CONCLUDE
Informed Decision Making

Case Study
Low Energy – Low Carbon Hospital Design

Project: Brighton & Sussex University Hospitals NHS Trust: £420 Million 3T's Redevelopment

- The 90,000m^2 redevelopment in Brighton, UK and which is a quintessential English sea-side resort that rose to prominence in the Victorian era. It has been designed to replace buildings a collection of buildings dating back to that period.
- The planning for the new facilities has been based on standard Department of Health Guidance, where Health Planners have interpreted these standards and developed the requirements for the new facility using Trust data and forecasts to size the facilities.
- The Integrated Decision Support team under the leadership of Professor Bacon of the Conclude Consultancy was appointed in October 2010 to lead the low energy – low carbon strategy for the project. The multi-disciplinary team comprises Professor Fried Augenbroe who leads the analytics team out of Georgia Tech University, Atlanta in the United States, and Timo Husu who leads the energy modelling team out of Granlund OY, Helsinki in Finland.

Context for low energy – low carbon hospital design in the UK:

- Acute hospitals in the UK tend to be oversized. Indeed the Kings Fund (a not for profit research organisation) has quantified the over-capacity in the UK health sector as nearly 2.0m square metres. This is equivalent to the combined retail floor space of two of the UK's largest supermarket chains.
- Carbon emissions from public sector acute hospitals continue to rise, despite the obligations of the UK government to the Carbon Reduction commitment.

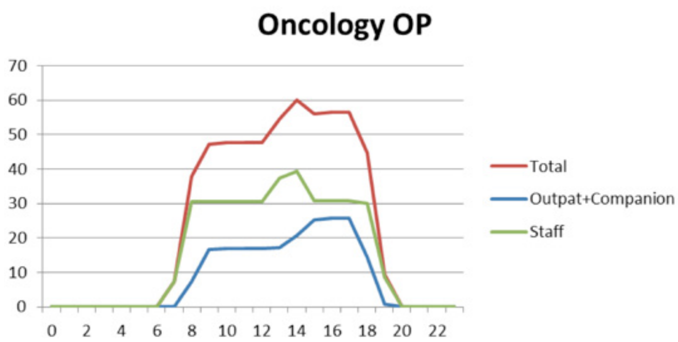
- Over-sizing of HVAC plant in the UK has been a continual issue for many forms of commercial and public sector developments. Over-sized plant is responsible for unnecessary capital expenditure (CAPEX) and operational expenditure (OPEX).
- Design team forecasts of acute hospital performance tend to be very inaccurate. The Chartered Institute of Building Services Engineers (CIBSE) has quantified the difference as a factor of least five. Buildings forecast to perform at the highest energy efficiency rating all to often perform near to the lowest efficiency energy rating.

A low energy – low carbon strategy for acute hospitals in the UK.

- Research and analysis by The Conclude Consultancy has identified the key reasons for the poor energy and associated carbon performance of acute hospitals in the UK. It originates with the substantial assumptions that engineering design teams often have to make in the design of the heating, cooling and ventilation systems. These assumptions are rarely challenged and this lead to the poor energy performance that was identified earlier.
    - A key element of the project at Brighton has been to establish a basis of engineering design founded in a new contribution to building engineering science called 'Occupancy Analytics'. This is a form of analysis developed by Conclude that investigates how the facilities would be used by the clinicians, and translates the knowledge of that use, into data that is used by the engineering design teams in the design of the HVAC systems.

Occupancy Analytics in

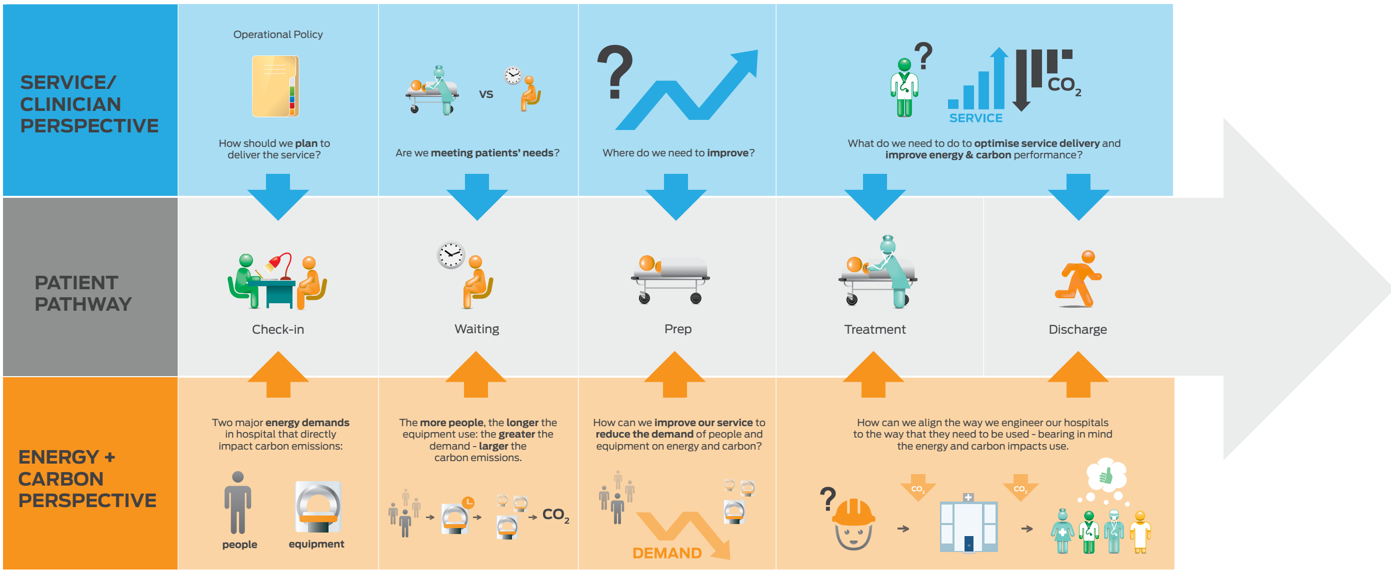
Department			7	8	9	10
Results	Oncology Day Treatment	M	10	47	55	6
		L	0	38	45	5
		U	34	57	67	7
	Oncology Day Treatment Pat	M	0	4	13	2
		L	0	0	7	1
		U	0	9	19	3
	Oncology Day Treatment Sta	M	10	43	43	4
		L	0	38	38	3
		U	34	48	48	4
	Oncology OP	M	7	38	47	4
		L	0	26	40	4
		U	24	49	55	5
		M	0	7	17	1



In these two illustrations the probability of occupancy and the occupancy profile at each hour of the day are illustrated. (Please note: M,L,U values relate to the probability of occupancy based on different percentiles)

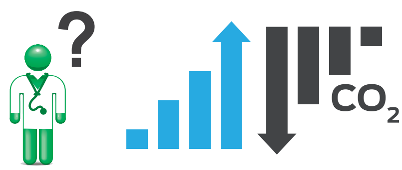
- The assumptions concerning occupancy and equipment use lead to over-sizing of major plant, over-sizing of facilities and engineering solutions that are not properly aligned to the users needs of the facilities. Research in the UK, Australia and the United States confirm that this is not just a problem for the UK. These assumptions are even embedded in 'formulaic rules of thumb' and also in design guidance such as Health Technical Memoranda (HTM's).
    - A key objective for the Brighton project was to clearly demonstrate both the CAPEX and OPEX savings that would be possible through optimised engineering design, founded in a new understanding of how the facility would be used in practice.
- Typically clinical users have a limited understanding of the energy and carbon impacts of their working practices. It would be rare that they would be able to experiment with different working practices and so understand the impacts of them on energy and carbon.
    - A key objective for the Brighton project was to correlate the energy and carbon impacts performance of departmental working practices. The Conclude Consultancy developed

a Whole Facility Energy Model that processed the occupancy analytics data into it and thus enabled the energy and carbon impacts of use to be modeled.



- Typically energy consumption reporting is rarely possible at functional level in an acute hospital. Without an understanding of how working practices impact energy consumption, users are ‘flying blind’ so far as control of energy and carbon emissions is concerned. Furthermore, it is typical to report energy consumption using metrics that have little meaning to clinical users.
  - A key objective for the Brighton project was to establish departmental energy budgets with the users. The strategy has been to directly correlate the energy and carbon impacts for each patient visit and each patient type visiting the hospital. The Conclude Consultancy has modelled the forecast hourly energy consumption and forecast hourly patient movements in each area of the hospital. This data provides the basis of energy budget for each department, where the forecast accumulated activity directly informs the energy budget.

How can we **improve our service** to **reduce the demand** of people and equipment on energy and carbon?



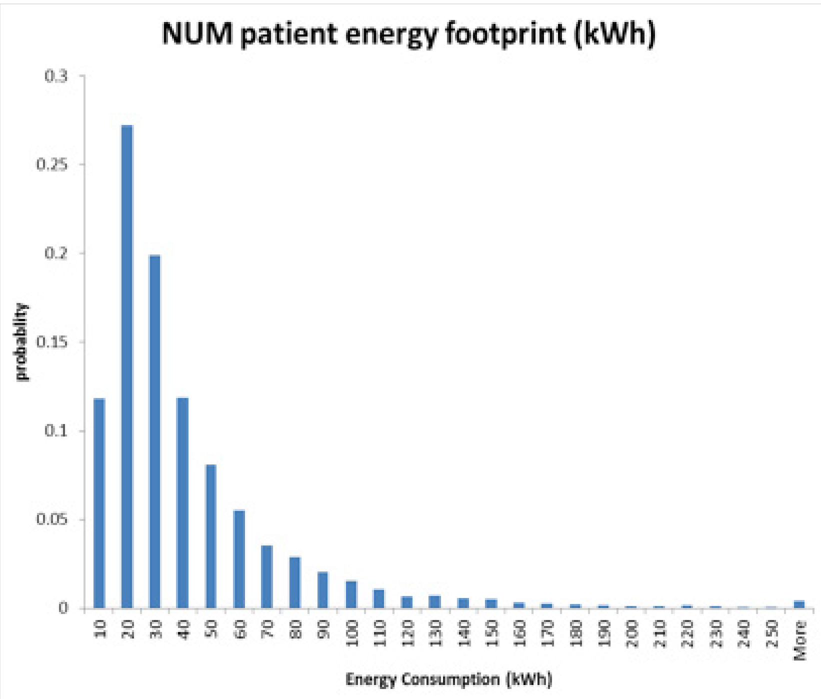
What do we need to do to **optimise service delivery** and **improve energy & carbon** performance?

Results

- The basis of our dialogue with clinicians has been through their Operational Policies. In translating those policies into a Health Activity Model database we have developed the mean to systematically analyse them within the Occupancy Analytics simulation. The analysis results in:

    1. Probability of occupancy profiles at each hour of the day.
    2. Probability of major equipment use at each hour of the day, including equipment usage profiles.
    3. Space utilisation at each hour of the day including the probability of either under or over-utilisation.

- An engineering review concluded that the engineers could never have assumed the extent of diversity of use that Occupancy Analytics provides.
- The diversity profiles for can then be modelled to understand the energy and carbon impacts where the engineering systems can be controlled to achieve those profiles.
- The energy impact of each patient type can then be modelled as illustrated below



Energy footprint for a Nuclear Medicine Outpatient appointment.

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- The Occupancy Analytics data enables the engineering design to be carried out from first principles for each functional entity in the hospital. This means that cooling and heating load profiles can be constructed 'bottom-up' rather than through 'top-down' estimates based on the over peak ventilation, cooling and heating load profiles for the whole facility.
- Occupancy Analytics enables the peak loads in each functional entity to be optimised based on agreed Operational Policy. In other words by working with the clinicians we control peak ventilation, cooling and heating loads between functional entities and so reduce the overall peak loads.
- Departmental energy budgets can be constructed from an analysis of patient pathways within each department. This is achieved through simulation aligned to Operational Policies.

Conclusions

- The impact of Occupancy Analytics on CAPEX can deliver savings in HVAC plant, Combined Heating and Power (CHP) and Boiler capacity of between 15%-30% depending on the system. These savings result directly from the new basis of design provided by Occupancy Analytics. At Brighton these reductions are expected to deliver between £10m-£15m of CAPEX savings.
- The Whole Life Cost benefits of Occupancy Analytics are equally dramatic. Current forecasts are that the payback on improved controls and other energy control measures would be between 4-5 years. After 25 years the Cost consultants forecast £38m of OPEX savings.