1. Background and contact information about your business, organization, or company.

Background

Iarnrod Eireann, is the Gaelic (Irish Language) for Irish Railways (literally... Iron-roads of Ireland)

Iarnrod Eireann is the company responsible for providing all of the country's Intercity, Regional, Suburban and Metropolitan heavy rail services in Ireland.

The company is undergoing a period of unprecedented investment in the railways, which is coming from a Government which now comprises of a coalition including Green Party members.

The reason railway is receiving such investment, even under the present worldwide economic difficulties, is due to the fact that rail transport is seen as the most sustainable means of transport on many levels including:-

1 The ability to move large numbers of people without using cars
2 The ability to significantly reduce the dependency on carbon based fuels (Ireland is the highest consumer of oil in the EU and as such is the most vulnerable to fuel and energy price shocks)
3 Last but not least, the ability to significantly reduce the carbon dioxide (carbon) emissions related to transportation in Ireland. Train travel is typically one third of the carbon emissions produced by private transport.
http://www.emissionzero.ie/

My name is David Hughes.

I am the Senior Architect for Iarnrod Eireann, and I am employed directly by them.
I have been an architect for 21 years now, 16 of which have been with Iarnrod Eireann as a transport architect.

I am responsible for the overall building design and philosophy. I have held an interest in energy issues ever since my technical dissertation on solar thermal panel in Ireland in 1985 as an undergraduate.

contact information
My contact information is as follows...

David Hughes,
Senior Architect,
B.Arch., M.R.I.A.I., R.I.B.A.

Iarnrod Eireann – New Works
Track and Signals H.Q.
Inchicore, Dublin 8.

Tel: +353 (0)1 703 4281 (direct line)
Cell: +353 (0)87 2835136
Fax: +353 (0)1 703 4454 (general fax)
eMail: david.hughes@irishrail.ie

2. Detailed explanation of the entry

The Entry is for a new Station Concourse and Car Park building in Ireland's second city, Cork City, in the very south of Ireland. The station is known as Kent Station.

Given the fact that in Ireland's carbon emissions are largely generated in the transportation and the built environment sectors, and having watched documentaries including "An Inconvenient Truth" it seemed to me that there was a real opportunity, not to say imperative, to "kill two birds with the one stone" by designing a state of the art low energy 'transport' building.

I wanted the building to be a Net Carbon Zero building.

To date it is the only railway station in the world that has been designed to achieve a net carbon zero rating by actively meeting its own energy needs through integrating renewable energy systems into its architecture.

Ultimately I believe that the emphasis on low energy and low carbon design will be the single biggest influence in bringing about a new aesthetic in architecture, an architecture where form follows nature and makes the best uses of all of the available natural renewable resources.

I believe picking a high profile building such as a railway station will ensure that once built, this new approach to architecture will become very familiar to the public in general and that the building will both act as a showcase and champion of the move towards low energy and carbon buildings.

In particular as more emphasis is placed on the use of public transport, particularly trains, it is only correct that I as a designer of public transport buildings respond by making the station building and associated facilities as exemplary as possible in terms of low energy and sustainable design.

In this way the whole public transport experience will be seen as a holistic low energy and sustainable solution.

The design for this building was started in Fall 2006. At that stage there was no building energy rating scale in Ireland. So in setting out to design this building I set myself the goal of achieving a **Net Zero Carbon Footprint**. What is meant by this is that on an annual basis if you add up all of the energy generated by renewables the amount of carbon emissions they offset should match or exceed the amount of carbon emissions associated with the building's energy needs when renewable systems are unavailable (i.e. at night for solar PV, no wind for Wind Turbines).

In looking at achieving this goal it was clear that active renewable systems would have to supply most if not all of the energy needs for the building. So the question is what are the minimum levels of energy demands possible and how are these divided between different systems?

To arrive at answers to these questions the early stage of the design took many iterations as the whole team tried to minimise energy demands using various different strategies. I likened this experience to the Movie about Apollo 13, and how the crew went around the capsule turning off all non essential systems to ensure they had enough energy to get home.

In a similar way the design team constantly reassessed different scenarios to arrive at the best overall balance between different needs.

The final figures arrived at are set out in the figure 1 below..

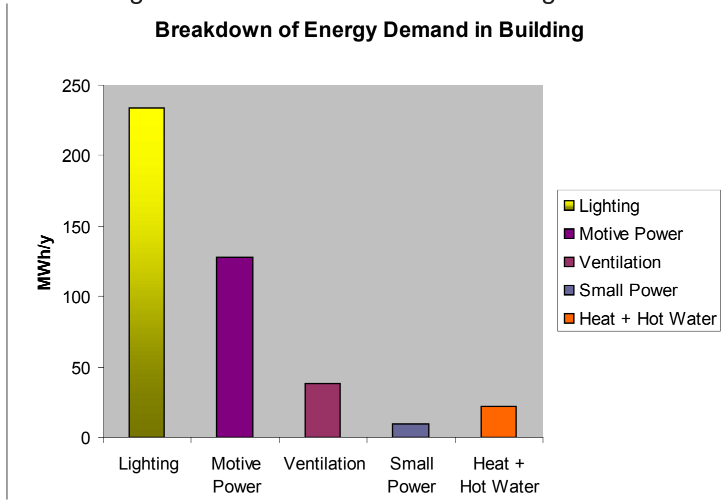

Figure 1. Breakdown of energy demands for building.

The graph shows the annual energy required for different systems in the building. What is significant and to an extent counter intuitive, is how little heat energy is needed (yes even in Ireland) and how much energy is needed for other systems.

In fact in descending order of importance (artificial) lighting is the highest, next is motive power (power for elevators and escalators), next is ventilation, finally there is small power which runs appliances, personal computers and so on. The last orange bar is for heat energy for both space heating and hot water heating. What is interesting about this bar is that it is the only non electrical energy requirement, all of the other categories require their energy as electricity.

It seemed logical therefore to try and 'convert' this last heat energy demand into an electrical energy requirement. This was achieved by using the ground as a 'free source' of heat, and to 'pump' this heat out using an electrical pump, and thus convert this heat bar into an electrical energy requirement as well. The result of this is shown in the next graph, figure 2, where all energy used is now in the form of electrical energy.

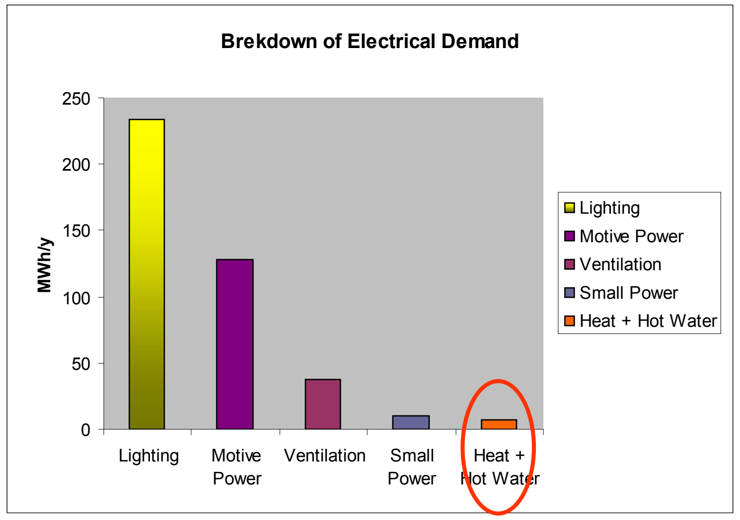

Figure 2. Breakdown of electrical energy demands only.

At this point I should point out that from the outset, I realised that if there was any hope of providing energy for the building from renewable sources, then the energy requirements would have to be reduced to the absolute minimum.

To give you an idea of the extent to which energy demand has been reduced the following graph shows a comparison between the energy demands (per square meter (sq m) of floor area per year) of a building designed to meet up to date building regulation energy standards in 2008 (in red) and the proposed new Railway Station building (in Green).

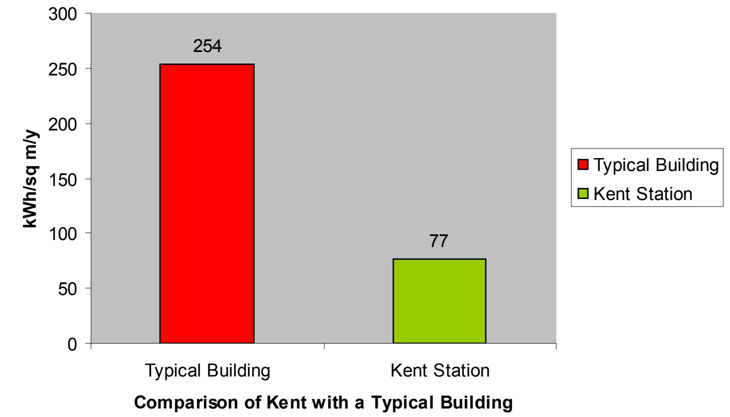

Figure 3. Comparison of 2008 compliant building with Proposed Kent Station design.

Even the figure in red is comparatively good and until quite recently 'typical' buildings could have had an annual energy demand that was multiples of that figure.

The key drivers to reducing the energy demand were two fold.

The first was the cost of renewable technologies and the second was the maximum yield possible from renewable technologies.

Dealing with the cost factor first the following graph (figure 4)shows the different cost of renewable technologies if the capital cost of that technology is 'written off' over a single year. This allows us to compare like with like and also to work out a pay back period.

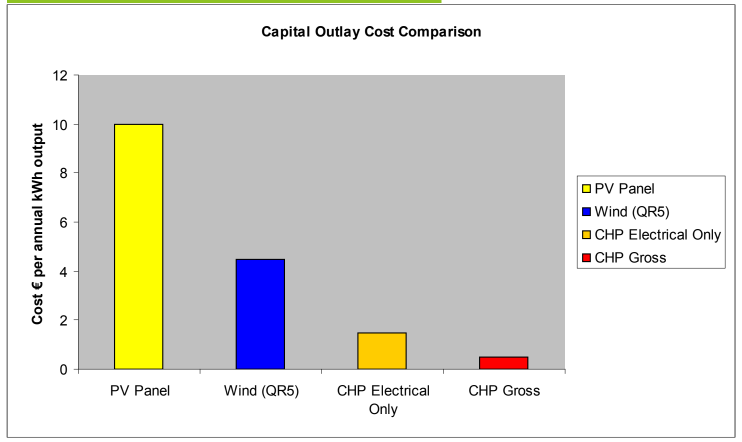

Figure 4. Cost comparison of different renewable systems.

In this graph it can be seen that Photo Voltaic (PV) is the most expensive technology, followed by wind, followed by Combined Heat and Power (CHP) or Cogeneration.

The first orange bar for CHP shows the cost if only the electrical part of the CHP energy is used (i.e. the heat is discarded). The red CHP bar shows the cost if all of the useful energy is used. However as CHP generates two units of heat for every single unit of electrical energy and as (you can see from the earlier graphs) this building requires very little heat energy, the use of CHP technology was discounted for two reasons, first there was too much waste heat energy to be viable and second, to ensure that the emissions are zero carbon the fuel source would have to be a biofuel of some description. At present there is a lot of debate about whether we should be using biofuels due to the impact they have on food crops and prices. In addition it is felt that where biofuels are used they should be used for transportation and other uses where it was not possible to generate the energy requirement on site.

As the philosophy behind this building was for it to generate its own energy needs on site, the importation of biofuels was dismissed as an option during design development.

Returning to the key parameters for driving the building's own energy demands down, the second parameter was the maximum physical yield available from renewable technologies.

In considering the yield of wind turbines you need to factor in how closely the turbines can be spaced together and how much energy each turbine is likely to generate annually. So for example if a wind turbine generates 10,000 kWh of energy per annum and needs a foot print of 100 sq m, to ensure it does not interfere with adjoining wind turbines, then the yield of a wind turbine is 100kWh/ sq m. The correct figure for the wind turbines proposed and a similar figure, arrived at in a similar way for PV, are illustrated in the next graph.

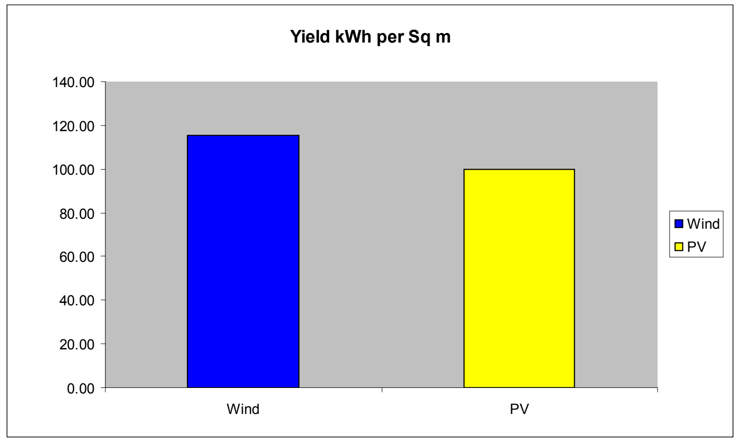

Figure 5. Yield of Wind and PV

Here we can see that for every square meter of roof area we will in fact generate just under 120kWh of energy per year, and for every square meter of correctly orientated facade and roof surface we will generate just over 100kWh/sq m per year.

If you bear in mind that the gross energy demand for the building is 75kWh/sq m/year this means that it can be seen that buildings which want to generate a substantial part of their own energy needs will need to have a 'renewable energy systems footprint' more or less equal to the 'net usable space footprint'.

This fact, combined with the need to drive the base energy demand for the building, lead to some interesting design decisions and this is why I feel that the design of buildings will radically change as buildings strive to become energy self sufficient.

The 'unusual' decisions that were taken in this case relate to the integration of the car park into the overall design.

Typically these days car parking is placed underground. This decision is almost a 'no brainer'. However if you consider the impact of putting car parking underground it can be seen as an unsustainable design decision if you consider the following factors.

1. Underground Car Parking need artificial lighting 24/7. If this was the case in this design the yellow bar for energy shown in Figure 1 would be double the value shown and would add considerably to the buildings overall energy requirements and consequently would mean that the building would be less likely to be self sufficient in energy terms.

2. Underground Car Parking need mechanical ventilation to ensure that the toxic fumes are safely dispersed. Again if the car park was underground the energy shown in Figure 1 for ventilation would also more than double, further adding to the buildings energy burden.

3. Underground Car Parking, especially where more than two levels are required, is very expensive, can affect the water table and aquifers in the area.

So taking all of these factors into consideration, the logical decision was to place the car park above the double height station concourse building. By doing this the car park could use natural light when available by day, only needing artificial light at night. In addition the car park could avail of natural ventilation 24/7. This is provided for in another key design/ aesthetic decision by providing a facade of Western Red Cedar slats. This material was chosen for both its aesthetic and sustainable qualities and contributes immensely to the building's overall aesthetic.

Figure 6. The cladding to the multi-storey car park above the station concourse will consist of tubular Western Red Cedar 'slats' which will be suspended from the main strucutre at roof level and enclose the car park following a gentle elepitcal curve in plan.

Next by placing the car park above the station, over four levels, running east west, a significant area of facade was ideally orientated to the south, which provided an area for integrating PV panels.

Finally, as savings had been made on the construction cost by choosing not to go underground, an elegant suspension structure could be provided for the car park. This structure allowed the footprint of the car park to use the air space above the rail roads at high level. The structure comprises of a central array of columns which rise through the building much like the trunk of a tree. From the tops of these trunks, suspension cables support the exterior of the car park and its facade. However the tops of these trunks also provide ideal mounting points for the vertical axis wind turbines chosen for this design.

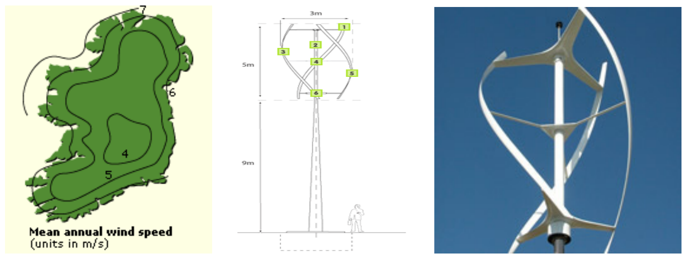

Figure 7. Wind speed map of Ireland shows speeds in excess of 6 m per second for Cork. This combined with the use of a vertiacl axis wind turbine mounted at the top of the suspension mast structure, means that wind can be succesfully integrated into the renewable energy mix, for the building.

So all in all by following a need to reduce energy demands in the first place, a series of key design and aesthetic strategies emerged which very strongly influenced the design of the building as a whole.

Solar Energy In Ireland.

The idea of using solar enegy in Ireland will seem like a contradiction in terms.

However for this project in particular, and largley south Ireland as a whole, the amount of solar irradiation available is in fact quite high and compares very favourably whith Germany where there is an extensive amount of installed PV panels both on a domestic and commercial scale.

The following graph shows geographically where Cork City is and where it lies in terms of overall solar irradiation levels in Europe.

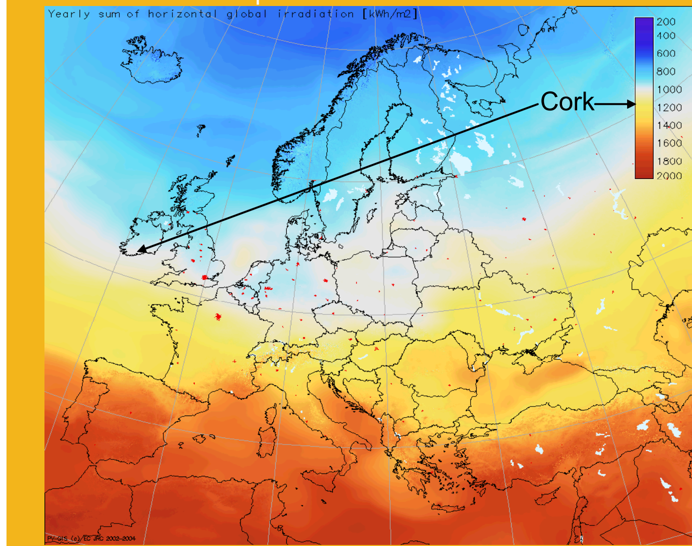

Figure 8. Solar Irradiation Chart for Europe. Cork here has a value of 1200kWh/sq m/year which is comprable to central France.

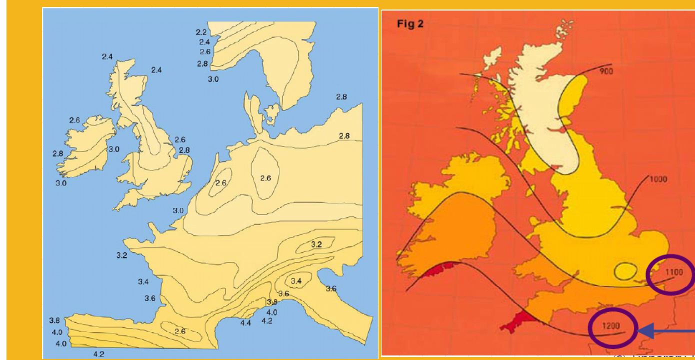

Figure 9. Left Daily Solar Irradiation Chart for Europe. Right Detail view of Chart for the British Isles. Cork City lies in the red area to the south of Ireland here has a value of 1200kWh/sq m/year.

I believe as our expectations for what buildings can do are raised, the whole aesthetic of architecture will change and will lead to very exciting designs.

So in the end the mix of renewable technologies possible on this building was as follows.
(Note a Mega Watt Hour MWh is 1000 kWhs, the kWh is the typical unit for electrical energy consumption)

On the roof
12 Helical Vertical Axis Turbines
generating 120 MWh per annum
Two flat circular discs is 628 sq m of Hybrid PV panels
generating 92 MWh per annum
On the facade 600 sq m of Hybrid PV panels which are hung like a series of brise soleil
generating 83 MWh/y

At ground level a large glass canopy of some 900 sq m has glass on glass PV cells integrated into the canopy. This generates a further 93 MWh (the yield is lower as the PV cells are spaced out to allow natural light through the canopy as well, however the PV cells also act as a natural shading device for the summer sun)

Thus the total power available from renewables is 388 MWh per annum.
The total need of the building is 416 MWh of in other words the building generates 93.3% of its own energy needs.

Figure 10. Breakdown renewable energy systems used.

However if you look at the Carbon footprint of the building it tells an even better story.

When you look at the Carbon emissions for Electricity Generating Power Stations the average is made up of Power Stations that are very polluting all the way to renewables sources which are non polluting.

As more and more energy is provided into the national grid by renewables, this average figure will both be reduced mathematically, but in addition, a tipping point will be reached where the most polluting power stations can be decommissioned once there is enough renewable supply in the mix.

These facts are reflected in how carbon emissions and offsets are calculated.

The following calculation shows how the Carbon Footprint is calculated.

Total Energy Requirement for building is 416 MWh/annum
this is 416,000 kWh/ annum
Total Renewable Energy Supply per annum 388 MWh/annum
this is 388,000 MWh.

Carbon emissions for electricity taken from the grid are calculated at 0.422 kg CO_2 per kWh.
Carbon emissions displaced by supplying renewable energy are calculated at 0.568 kg CO_2 per kWh.

Using these figures the following equation gives the
Net Carbon Footprint.
416,000 kWh x +0.422 kg CO_2 per kWh = +175,553 kg CO_2
388,000 kWh x -0.568 kg CO_2 per kWh = - 220,385 kg CO_2
Net Carbon Emissions are -44,832 kg CO_2

As the final figure is negative, this means the building takes more carbon out of the environment than it contributes. This means that the building is in fact better than Net Carbon Zero target, which was the original objective.

In short the building is Net Carbon Negative.

3. How the entry is manufactured and delivered to its consumers

The building will be built using traditional procurement procedures, that is to say it will be fully designed and detailed before seeking tenders. A contractor will be selected from a public tender process. Specialised systems such as the renewable energy systems will form the basis of separate tenders and will be provided as 'Prime Cost Sum' figures in the main contract. As Iarnrod Eireann are both the designer and client and end user, there will be a unique opportunity to deliver a building to an expert client, who in turn will be able to monitor the performance of the building and in turn inform the inhouse designers. Railway stations are buildings that tend to stay in business for a long period of time. Thus this building type is an ideal building type to include more innovative sustainable technologies with longer than average pay back times, as the building's life expectancy is equally long and therefore the company can afford to take a long term view.

4. How the entry and its function/use maintains excellence in eco-sustainability in an environmentally friendly and responsible manner.

Much of this has been covered in the detailed explanation given under heading 2. However by way of a summary I would offer the following description.

What this building attempts to do is to move the whole debate about what constitutes eco-sustainable and environmentally friendly building design away from rhetorical positions into real designs and built architectural examples. In the design development of this building and ultimately when built, this building will provide tangible evidence of what is possible when one considers from the outset, in a responsible manner, all of the issues pertaining to sustainable design.

The key to arriving at this design was the close coordination and involvement of all key design professionals, particularly service and environmental engineers from the outset. It is clear that excellence will only be achieved if this occurs very early on and that each discipline in the building team needs to cross boundaries to understand the other disciplines' point of view in order to arrive at a seamless design solution. This building provides such a solution.

5. At least 1 photograph or rendering that represents the entry. It is optional to upload up to 5 additional JPEG images.

Separate Image files showing the external perspective shown here and four key floor plans have been included/uploaded as part of this submission.

The image shown below here shows the double height concourse level at the ground, with the four storeys of car parking clad in a western red cedar slat system above.

The canopy at ground level has PV cells integrated into the glass, while the car park cladding has a series of high performance PV units mounted as brise soleil type elements on the facade.
The mast like structure used to suspend the car park over the railroad track below and to the rear (out of shot in the image) provide ideal mounting points for the vertical axis wind turbines.