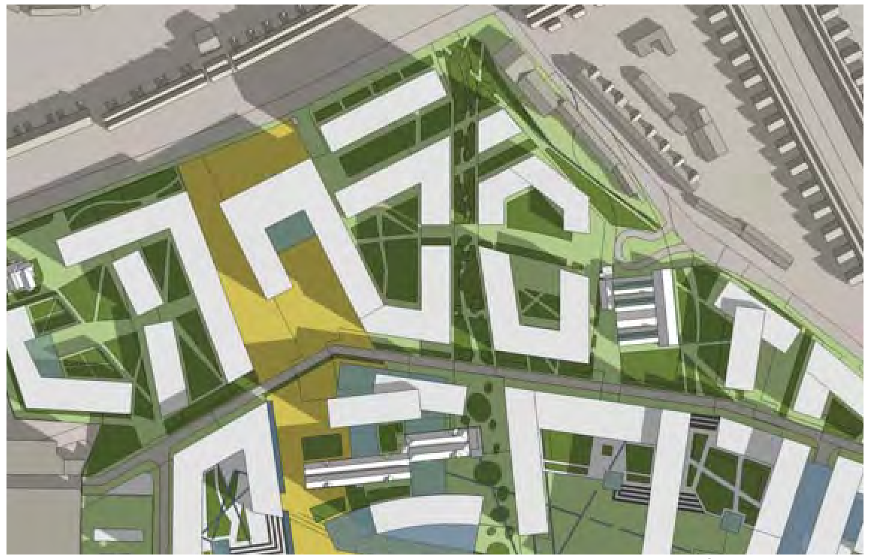
Detail view of a daylight and shadow study showing the effects of the building massing and heights for certain periods of the year at the latitude for Dublin, Ireland.

June 21, 9 am

June 21, 12 pm

June 21, 3 pm

SUMMER SOLSTICE



September 21, 9 am

September 21, 12 pm

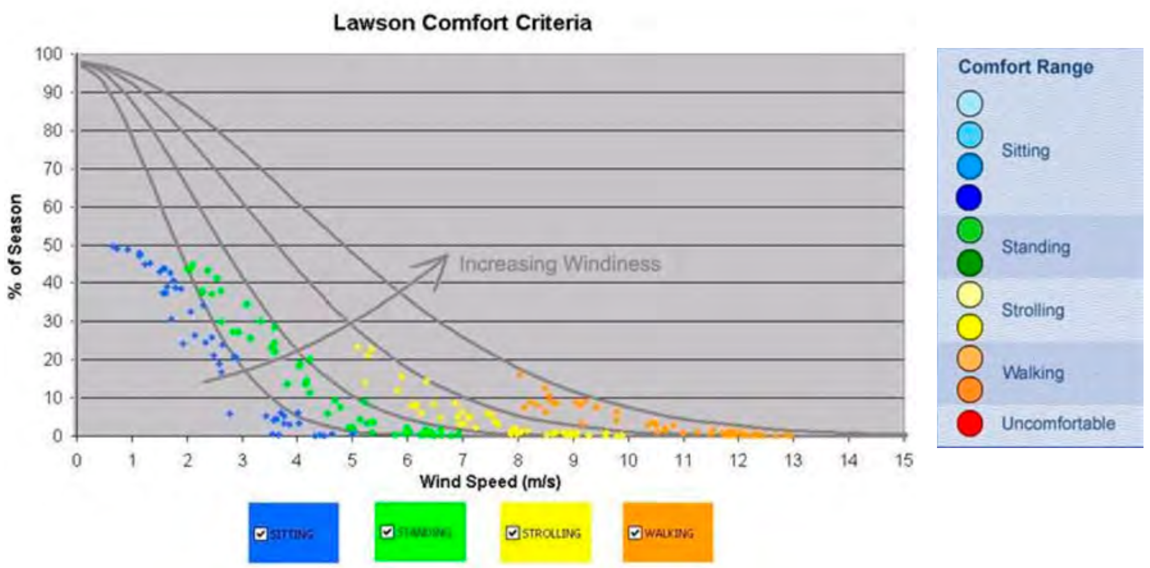
September 21, 3 pm

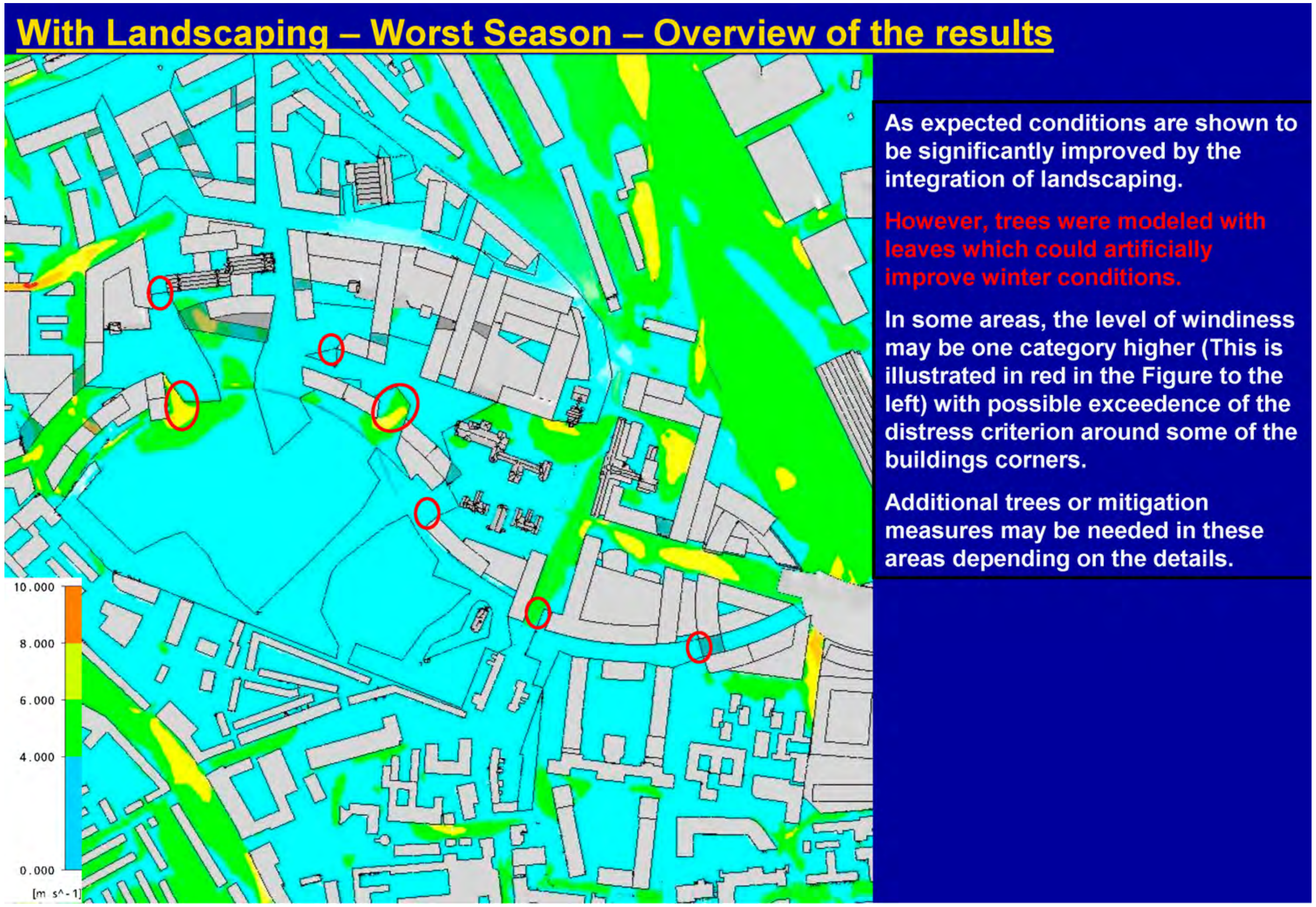
FALL EQUINOX

Daylight and Shadow Study, HSE view

Detail view of a daylight and shadow study showing the effects of the building massing and heights for certain periods of the year at the latitude for Dublin, Ireland.

Criteria	*Description*	*Wind speed > 6 m/s (# of days exceeded during season, eg winter)*
'Sitting'	Reading newspaper, eating drinking	<1 days
'Standing' or short term sitting	Bus stops, window shopping & building entrances	5 days
Walking or 'Strolling'	Walking & sightseeing	15 days
'Business Walking'	Areas around tall buildings where people are not expected to linger	30 days





Wind Analysis

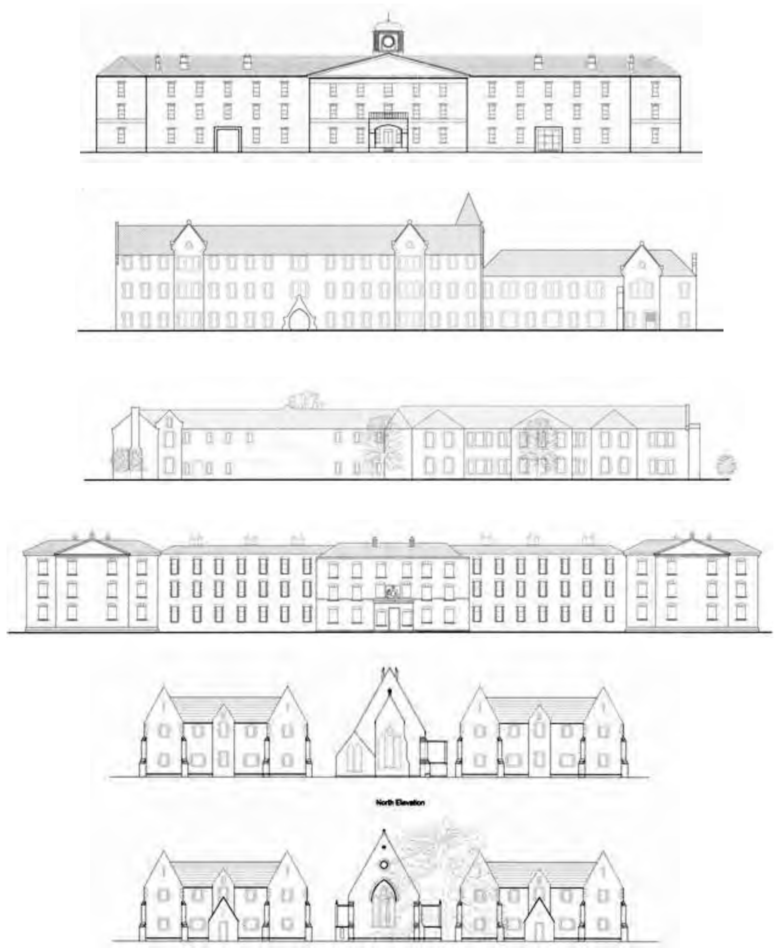
The windiness in and around the Grangegorman development was quantified using a CFD wind assessment by ARUP Consulting Engineers. This assessment was carried out to help understand the ground level wind conditions affecting pedestrian comfort throughout the scheme. The general conclusions of the CFD analysis are:

- The arrangement of the buildings on the north side of the site are sheltered by the taller buildings on the south side of the site. The southerly buildings are exposed to the prevailing winds across the sports fields. As a consequence, conditions in the areas towards the north of the site are anticipated to be calm, generally in the "Standing" range. These conditions are typical of an appropriate pedestrian environment.
- The area around the southerly buildings, particularly around the campanile, would be excessively windy without landscaping. These areas would be significantly improved by the proposed dense landscaping and the addition of further mitigation measures (on the individual buildings) such as windscreens, canopies, etc...
- The routes within the Grangegorman development facing the prevailing winds are subjected to "Strolling" conditions with local "Business Walking". These conditions would be generally acceptable for walking access. Clearly, there is value in installing dense landscaping as proposed to achieve suitable conditions for an appropriate pedestrian environment.
- Conditions around the train station were shown to be generally acceptable for the intended use of the area. The proposed development would have very limited off-site impact.
- With no trees, conditions in the sports fields are in the "Standing" or "Strolling" range and are acceptable for the intended use of the area. With the proposed landscaping, conditions are expected to improve.
- Entrances or areas of sensitive use should be generally kept away from the corners of the exposed buildings. The gaps through the buildings and roof overhang are shown to be windy and may require massing adjustment or additional mitigation measures. (The proposed landscaping is not enough to solve the windiness in these areas).
- External seating areas or outdoor cafe terraces should be placed in area of "Sitting" conditions for the possibility of a regular use of these areas in summer.
- The CFD wind analysis is based on the Lawson Criteria. It is important to recognise that 1) Acceptability of windiness is subjective and depends on the activities of the individual. 2) The windiness in any one place can vary depending on the ambient weather conditions. 3) The only way to compare conditions in two different places is statistical, in terms of curves of wind speed vs. fraction of time exceeded.

It should be noted that the percent of time wind speeds are exceeded in each season: Winds are predominantly from the south-west in winter months, Winds shift westerly in the summer months, and Southeast winds are strong in the spring months.

Existing protected structures on the site will be re-purposed in the new development.

The Masterplan maintains much of the existing healthy mature landscaping.



preservation of existing natural and cultural heritage

Habitat Conservation

The Grangegorman site is an important sanctuary for urban wildlife, especially birds. Given the sites proximity to the City Centre, the local value of the remaining semi-natural habitats is greater than would otherwise be the case. While the wildlife link through the site is already explained in previous sections, it should be noted that other landscape features such as the Green Finger Parks will provide additional habitat and feeding routes. The retention of much of the stone walls will also help retain the existing habitats on the site.

Landscape Conservation

The site is not covered by any nature conservation designations but there are some habitats of local ecological significance including areas of dry grassland, trees and shrubs. The Dublin City Biodiversity Action Plan 2008 should be referred to during the redevelopment of the site. As demonstrated in the Architectural and Landscape design narratives, much of the existing healthy and mature trees are being retained as is the large existing open space area to the south of the site. The implementation of SUDS (Sustainable Urban Drainage Systems) will enhance and augment existing habitats. There is the opportunity to eradicate invasive alien plant species such as Japanese knotweed and giant hogweed.

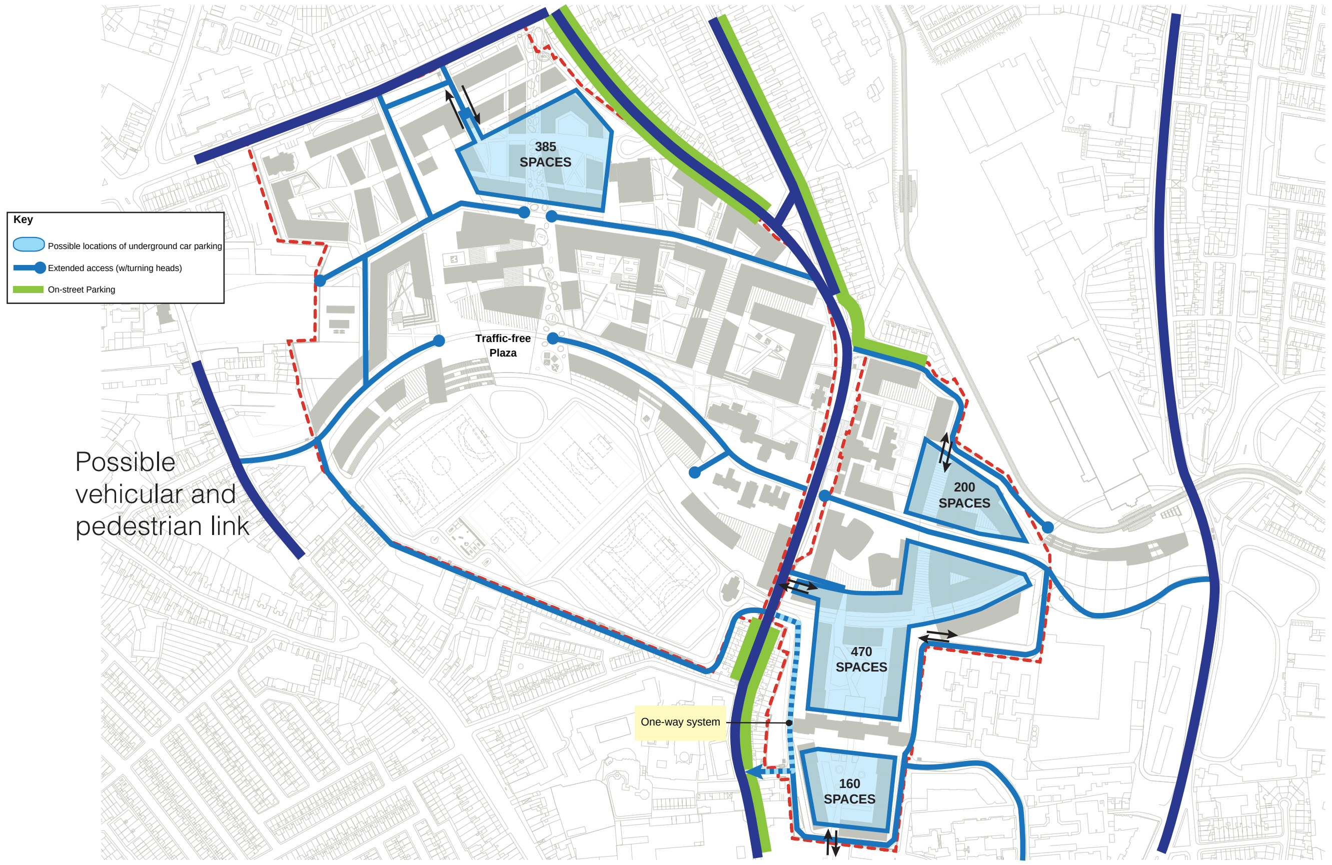
Cultural Heritage Resources

There are 30 existing structures on the site. Twelve of the buildings, the entrance gates and the boundary walls are protected in the Dublin City Development Plan 2005-2011. The Conservation Strategy outlines principles and guidelines that should be adhered to for repairing, reusing, intervention and adaptation of buildings. This will impact on the settings of buildings but will reuse historic properties. This gives new opportunity for buildings to have long term use. The re-use and re-purposing of these existing buildings not only conserves the embodied energy used in their initial construction and saves the energy that would be used to replace them, but helps create a connection to the past history of the site.

Archaeological Resources

The archaeological heritage of the site will be investigated. There are currently no stray finds from topographical files of the National Museum of Ireland recorded from the locality and no recorded archaeological monuments are located within the site. There is potential for revealing subsurface remains of archaeological material. There is the possibility of burials within the proposed development. The playing fields on the west side remain undisturbed and possess potential for archaeological features.

Pedestrian network



Parking and access network

transportation strategies

pedestrian and bicycle network

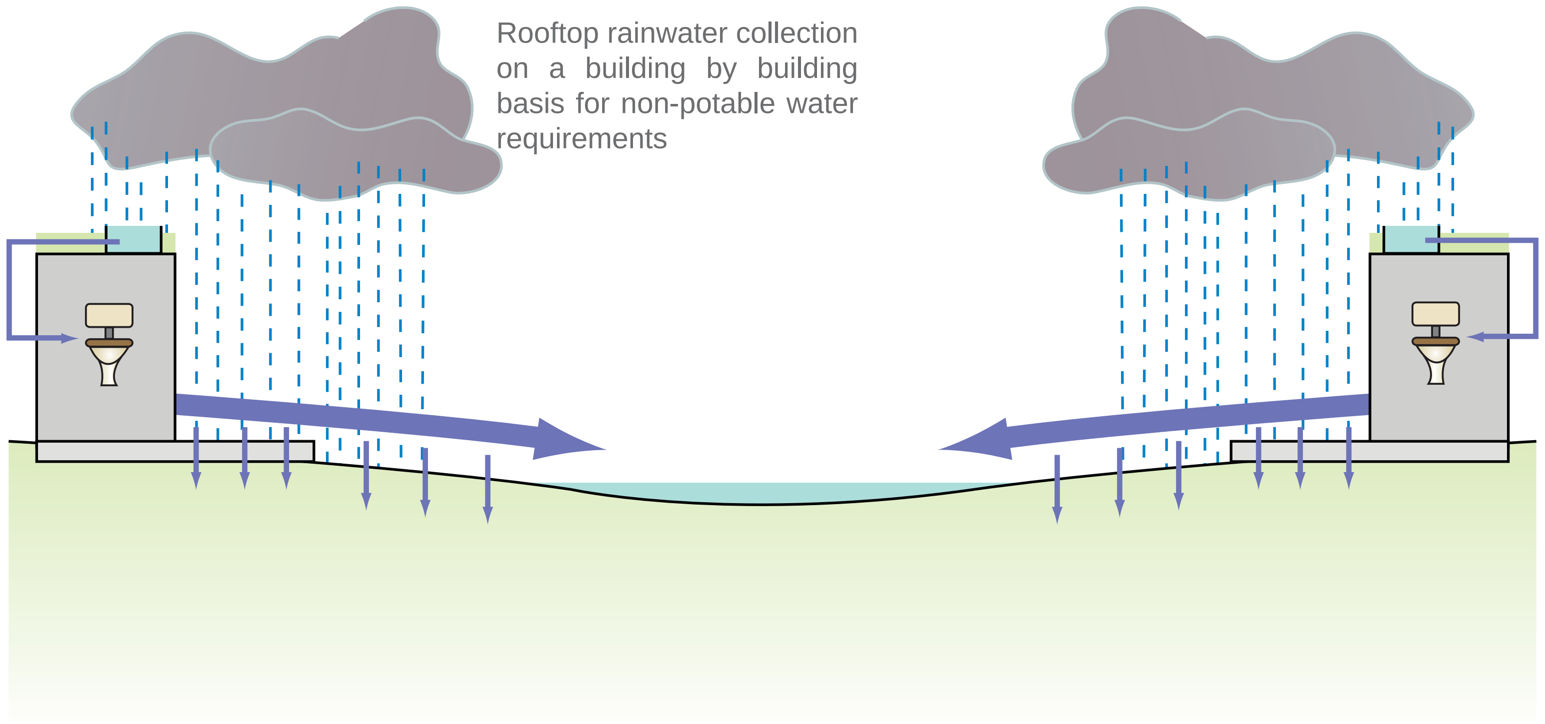
The Masterplan has been designed with a strong focus on pedestrian movements which guarantees the conditions for walking trips to be encouraged. In addition, the design entails a number of restrictions to auto traffic such as a system of traffic cells which will contribute to the creation of excellent quality pedestrian and cycling environments throughout the site. Cycle storage will be provided in a number of locations. This will take the form of 1) cycle parking for student residences which will be secure and at ratio of 1 space per 3 beds 2) Secure underground cycle parking for users that require longer periods of parking. (This element will be associated with facilities such as showers and lockers where appropriate). 3) on-street banks 4) Dispersed clusters of on-street cycle parking. A Pedestrian network plan has been included in the Site Access section of the Masterplan. Outdoor cycle parking locations can be seen in the Landscape Design narrative section of the Masterplan.

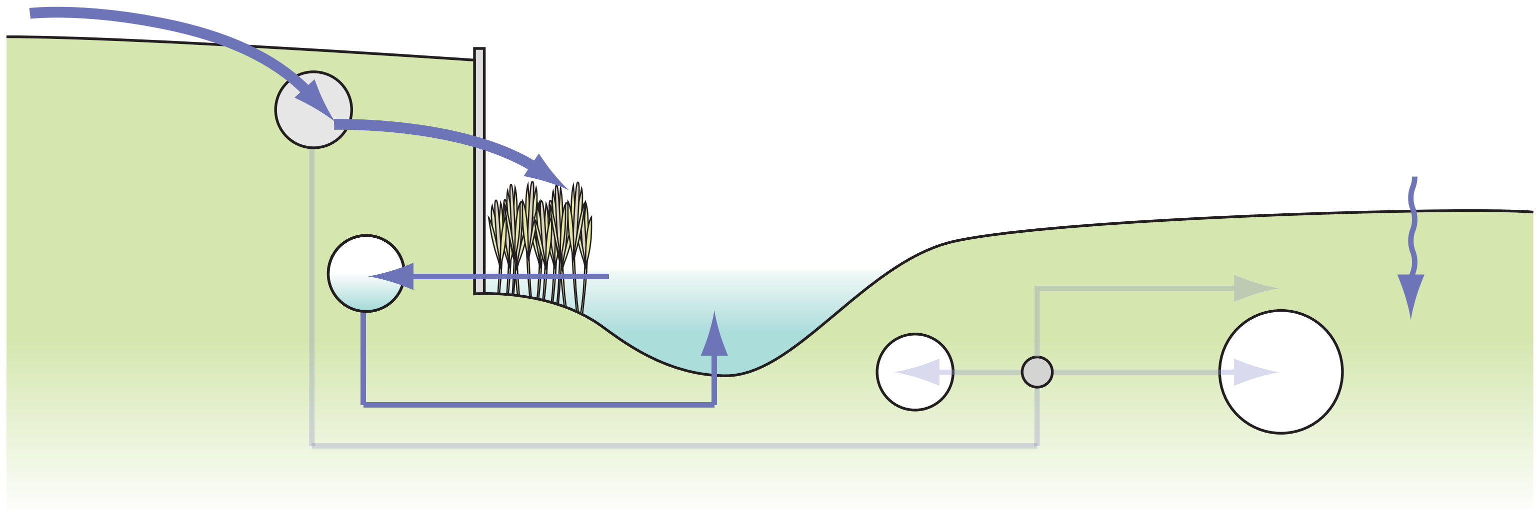
automobile parking

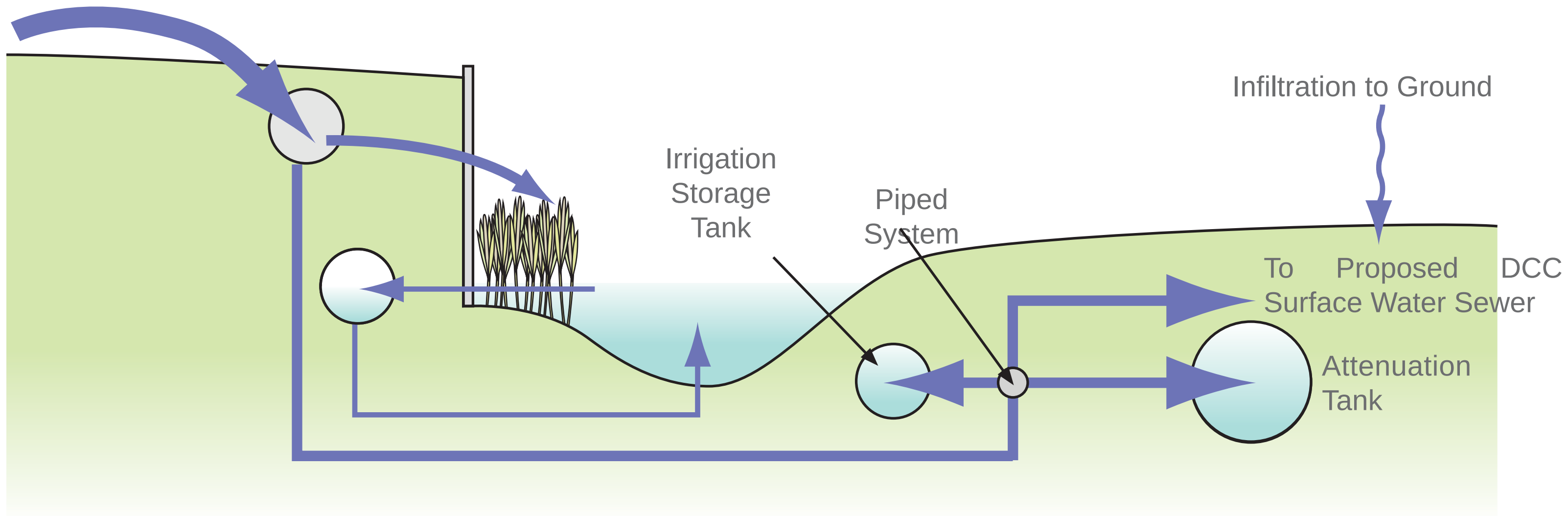
A limited quantum of car parking is to be provided within the Quarter. A provision of car parking in the region of 1,150 spaces is seen as modest in the context of an overall population of over 25,000 and a variety of uses ranging from primary health care to higher education, and including offices, retail and a primary school.

public transportation

A main goal of the Masterplan is to enable the seamless connection to the existing and future transportation networks, taking full advantage of Grangegorman's sustainable city centre location. Connections to the south and the east are considered to be vital because they will provide access to the city centre, but also to Luas and bus networks, as well as to Metro North and the commuter rail services at Heuston and Connolly stations. The Masterplan's emphasis is on the design of quality linkages from the site to the established city grid and to the high quality public realm within the site.







Ha-ha/sports field water management - flood event

water management

Surface Water Run-Off Management

The main goal of any new development's water strategy is to ensure that there is minimum increase in surface run-off. However due to climate change rainfall levels and therefore surface run-off levels are likely to increase. The result of which is that any developments water management strategy must ensure minimum surface run-off on current levels but based upon the potential of future increases in rainfall levels. To achieve this the surface water management strategy consists of two varying techniques, courtyard depression water management (incorporating rainwater rooftop recycling) and ha-ha/sports field water management.

Courtyard Water Management

During a rainfall event surface water run-off will run into a slight depression in the centre of the courtyards spaces that acts as a small attenuation pond, allowing the water to discharge at a slower rate. Any additional run-off will flow south towards the ha-ha. Rainwater will be collected from building roofs where possible and used for non-potable water applications (WC's, etc) within each individual building unit.

Ha-ha/Sports Field Water Management

During a rainfall event any surface run-off from paved areas and attenuated discharges from block landscaped areas and swales will travel towards the Ha-ha through a possible reed bed cleaning system (or perhaps through petrol interceptors). This system is intended for use during light to moderate rainfall events only. This body of water in the Ha-ha is maintained through a storage tank which feeds the Ha-ha during dry periods.

During a flood event the flow diversion chamber restricts the water supply to the Ha-ha and instead directs the majority of surface run-off towards the piped system. The piped system will divert water to the irrigation storage tank. Once this is full water will then be diverted either to the attenuation tank located under the sports field and to the proposed DCC surface water sewer depending upon the size of the rainfall event.

renewable and long lasting building materials

The Masterplan encourages the use of recycled and renewable building materials through the various energy efficiency and environmental sustainability standards that it is under the authority of. Using renewable construction materials prevents pollution and waste generation, creates new recycling industries and reduces landfill disposal and expansion. Using low VOC paints, formaldyhyde free adhesives, and other safe building materials creates high indoor air quality and promotes greater efficiency for the occupants.

Prohibited Building Materials

The following list identifies a list of materials that are prohibited as stated in the "*Hazardous Building Materials, Second Edition, 2002*" by Steve Curwell, Bob Fox, Morris Greenberg and Chris March".

- No non sustainably sourced timber (except for reclaimed timber) to be used for building structure.
- No insulating material to have an ozone depletion potential greater than 0 and of a global warming potential of greater than 5.
- Asbestos – exposure to it increases risks of asbestosis, lung cancer, and mesothelioma in a dose dependent manner. No threshold has been identified for carcinogenic risks.
- Lead – historically, the criteria of lead toxicity were such effects as convulsions, paralysis, anaemia, severe colic and an associated malaise. Latterly, concern has been for whether covert effects might occur at levels of intake below those causing frank disease.
- Urea formaldehyde foam (UFF) – it is capable of liberating detectable amounts of formaldehyde vapour that cause irritation of eyes, nose, throat and chest accompanied by weeping, sneezing, coughing and breathlessness. Additionally it has been classified as a possible human carcinogen.

Building materials known to have a health risk during construction and occupancy of the building (materials which we feel are of significant importance are highlighted in **bold**):

- Stone
- Slate
- Concrete
- Vermiculite
- Calcium Silicate
- Gypsum
- Ionising lightning conductors
- Non-asbestos mineral fibres
- Cellulose fibres
- Polyisocyanurate foam
- Polychlorinated biphenyls (PCBs)
- Polyvinyl fibres
- Para-Aramid fibres
- **Heavy metals**
  - **Chromium**
  - **Zinc**
  - **Cadmium**
  - **Halogenated Flame Retardants (HFRs)**
- **Perfluorocarbons (PFC)**
  - **Wood preservatives**
  - **Wood surface treatment**
  - **Ply, block and compound**
- **PVC**
  - **Polyurethane resin & foam**
  - **Epoxy resin & glues**
- **Volatile organic compounds (VOCs)**
- **Phthalates**
  - **Natural & synthetic rubbers**
  - **Asphalt & bitumen**
  - **Ozone depleting materials**

Source: 'Hazardous Building Materials' Second Edition, 2002

Other materials known to have national and global issues associated with environmental impact are:

- **Peat**
- **Weathered limestone**
- **Uncertified timber**
- **Global warming potential materials**

Embodied Carbon

Material	Embodied Energy in MJ/kg	Material	Embodied Energy in MJ/kg
Green Concrete	0.64-2	Mortar	2.25
Concrete block	0.86-1	PVC	59-65
Concrete Poured	1.3	PVC Recycled	29
Concrete pre-cast	3.5-2	Polyethylene	85-98
Steel	28-40	Polyethylene recycled	56
Steel Recycled	8-18	Polyurethane	65
Steel Rebar	40	Polystyrene	96
Stainless Steel	11	Aluminium Doors/ Windows	218
Copper	60-150	Timber Doors/ Windows	26.85
Copper Recycled	10-25	UPVC Doors/ Windows	53.82
Brass	70-160	Plaster Board	5.73
Brass Recycled	10-30	Plaster	2.45
Zinc	65	Linoleum	70.95
Aluminium	145-250	Ceramic tile	2.9
Aluminium Recycled	10-27	Membranes	68.42
Hardwood	0.5-9.54	Roofing Tile	2.9
Softwood	5	Mineral wool ins.	18.4
Glass	16.2	Polyurethane ins.	82.33
Bricks	2.9		

CO_2 Emissions due to Transportation

Transport Mode	CO2 Emissions(kg CO2 / tonne)
Air	1160 to 2150
Inland Waterways (Canals)	40 to 66
Rail	39 to 48
Road	207 to 280

Material/Product Selection Procedure

For building development on-site it is recommended that a procedure for the selection of environmentally appropriate materials should be followed. A typical selection process is outlined in the table below.

Stage 1	Create prohibited material list for the project.
Stage 2	Specify material/product characteristics Physical properties (such as U-values, strength, stiffness, hardness, etc) Lifespan Toxicity (such as percentage of VOCs, HCFCs, CFCs, virgin PVC, formaldehyde, etc)
Stage 3	Identify appropriate material/product selections. Include requirements within tender documents for contractor to follow and report against material selection procedure stages 4-8 and comply with prohibited material list. Evaluate materials available on-site for reuse and locally sourced reclaimed materials.
Stage 4	Evaluate more environmental alternatives using relevant guideline specifications. Log all selection choices and reasons with products/ materials have been discarded. (Relevant Ireland documentation yet to be analysed)
Stage 5	a) Assess ability to improve environmental impact by increasing recycled content b) Evaluate material/product selection against environmental impact c) Locate nearest certified manufacturer to site and consider how it would be transported to site d) Identify whether the supplier has either a Environmental Management System (EMS), ISO 14001 or if supplying timber can ensure a full chain of custody.
Stage 6	Report product selections against embodied energy, % recycled content.
Stage 7	Weight selections in order of least environmental impact based on findings of STAGES 4 and 5
Stage 8	Material/product selected in agreement with stakeholders.