"A design team which produces a total, balanced, efficient design can help to produce a better environment."

Sir Ove Arup, November 1968

Life Cycle Aspects in the early design stages

The foundation of a sustainable framework

Project OSCAR

Oslo 20th January 2015

Phil Nedin

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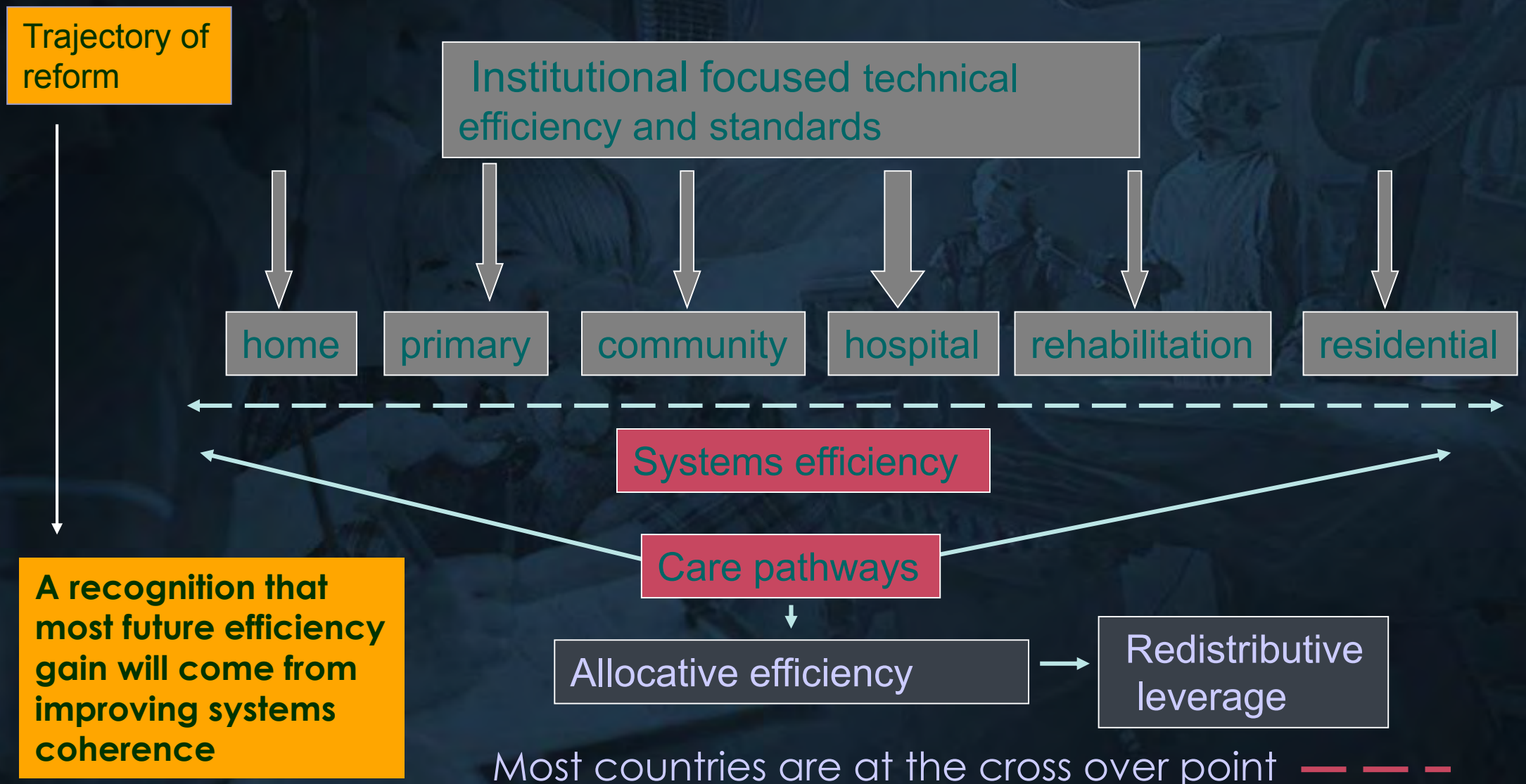
Facilitating reform in the mature healthcare markets
whole systems efficiency – extending the provision of care



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A shift in approach to delivery

Current view	Evolving model of care
Geared towards acute conditions	Geared towards long-term conditions
Hospital-centred	Embedded in communities
Doctor-dependent	Team-based
Episodic care	Continuous care
Disjointed care	Integrated care
Reactive care	Preventative care
Patient as passive recipient	Patient as partner
Self-care infrequent	Self-care encouraged and facilitated
Carers undervalued	Carers supported as partners
Low-tech	High-tech

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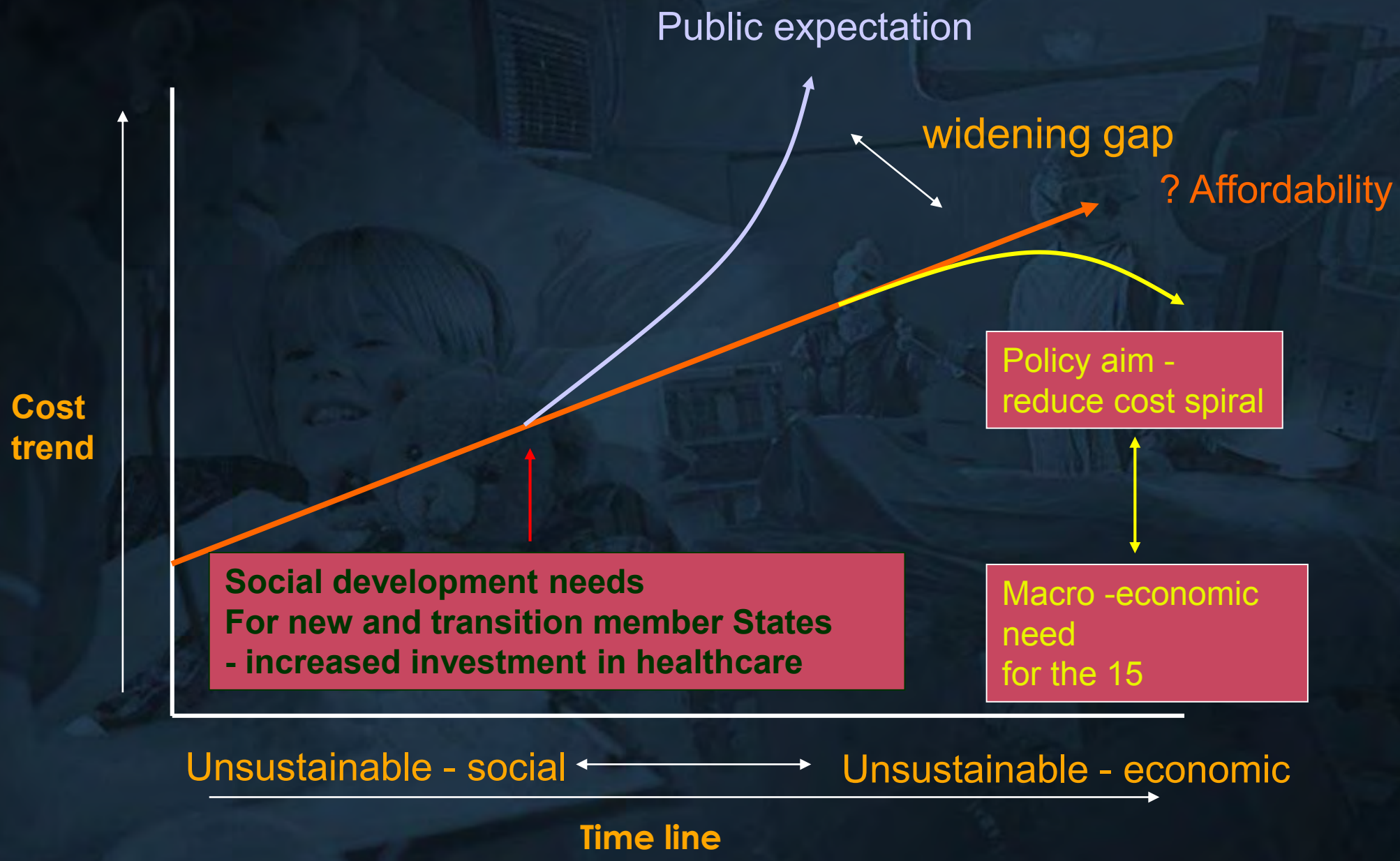
European gradation in health – and health facilities



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How easy is it to engage in the debate ?

The cost of Healthcare 2013

Country	GDP/Head (US$)	Health % GDP	Healthcare cost/head (US$, € & £)		
USA	47,150	17.9	$8,439.85	€6,680.69	£5,297.02
Norway	85,390	9.5	$8,112.05	€6,420.17	£5,090.46
Denmark	56,240	11.4	$6,411.36	€5,076.68	£4,023.25
Netherlands	46,900	11.9	$5,581.10	€4,418.77	£3,502.56
France	39,450	11.9	$4,694.55	€3,719.21	£2,946.84
Sweden	48,900	9.6	$4,694.40	€3,716.74	£2,946.09
Germany	40,120	11.6	$4,653.92	€3,687.12	£2,907.87
Belgium	43,080	10.7	$4,609.56	€3,649.88	£2,893.05
Australia	50,750	8.7	$4,415.25	€3,495.23	£2,771.29
Ireland	46,170	9.2	$4,237.64	€3,355.10	£2,659.44
Finland	44,380	9.0	$3,994.20	€3,162.46	£2,506.84
UK	36,340	9.6	$3,488.64	€2,763.84	£2,189.87
New Zealand	32,370	10.1	$3,269.37	€2,587.71	£2,052.07
Italy	34,080	9.5	$3,237.60	€ 2,473.42	£1,992.88
Spain	30,550	9.5	$2,902.25	€ 2,299.34	£1,821.49
Greece	26,610	10.2	$2,714.22	€ 2,149.98	£1,703.77
Portugal	21,490	11.0	$2,363.90	€1,872.49	£1,483.86
Poland	12,290	7.5	$921.75	€730.13	£578.59
South Africa	7,280	8.9	$647.92	€512.87	£406.66
China	4,430	5.1	$253.93	€200.98	£159.37
India	1,410	4.1	$57.81	€45.76	£36.28

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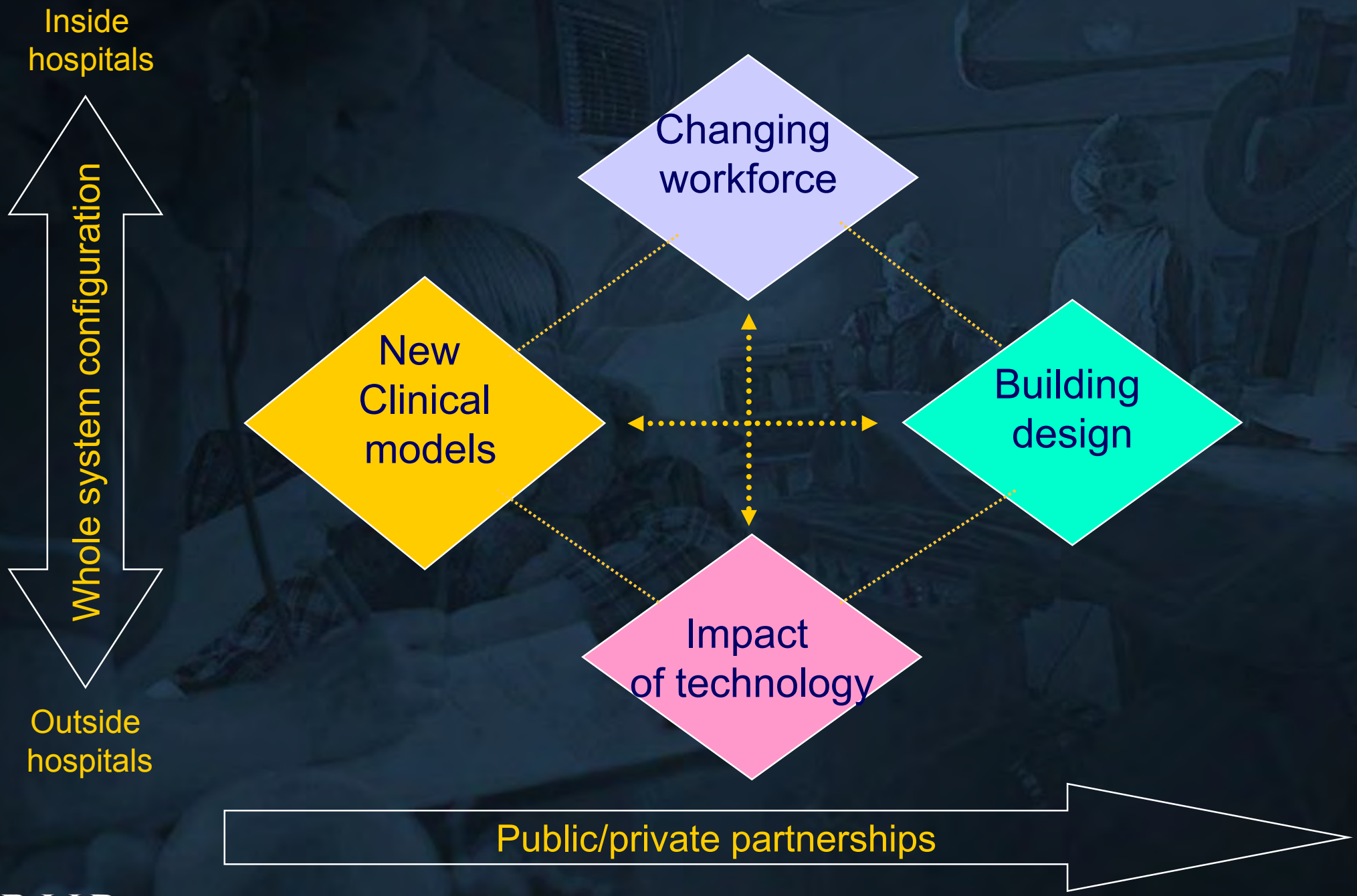
Source – World in Figures 2013. Conversion $ to € to £ Sept 2012

Drivers for change – The changing face of healthcare



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Design adds value

10

Maintenance cost

1

Capital cost

0.1

Design costs

100 Running cost of the business

By the time a building is completed up to 90% of its life cycle economic and ecological costs have been made inevitable.

More for less – design council 1997

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Sustainable Approach
Non Sustainable Approach
Communication
Past Experience
Project Leadership
Whole Life Costing
Clinical Efficency
Decision Making Process
Future Needs
Prescriptive
Low Carbon
High Carbon
Innovative
Current Needs
Therapeutic Environment
First Cost
Brief
Design
Procurement
Construction

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Communication
Past Experience
Project Leadership
Whole Life Costing
Decision Making Process
First Cost
Brief
Design
Procurement
Construction

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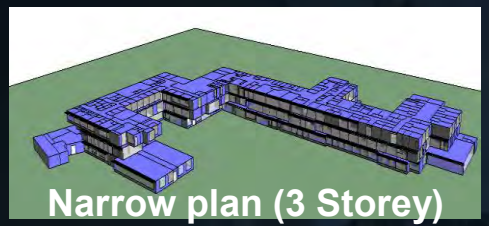
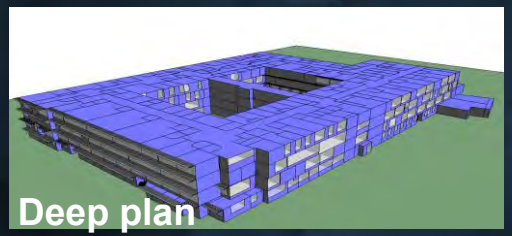
Hospital Geometry – generic options





	Narrow Plan (2 Storey)	Narrow Plan (3 Storey)	Intermediate Plan	Deep Plan
Total Floor Area	14,795m^2	14,663m^2	14,775m^2	13,956m^2
Number of Floors	2	3	3	4
Façade Length	1886m	1863m	2051m	1840m
% Façade	34.41%	34.31%	37.48%	35.60%
External Length of foundation	1008m	686m	681m	482m
Area of Foundation	8127m^2	5830m^2	5210m^2	3680m^2
% glazing	60.20%	60.35%	56.27%	35.42%
Ventilation strategy	Predominantly Natural Ventilation	Predominantly Natural Ventilation	Mixed mode	Predominantly Air conditioned

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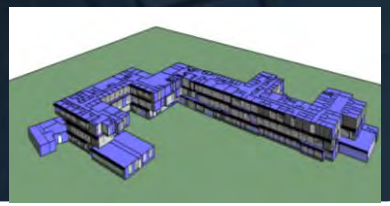
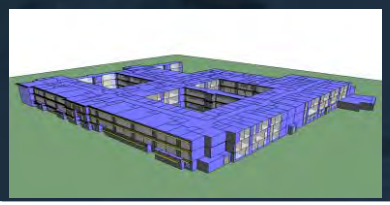
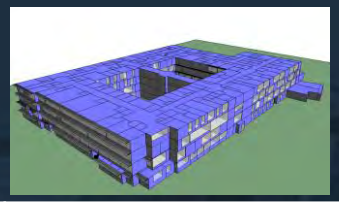
Capital Cost Breakdown

	Narrow Plan (2 Storey)	Narrow Plan (3 Storey)	Intermediate Plan	Deep Plan
Substructure	£2,082,540	£1,417,444	£1,408,147	£996,497
Superstructure	£2,379,005	£2,540,942	£2,612,866	£2,580,671
Roof	£1,865,548	£1,338,273	£1,195,924	£844,742
Façade	£4,678,560	£4,630,479	£4,882,135	£3,397,578
Internal finishes	£4,944,949	£4,931,111	£4,985,500	£5,004,332
Mechanical Services	£3,790,082	£3,762,333	£4,042,619	£4,740,210
Electrical Services (incl. lifts)	£4,150,357	£4,048,077	£4,106,319	£3,939,734
BWIC	£720,261	£617,680	£642,500	£617,680
Preliminaries and contingencies	£6,835,712	£5942,914	£6,367,686	£5,999,323
Total	£31,447,315	£29,229,253	£30,243,696	28,128,205

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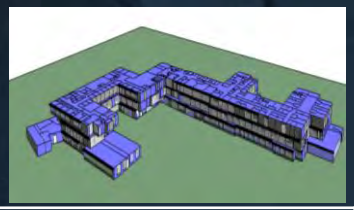
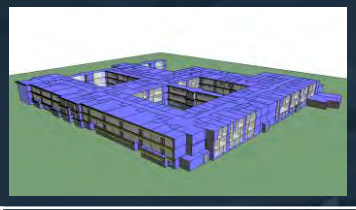
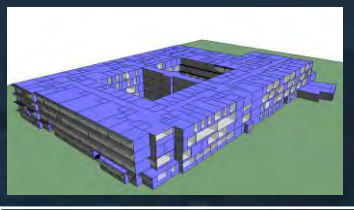
Whole life costing

	Narrow Plan (2 Storey)	Narrow Plan (3 Storey)	Intermediate Hospital	Deep Plan
Capital cost	£31,447,315	£29,229,253	£30,243,696	£28,128,205
Financial cost at Year 1	£2,258,348	£2,236,854	£2,396,193	£2,447,218
Financial cost at Year 10	£23,915,483	£23,574,025	£25,293,023	£25,715,045
Financial cost at Year 30	£92,87,066	£91,040,351	£97,796,126	£94,761,126
Financial cost at Year 60	£196,828,900	£192,524,507	£198,863,388	£196,488,271
Annual social cost of carbon (£70/ton)	£20,567	£20,266	£22,001	£36,440

Financial cost includes: Operation and maintenance, social cost of carbon and energy.

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Energy and Carbon

	Narrow Plan (2 Storey)	Narrow Plan (3 Storey)	Intermediate Plan	Deep Plan
Total natural Gas (MWh)	2375	2290	2577	1826
Total Electricity (MWh)	1473	1473	1559	3505
Annual Total (MWh)	3848	3765	4136	5331
Energy consumptions ($GJ/100m^3/yr$)	34.68	34.24	37.33	50.93
Carbon Emissions $kgCO_2/m^2$	45.38	44.62	48.45	103.90

- Energy data is based on a Cardiff weather profile
- 35-55GJ/100m3/yr mandatory energy target in England (as specified in HTM 07-02)
- We could save the CO_2 volume of 9650 Olympic pools or 16 Cardiff Millennium stadiums by moving from Deep plan to Narrow plan (3 Storey) design during the life of the hospital (60yrs).

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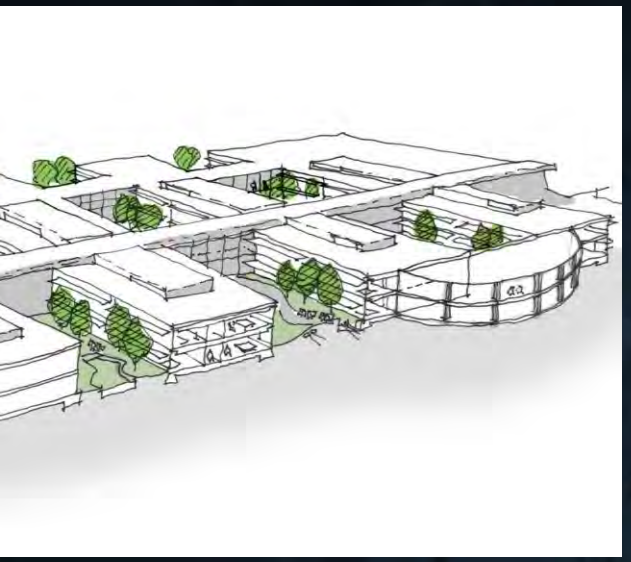
Narrow plan v's deep plan – Whole life costing



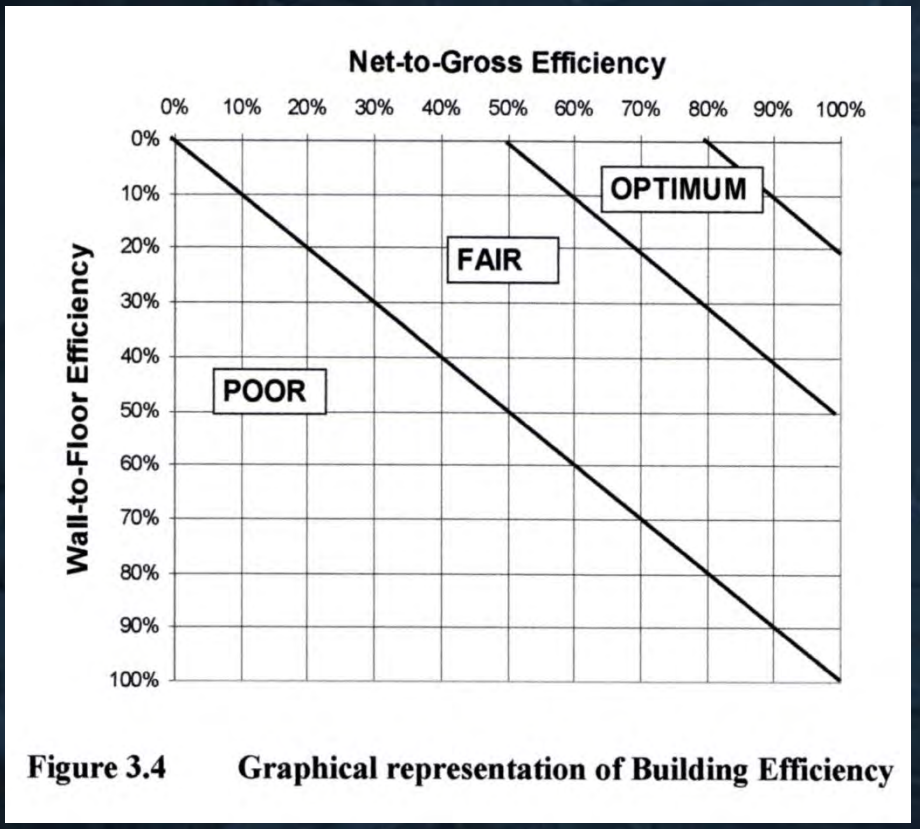
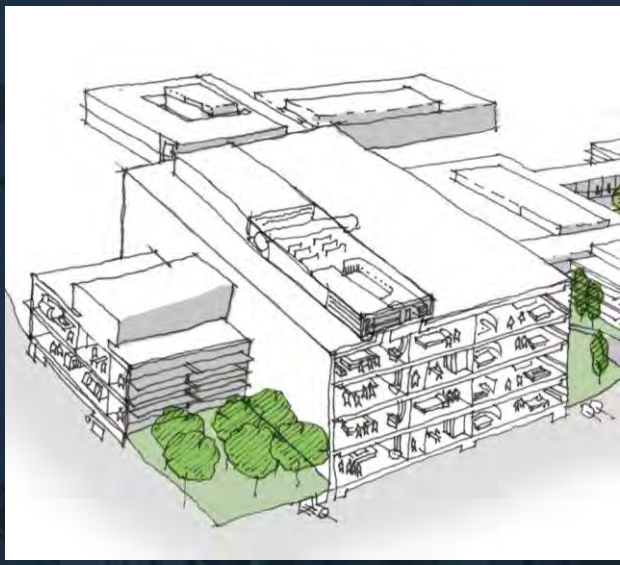


Figure 3.4 **Graphical representation of Building Efficiency**



- Departmental adjacencies = Clinical efficiencies

- Construction efficiency = Capital cost economies

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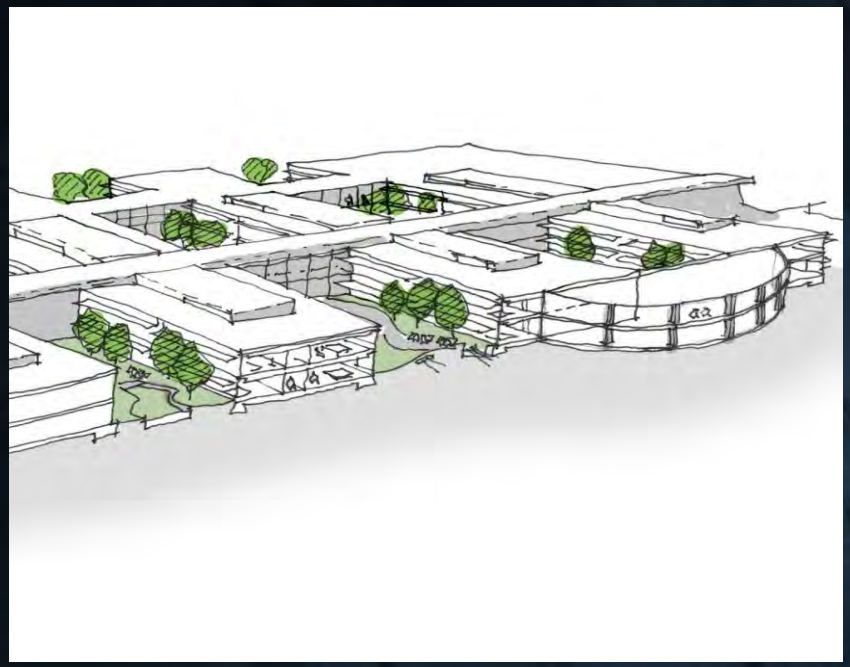
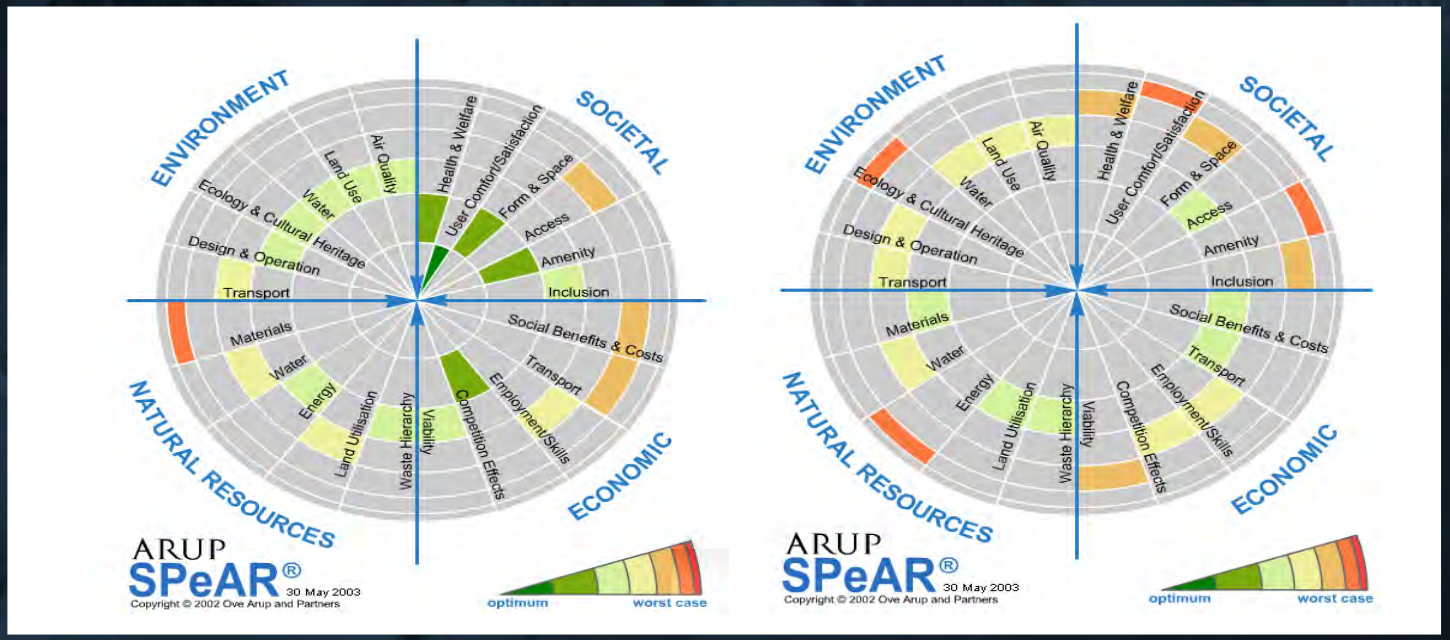
Sustainable planning – Narrow plan v's deep plan





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Innovation taking a historical perspective – Crimea model - circa 1850

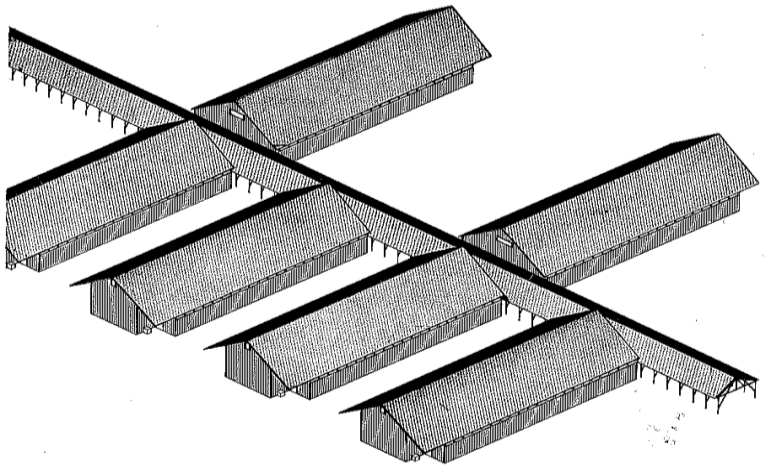

Fig. 11
Isometric drawing illustrating the linear organization of Brunel's standard ward units : pavilions either side of a connecting corridor, characteristic of indeterminate buildings. (Drawn by David Toppin)

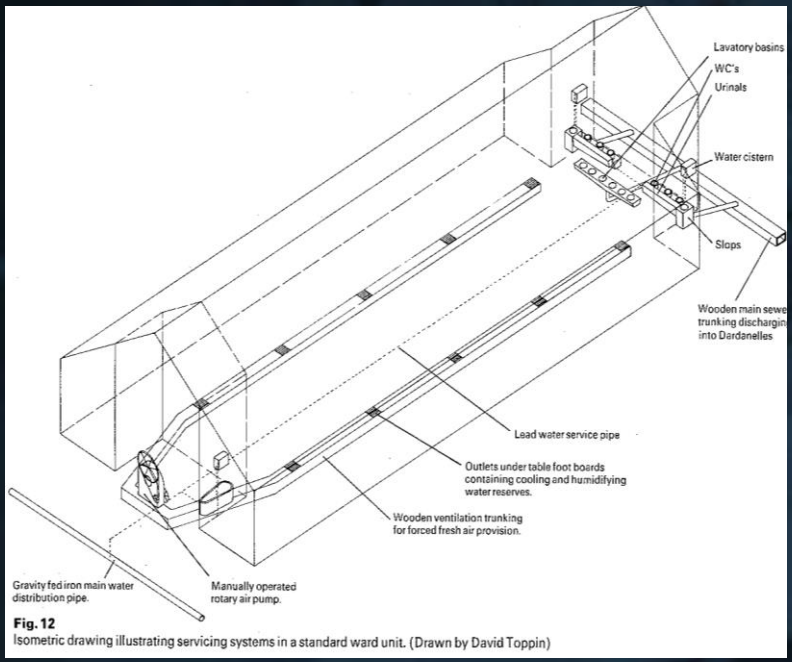

Fig. 12
Isometric drawing illustrating servicing systems in a standard ward unit. (Drawn by David Toppin)

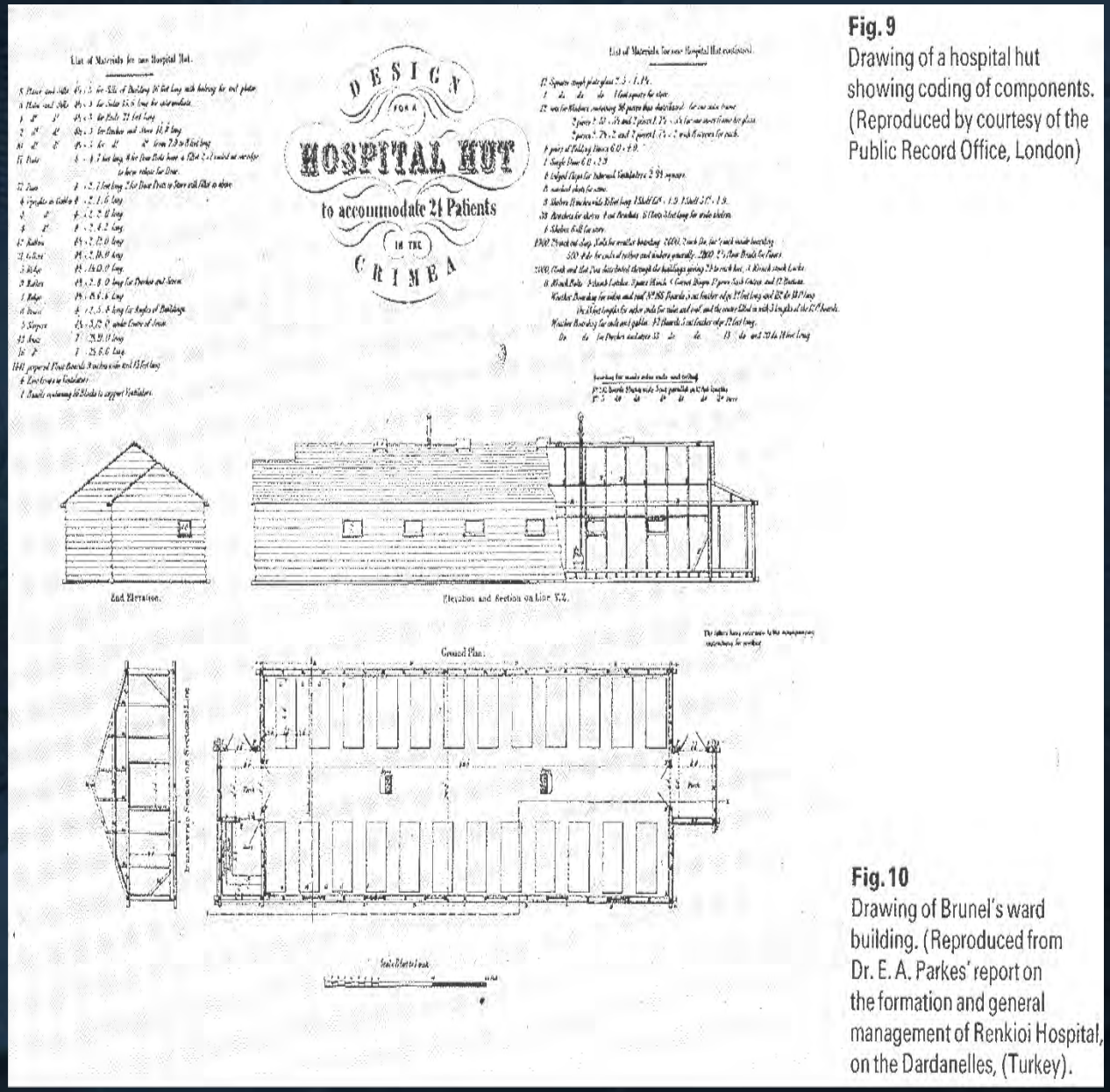

Fig. 9
Drawing of a hospital hut showing coding of components. (Reproduced by courtesy of the Public Record Office, London)

Fig. 10
Drawing of Brunel's ward building. (Reproduced from Dr. E. A. Parkes' report on the formation and general management of Renkioi Hospital, on the Dardanelles, (Turkey).

Modular design, offsite construction, flexible façade, logistics and underfloor systems

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Communication
Past Experience
Project Leadership
Whole Life Costing
Decision Making Process
Future Needs
Current Needs
First Cost
Brief
Design
Procurement
Construction

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Healthcare drivers that shape our business

Robotics

The intelligent patient

Infection control

Drug development

Private finance

Surgical techniques

Alternatives

Therapeutic environments

Intelligent pills

DNA, RNA, Stem cell

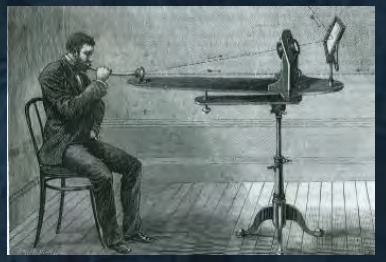
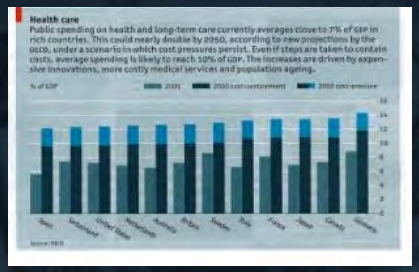


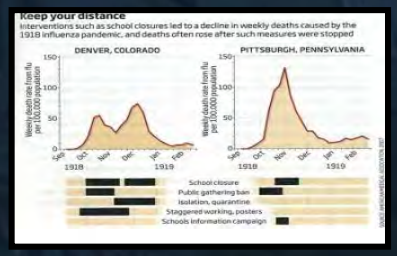
Photo acoustics

The elderly & chronic illness



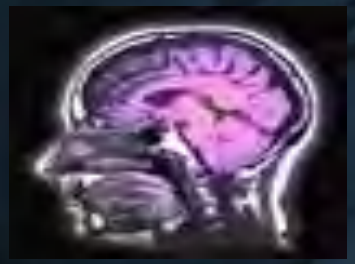
Affordability

Home diagnostics



Pandemic risk

Artificial organs

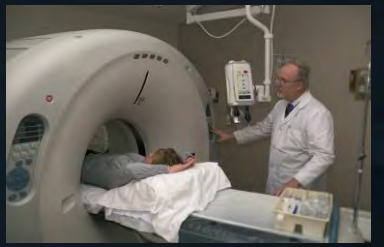


Public health

Government & Legislation

Global warming

ITC



Imaging

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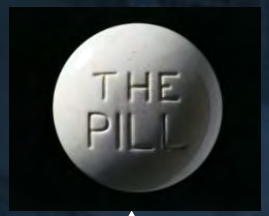
Patient generation - gratitude

60 Years

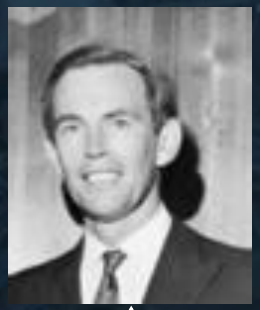
1942
Penicillin produced

1948
NHS created

1953
DNA by Crick & Watson



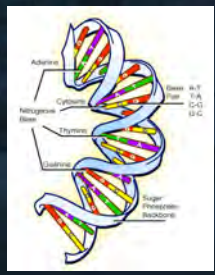
1960 FDA approves contraceptive pill



1967 First Heart Transplant

1977
First Human MRI scan

1981
HIV/AIDS CDC recognised



2002
Human Genome sequenced

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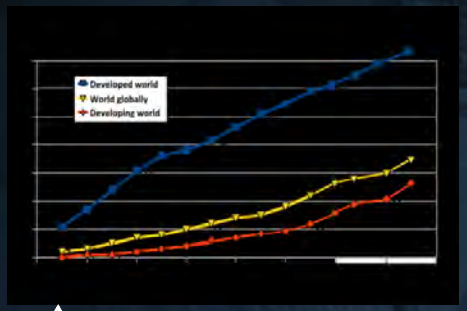
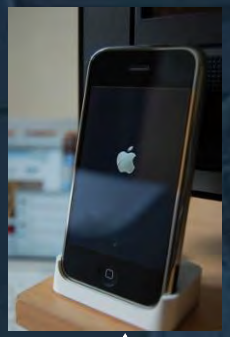
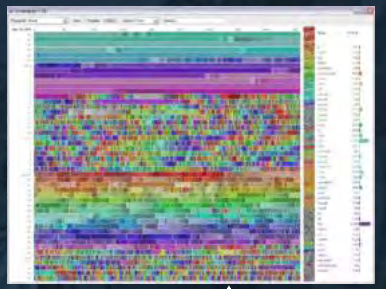
Patient generation - expectation

30 Years







1983 Apple Mac

1991 2G mobile phone

1995 Internet commercialised

2000 Google 10 languages

2002 XBOX

2004 Facebook

2007 iPhone

2008 iPad

2013 Big Data Genomics

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lifestyle developments!

- If eating habits met nutritional standards, 70,000 lives a year would be saved in the UK.
- Domino pizza & Kentucky fried chicken profits rose by 25% and 14% respectively in 2008 while McDonalds had their best trading ever year in the UK.





- Anorexia in girls under 16 in the UK has risen by 80% in the past decade.
- 23% of liver transplants in UK 2008 went to people with alcohol related disease – an increase from 14% in 2007.

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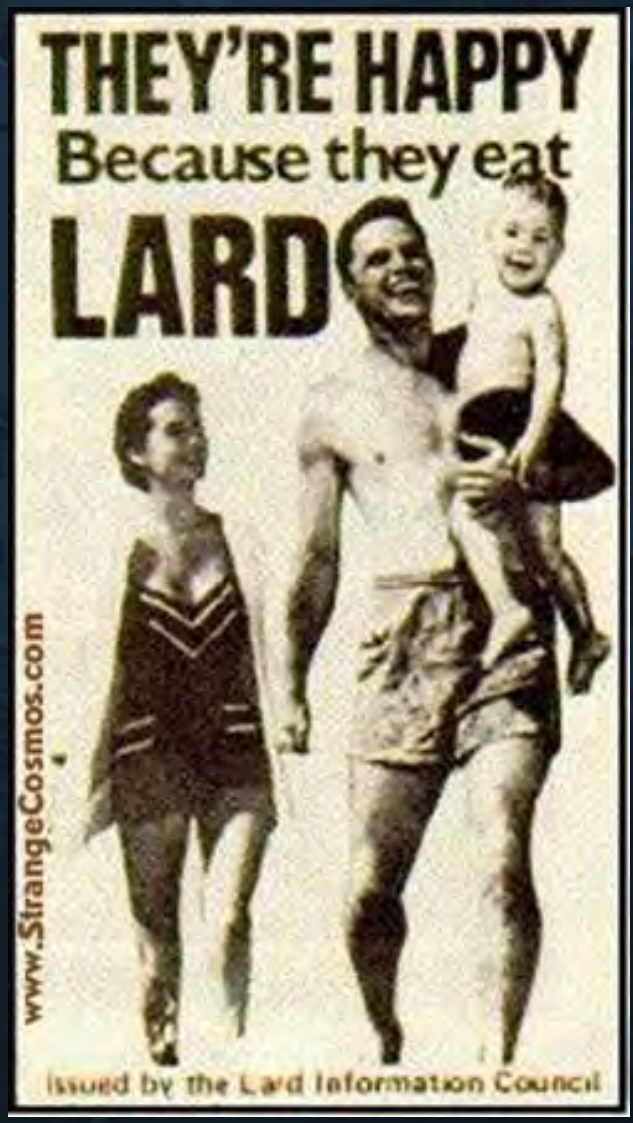
1930's adverts promoting lifestyle



Legislation v's the nanny state

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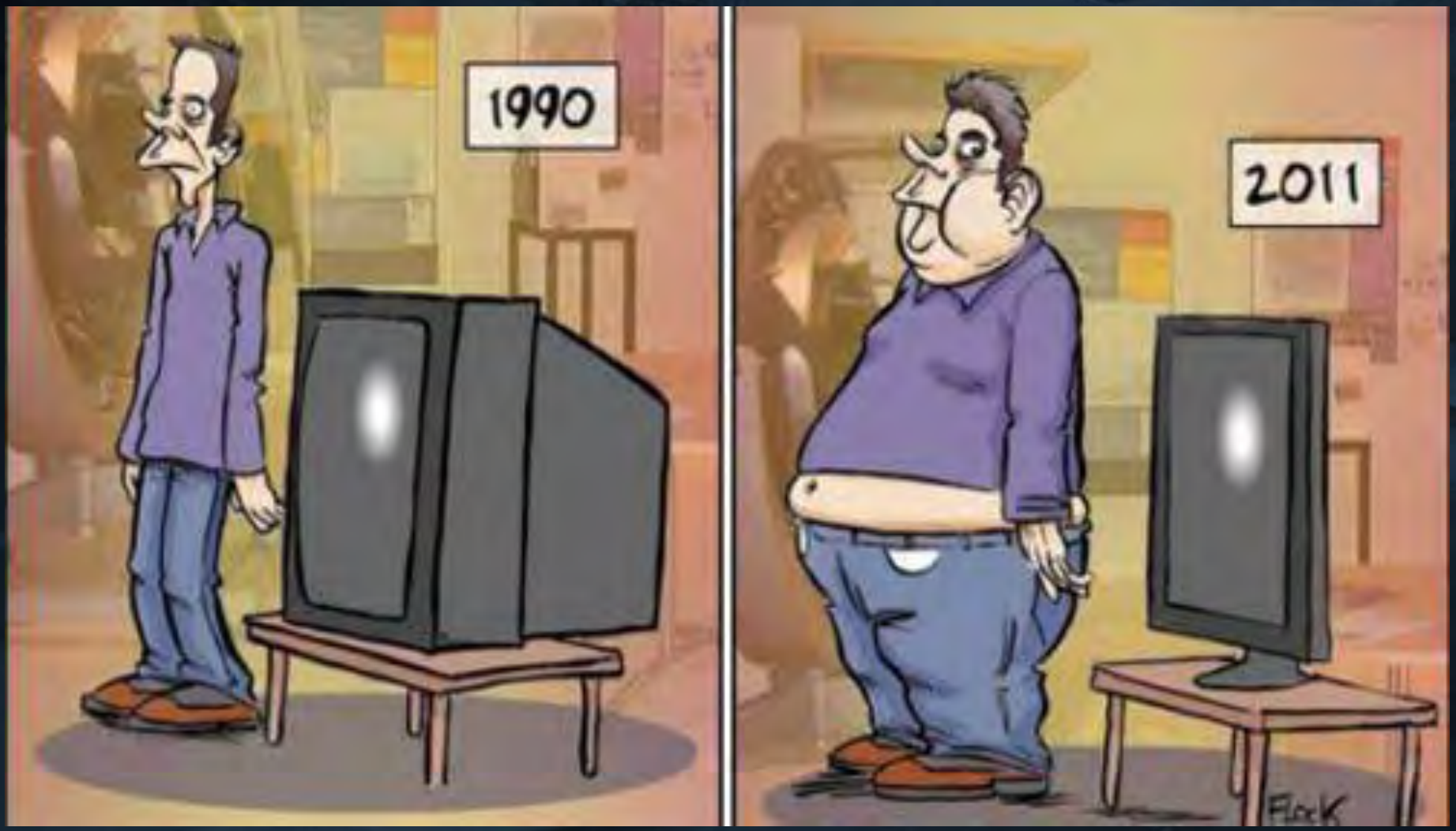
How things have changed!



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Non-Communicable diseases - Obesity %

(BMI of 30 or more)

	US	UK	Brazil	China
2002	34.90%	20%	10.90%	1.30%
2010	46.30%	25%	18.50%	3.80%
% diff	11.40%	5%	7.60%	2.50%
actual	38,760,000	3,000,000	14,516,000	32,500,000

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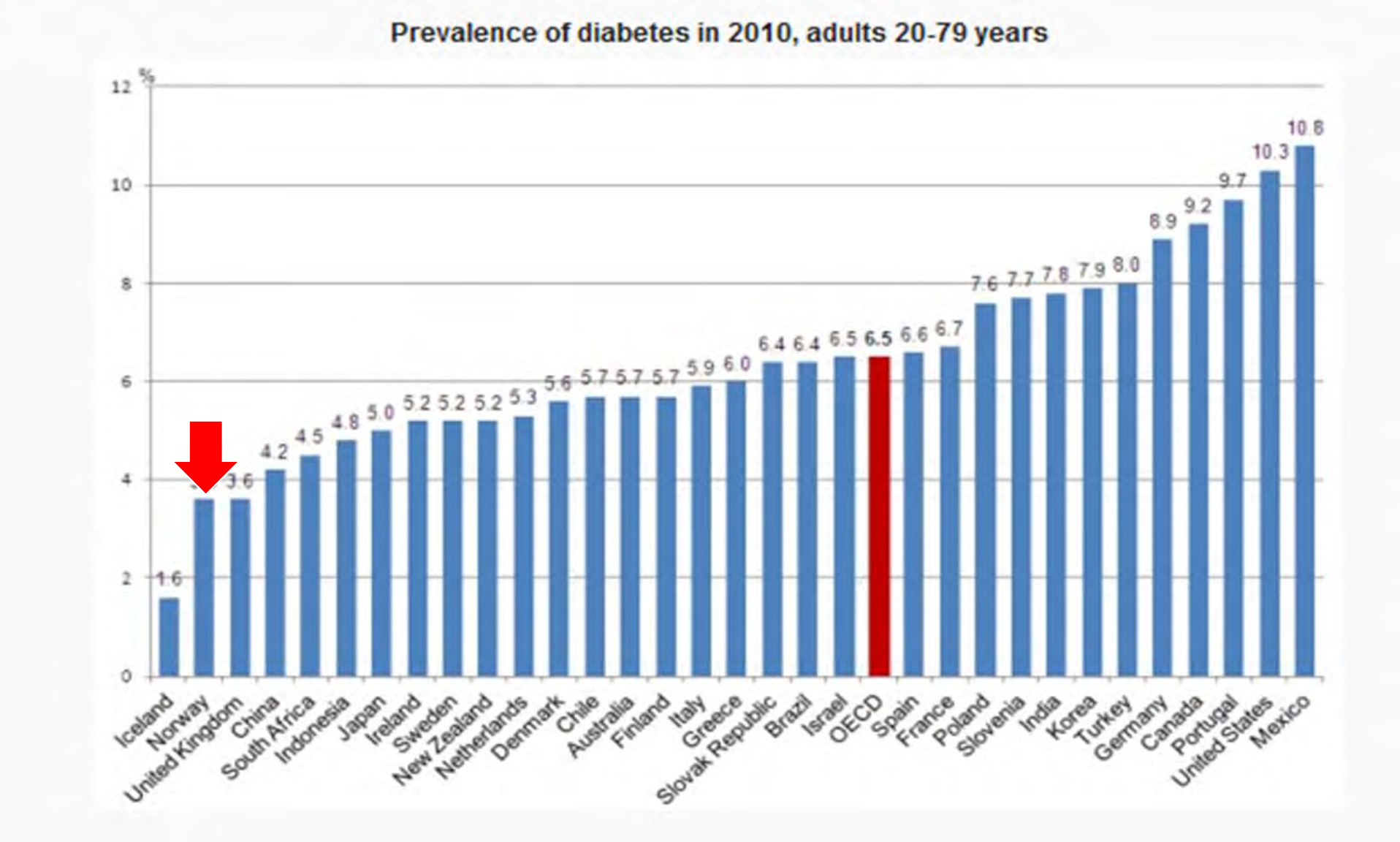
Prevalence of diabetes in 2010



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Australian temptation

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Danish temptation

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Alzheimer's Disease – UK trend

- 700,000 .....now
- 940,000 2021
- 1,700,000 2051
- 154% INCREASE OVER THE NEXT 45 YEARS!

Diabetes patients – UK current

2.5 Million diagnosed
7 million in pre-diabetes stage

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Caring for our elderly

Family lives 200 miles away

Poor vision and hearing

Low income

Lives alone

Own home

Has diabetes and arthritis

Does not qualify for L.A. home care assistance

Fiercely independent

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Genetic developments!

The completed human genome is only 5 years old but genetic pathways have already been successful:

- Age related macular degeneration
- Inflammatory bowel disease
- Cardiovascular disease
- Type 2 diabetes
- Obesity
- Cancer therapies
- Major genome centres are now able to sequence 1 human genome every day – the first one took many years

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Drug developments!

- The development of the Poly-pill to postpone cardio-vascular disease!

Surgical developments!

- Tumours to be illuminated with targeted dye to ensure first time removal!

Technical developments

- Proton beam for targeted radiation treatment – large scale
- iphone apps – small scale

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The internet, social networking sites & wireless devices

The catalyst for new healthcare business models

Smart phones (Apple Apps store)

Access to medical records

Health monitoring – exercise, diet and vital signs

Health advice by phone (developing countries)

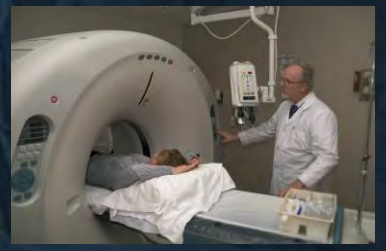
Medical education by phone and networking sites

Magic carpets for the elderly

Medication reminders

Personal health coaching by phone

Social networks organised for common ailment support



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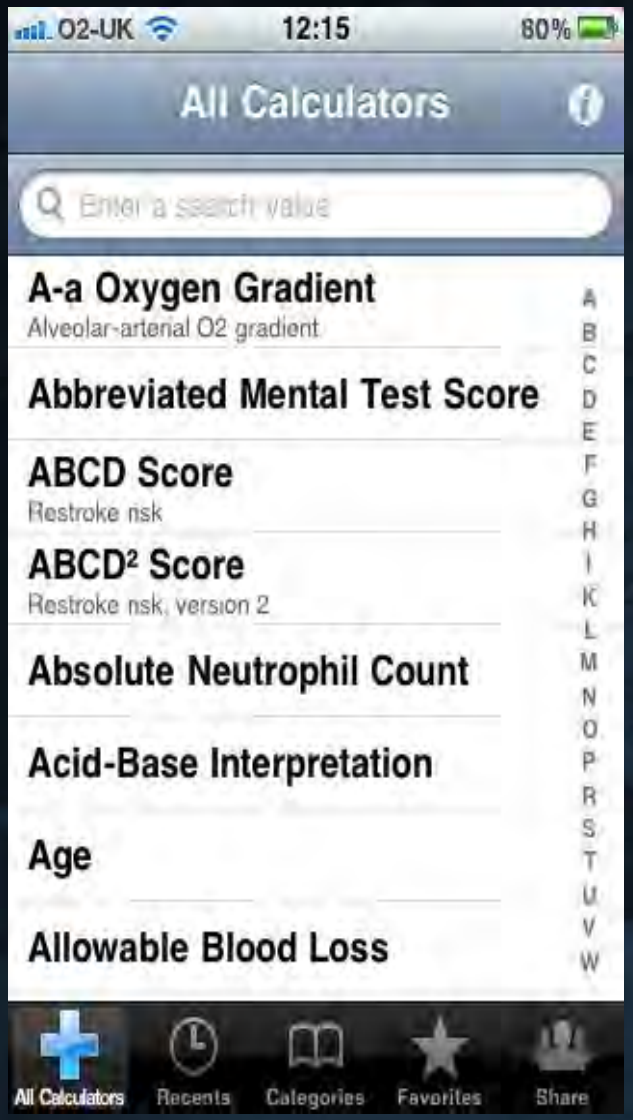
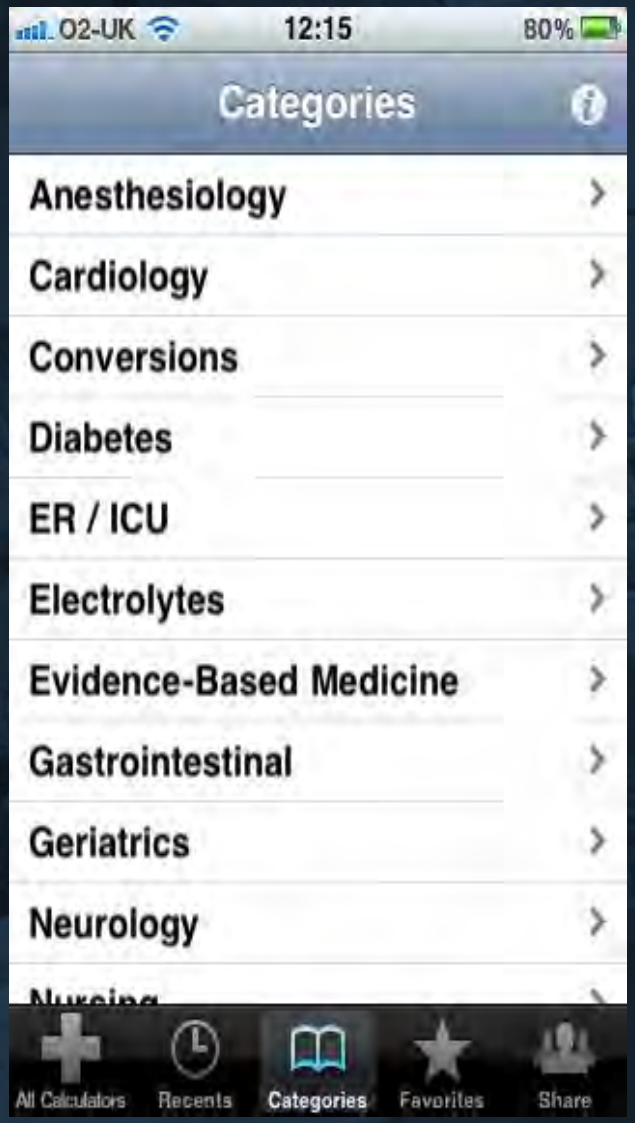
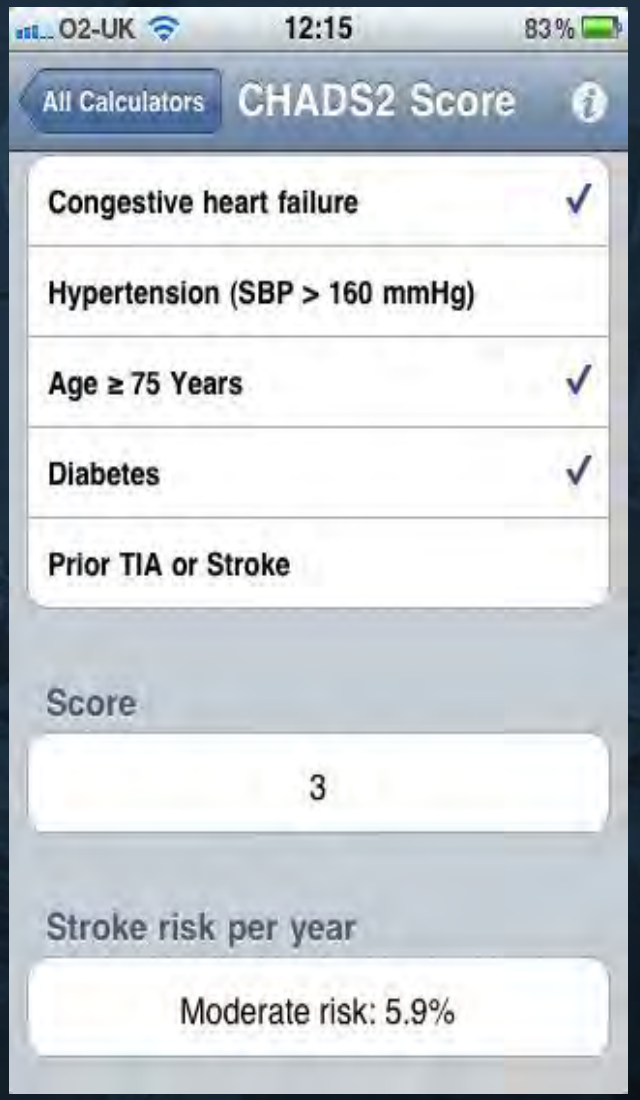
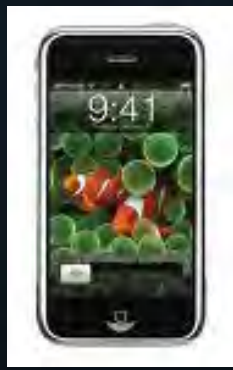
The available APPS technology









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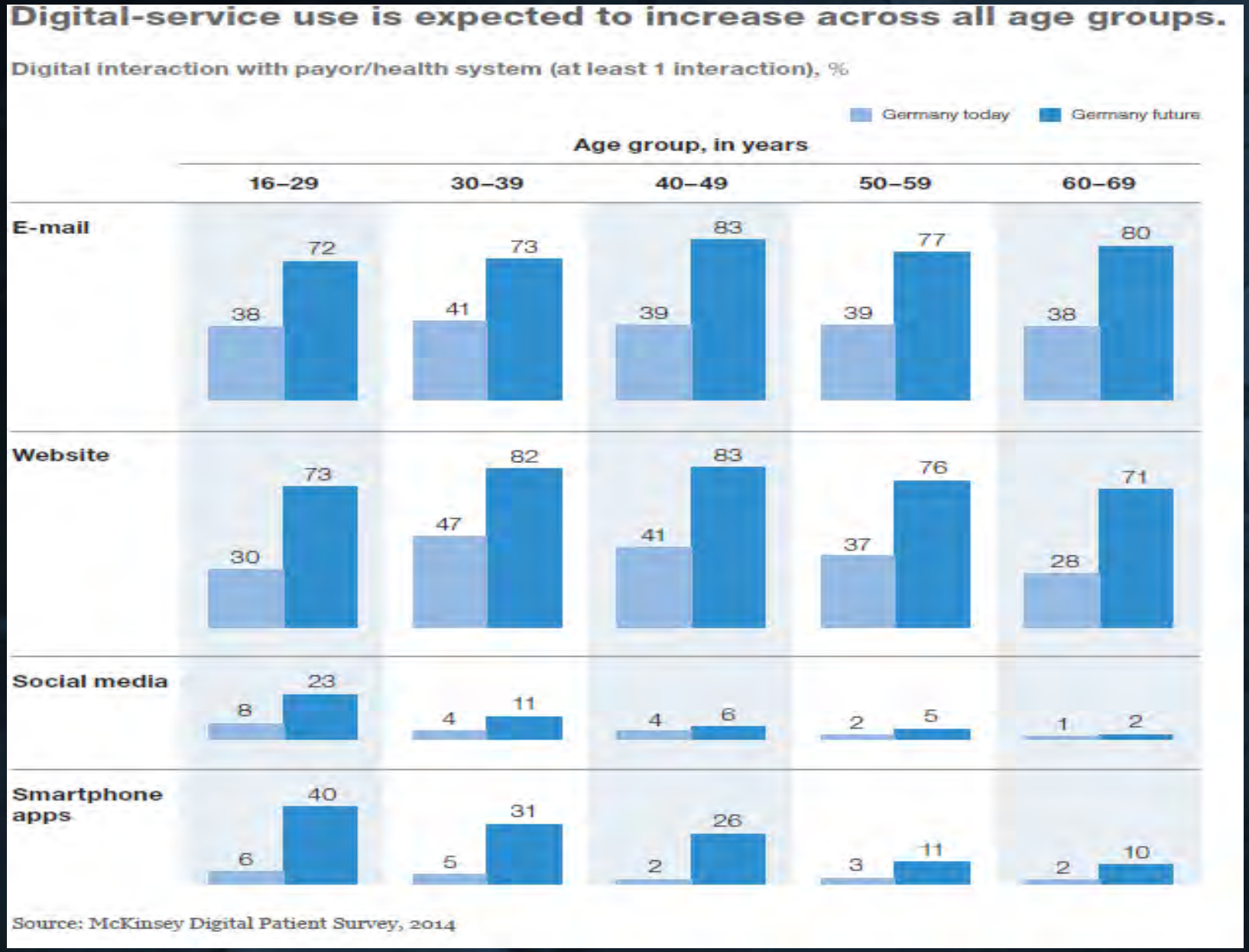
Increase in healthcare digital usage



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Estimated savings

david.muxworthy@alere.com

Ref: Data based on >1,000 NHS LTC patients monitored over 3 years

Area of Savings	Total	NHS Tariff	Gross Saved
COPD Admissions Prevented	472	£2,793.00	£1,318,296.00
Nurse Visits Saved	1,758	£30.00	£52,740.00
Mileage Saved	1,758	£8.00	£14,064.00
CHF Admissions Prevented	37	£2,987.00	£110,519.00
Nurse Visits Saved	205	£30.00	£6,150.00
Mileage Saved	205	£8.00	£1,640.00
Diabetes Admissions Saved	23	£2,112.00	£48,576.00
Nurse Visits Saved	160	£8.00	£1,280.00
Mileage Saved	160	£30.00	£4,800.00

Totals Gross Savings

£1,558,065.00

Formula: 20 Miles per journey @ £0.40 per mile
Nursing Time: 1.5 hours @ £20 per hour

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'Delivering outcomes – not boxes'

Technology

Smaller……smarter……..swifter

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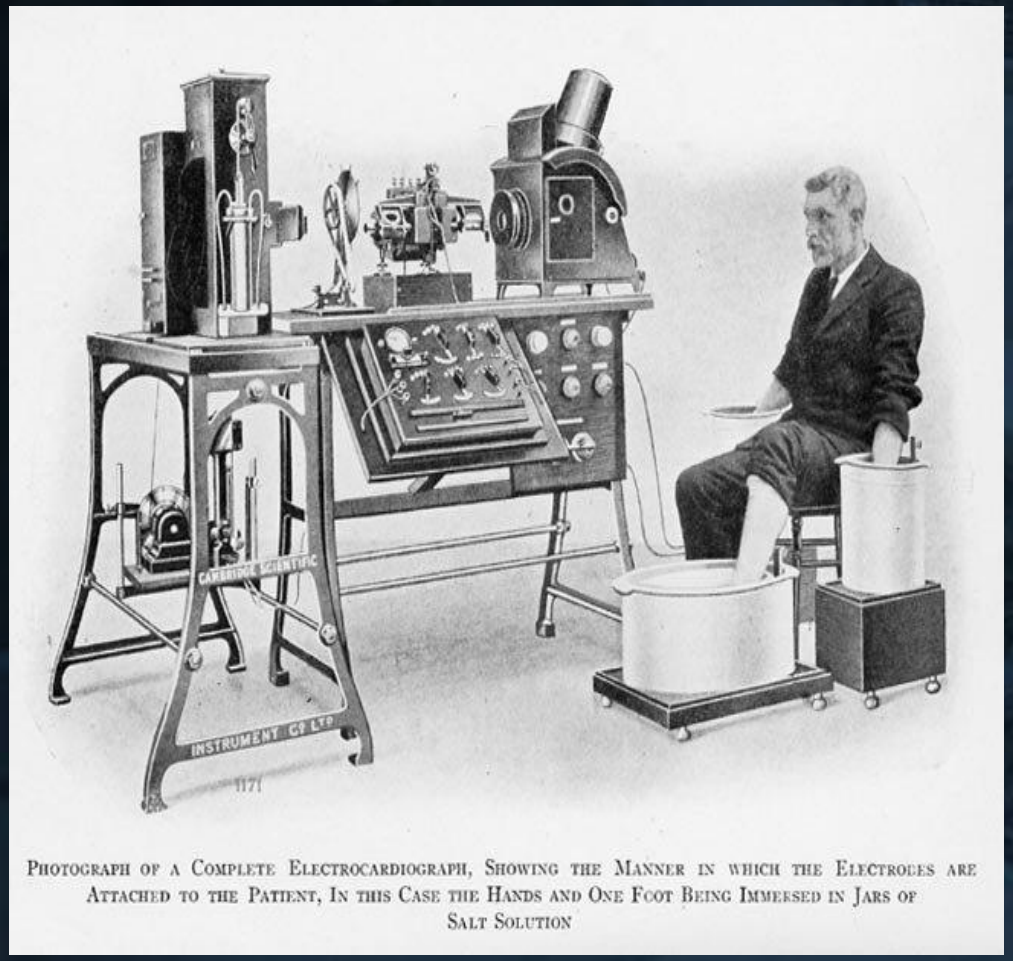
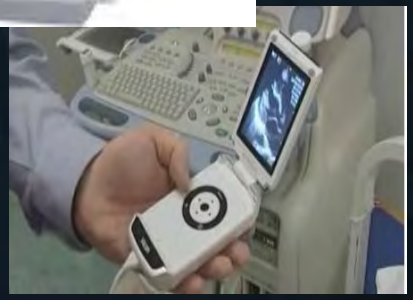
ECG development



PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

Experimental c1888



GE MAC 400 ECG - 2008

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Changing Technology: MROR

Space, engineering systems, vibration, magnetic fields

Children's Hospital Boston

Yale-New Haven Hospital

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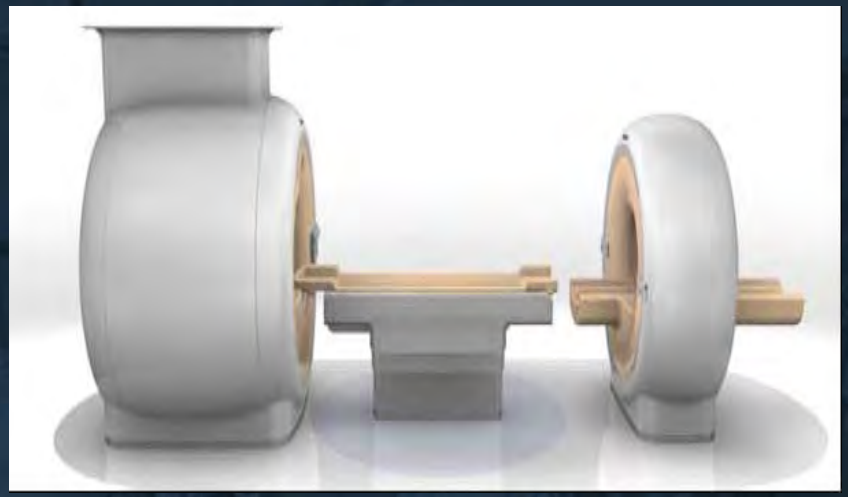
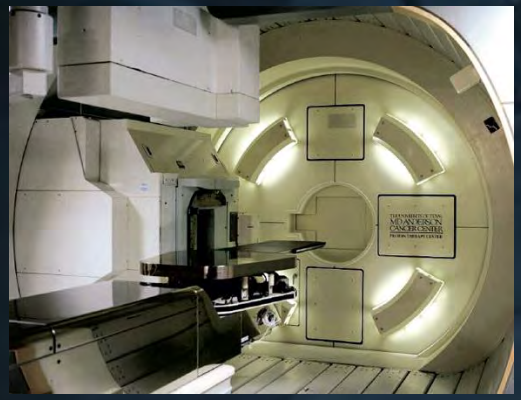
Technology developments

Gamma knife



CT/MRI



Proton Beam

?

Where next

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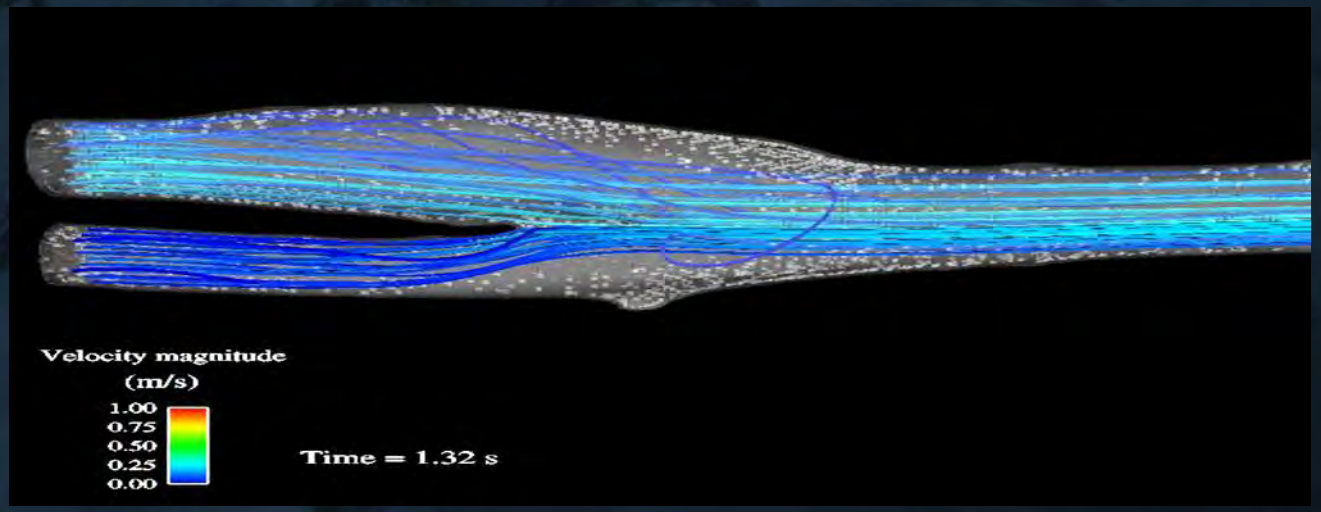
Molecular biology, genomics and nano-science will continue to revolutionise healthcare (prevention, diagnostics and treatment) in the next 10 years to levels that are unimaginable now.



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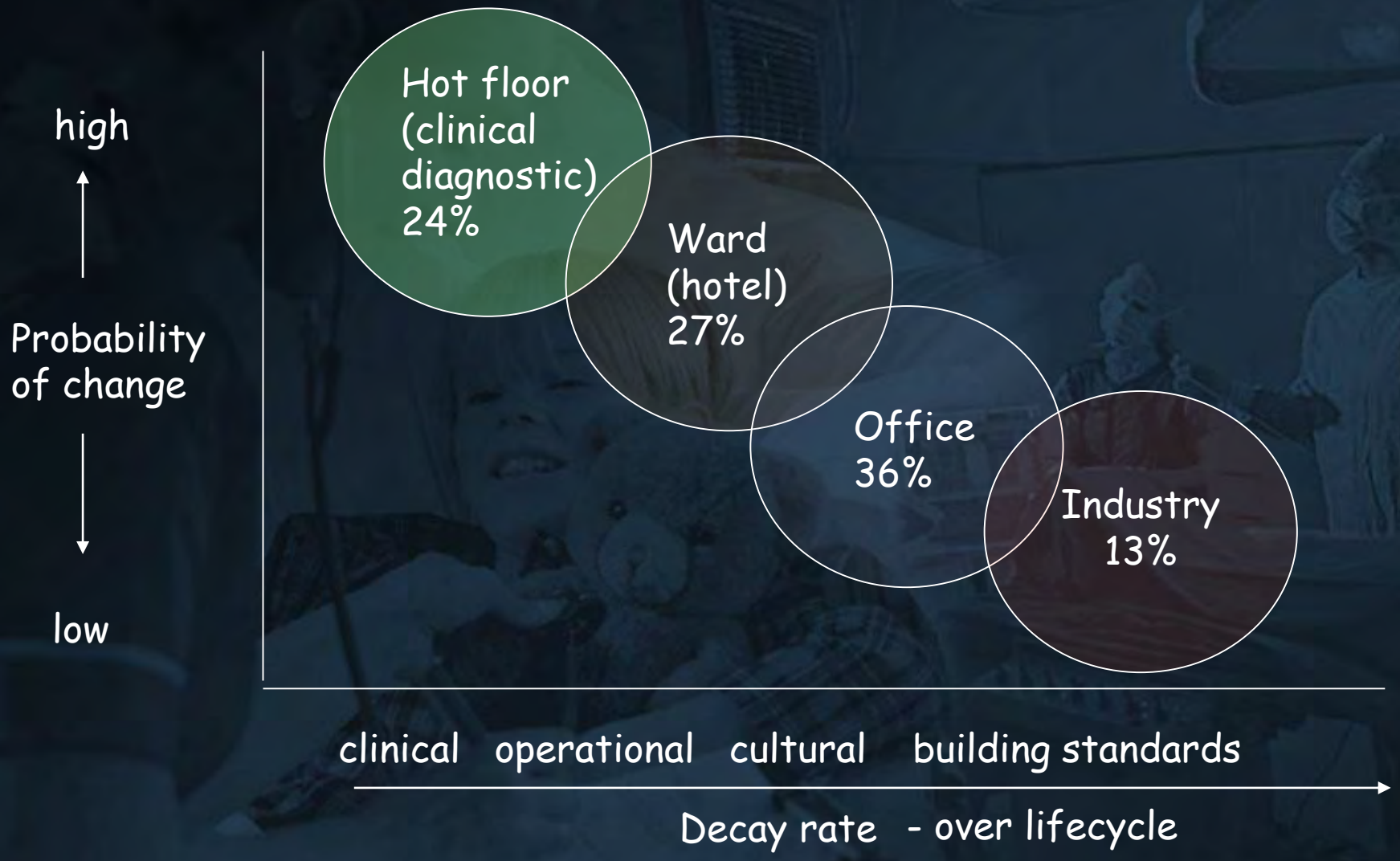
Its need to be flexible?



Ref: Bouwcollege

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Optimising flexibility - #3 Planning in advance

Flexible engineering services?

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Communication
Past Experience
Project Leadership
Whole Life Costing
Decision Making Process
Future Needs
Low Carbon
High Carbon
Current Needs
First Cost
Brief
Design
Procurement
Construction

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Design Audit to achieve a Low Carbon Buildings

- Building form and orientation
- Passive ventilation strategy
- Lighting Controls
- Reduced Air Leakage
- Exposed Mass
- Glazing Spec
- Increased Shading
- Increased Insulation
- Biomass boilers
- Solar Hot Water Generators
- CHP
- Ground Source Heat Pump
- Wind Turbines
- Small Scale Hydro
- PV
- Fuel Cells

Kg Carbon saved per £ spent

Carbon Neutral Building

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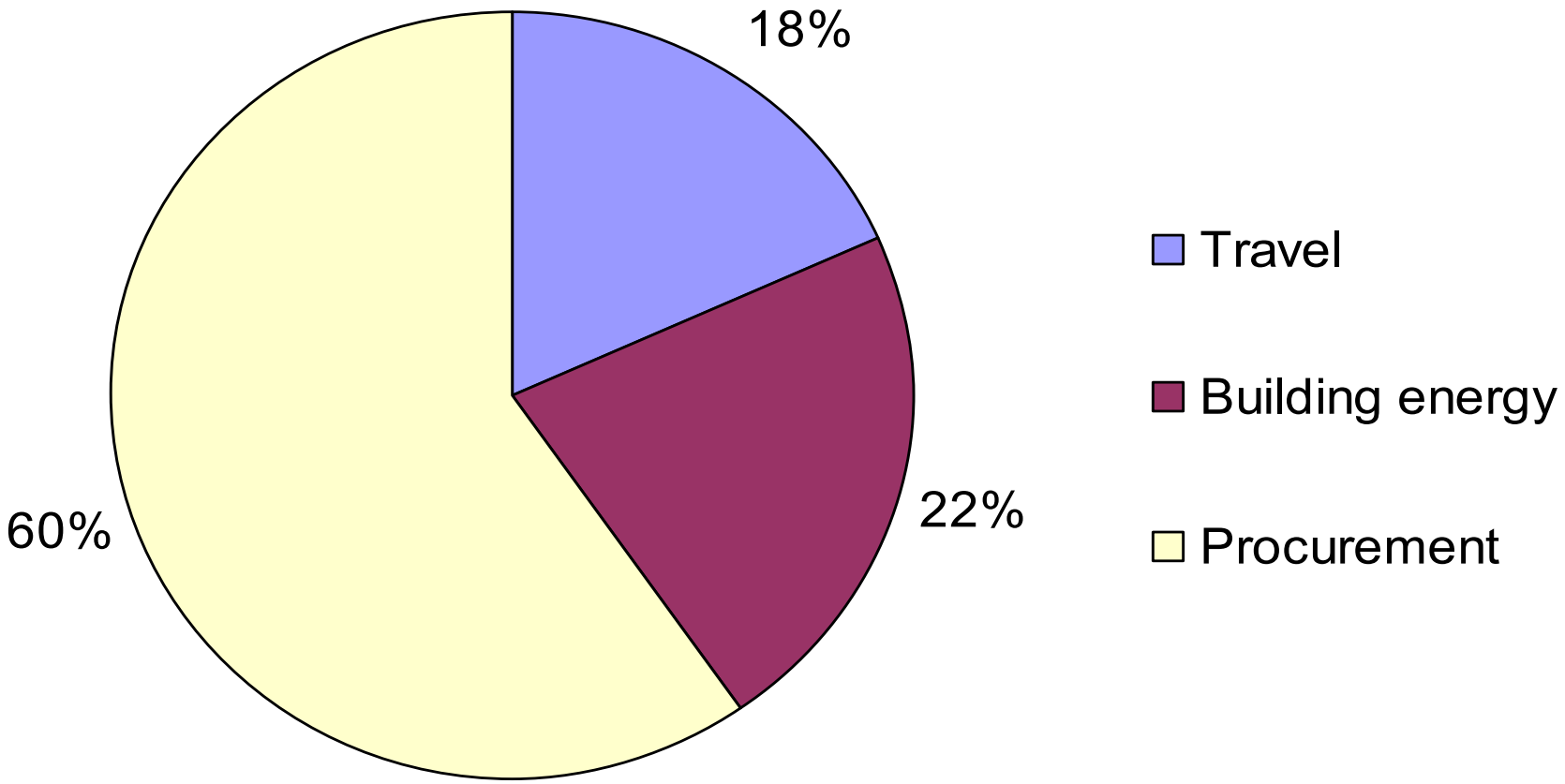
NHS England CF: Total consumption emissions



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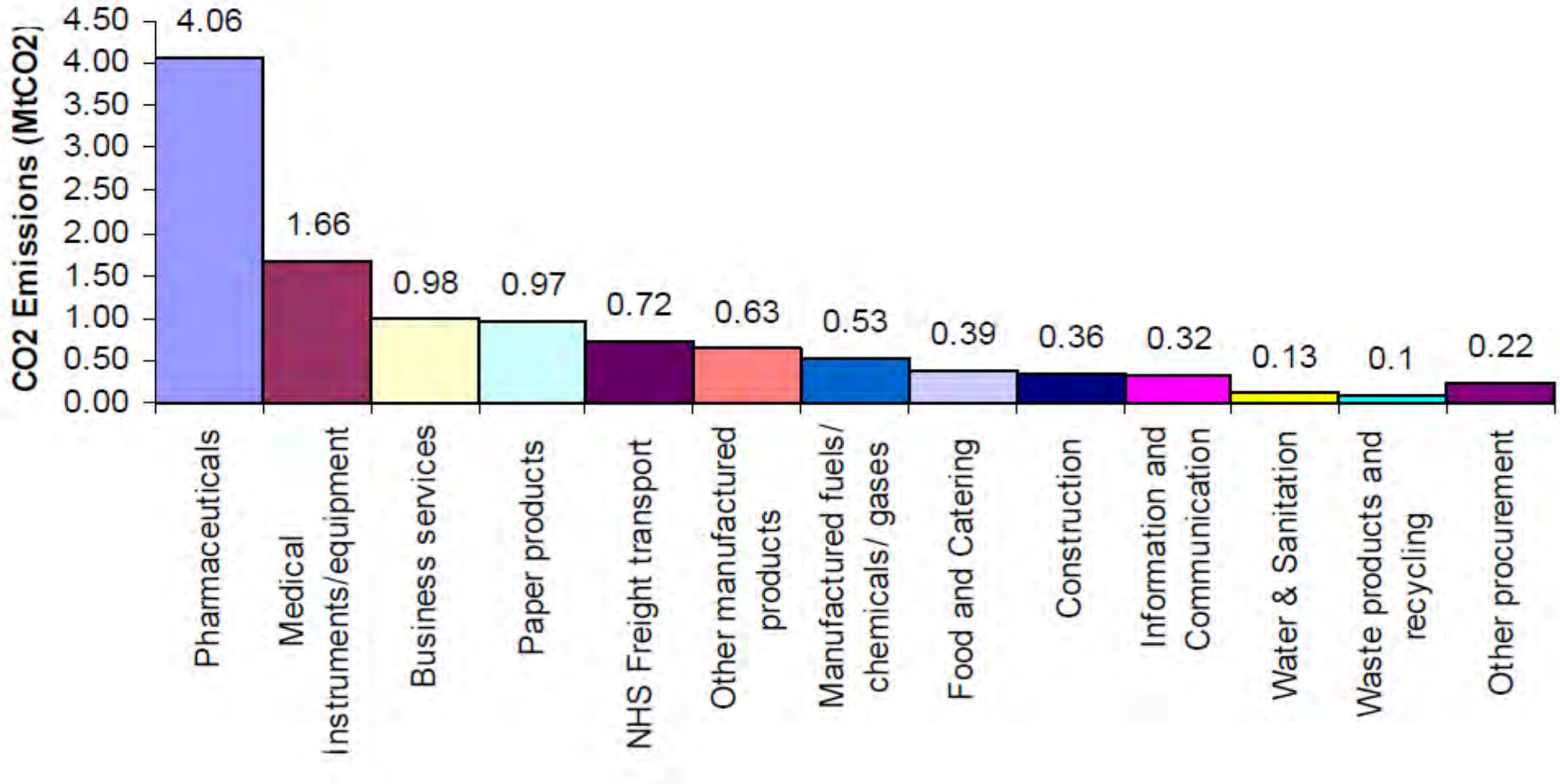
NHS England CF: Procurement emissions breakdown



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Reducing the use of natural resources through new technology

- Photovoltaic Panels
- Wind Turbines
- Combined Heat and Power Generation
- Biomass boiler systems
- Ground water heat pumps
- Water saving technology
- Rainwater Collection

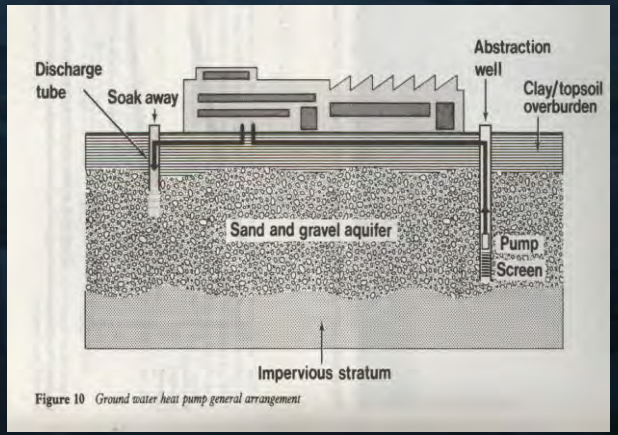

Figure 10 *Ground water heat pump general arrangement*

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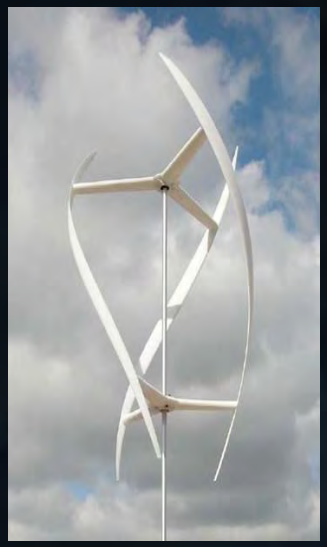
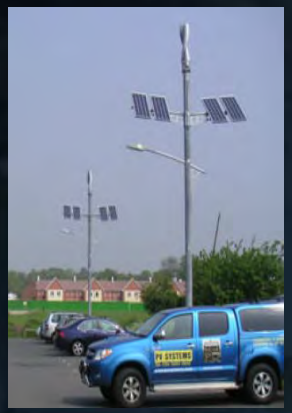
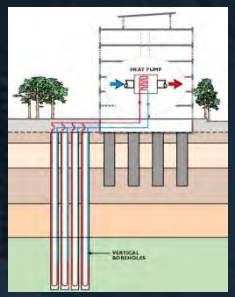
Proposed sustainable energy strategy



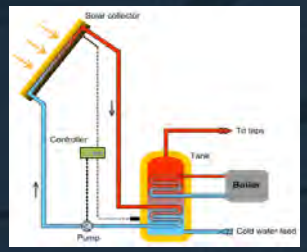
Small scale wind turbines for window control gear or extract fans in wards



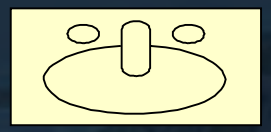
PV cells for Car park lighting



Ground water to A&E entrance underfloor htg.

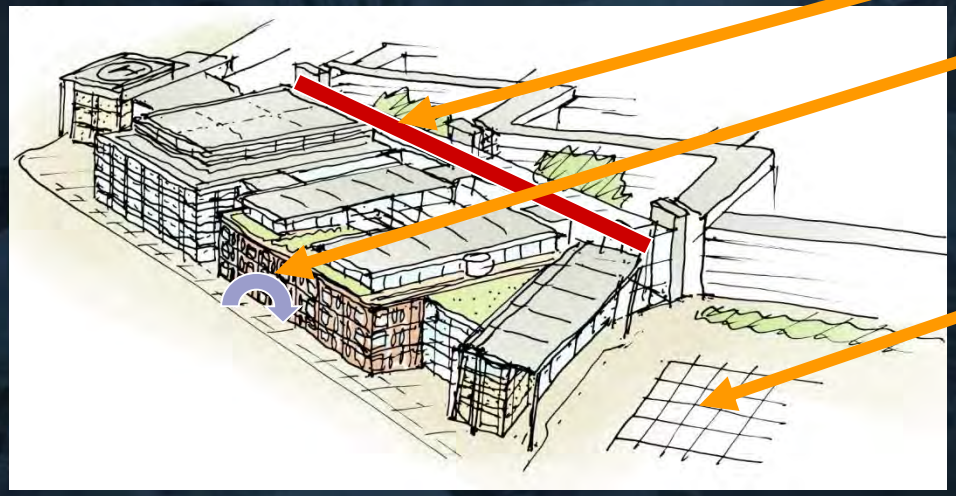


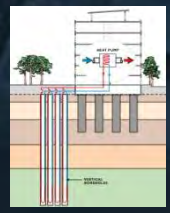
Solar panels. Summer DHWS



PIR water sensors on all basins

Solar chimney moves air from north side openings via simple labyrinth through atrium for summer cooling





Car park ground source heat pump

Rainwater harvesting
Feeding WC's or irrigation

CHP Tri generation -.Cooling for theatres 300KW refrigeration effect (cooling capacity).

Bio-mass boiler installation
2MW base load

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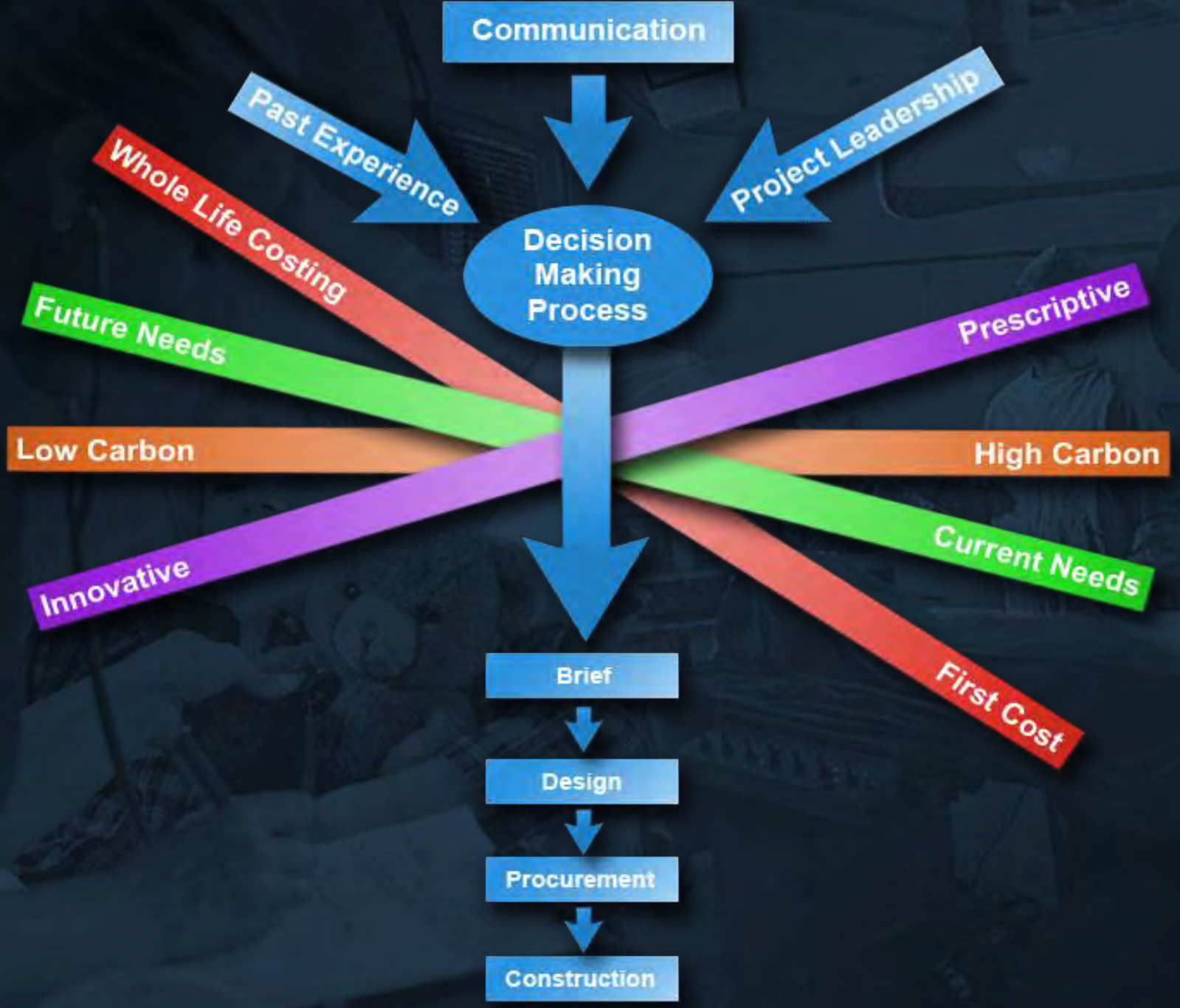
Communication
Past Experience
Project Leadership
Whole Life Costing
Decision Making Process
Future Needs
Prescriptive
Low Carbon
High Carbon
Innovative
Current Needs
First Cost
Brief
Design
Procurement
Construction

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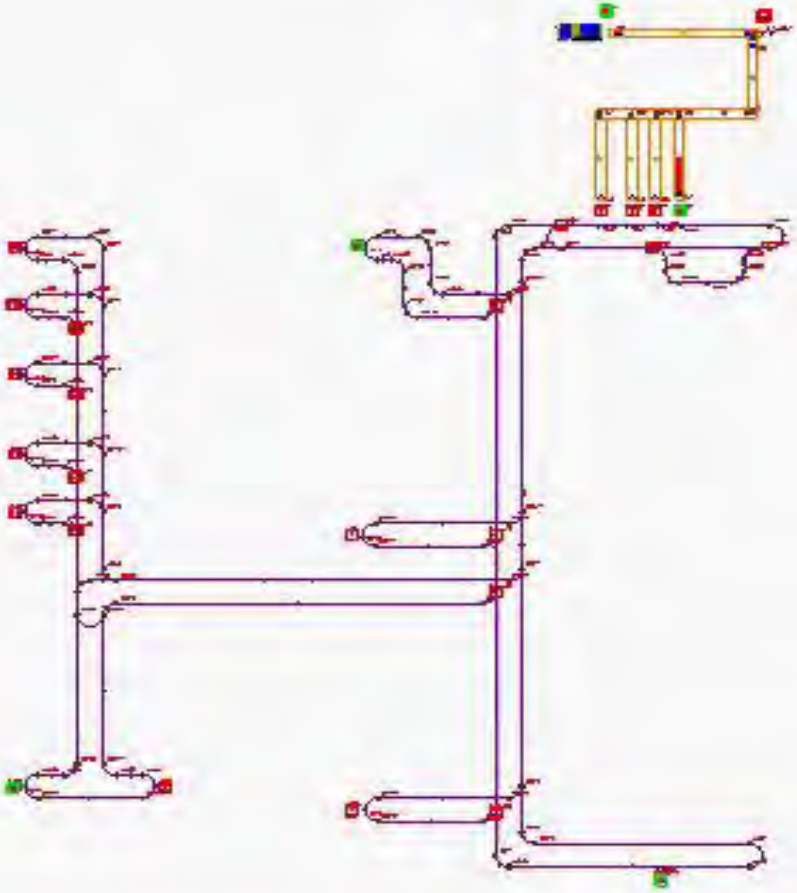
Logistic innovation from other markets



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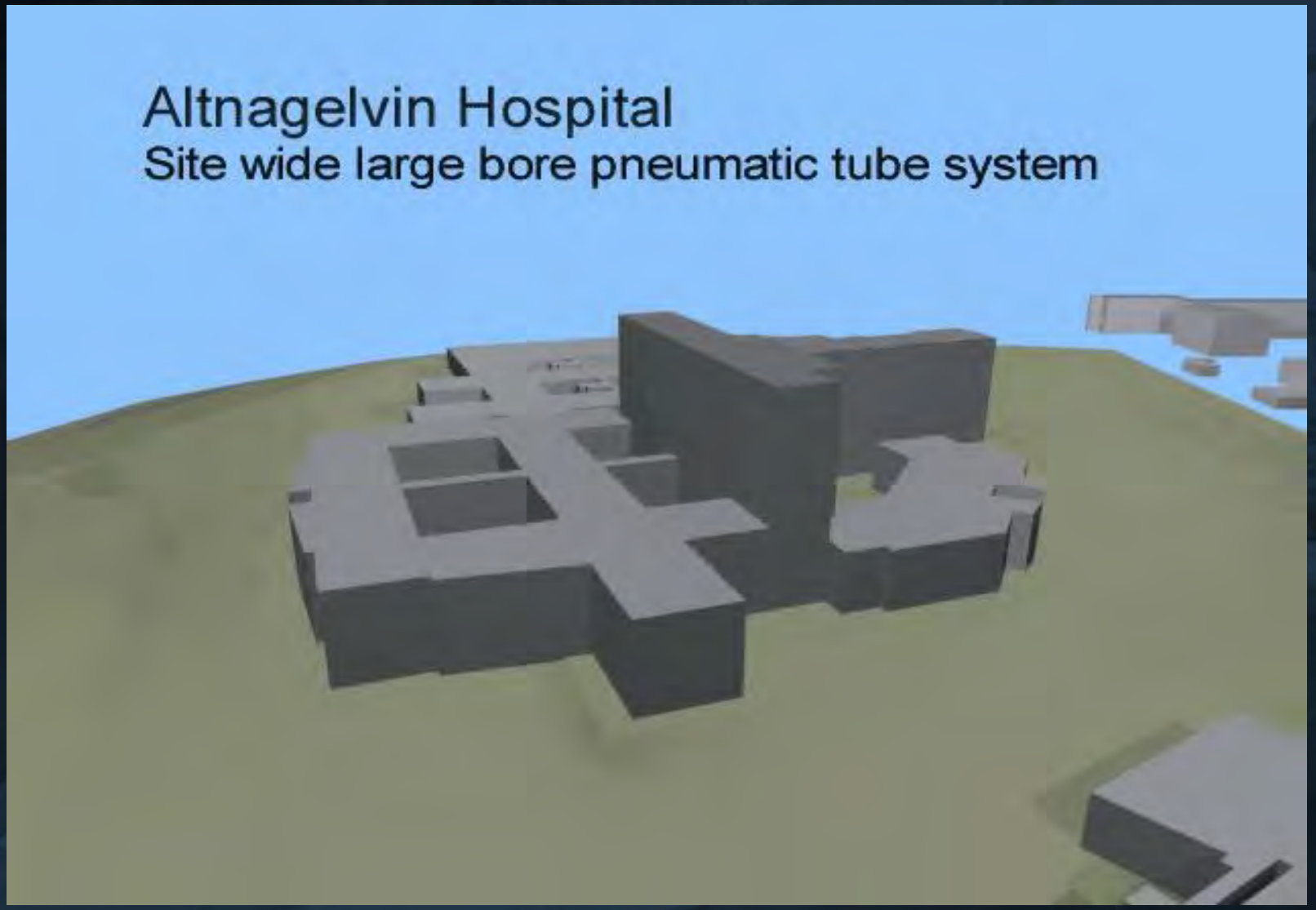
Systems innovation from other sectors



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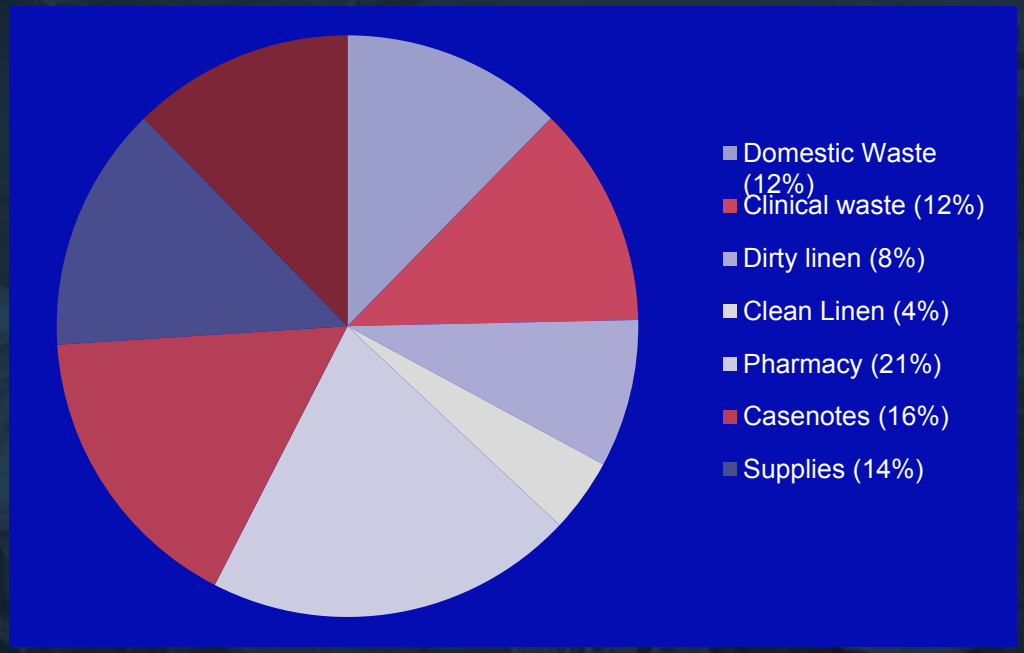
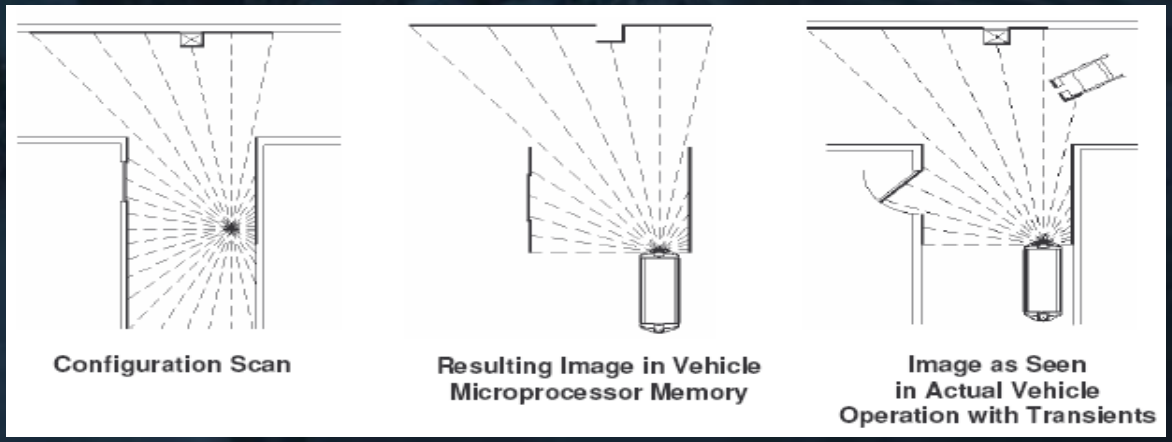
Automated guided vehicles



Movement by type



Navigation

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Spatial Innovation from other regions

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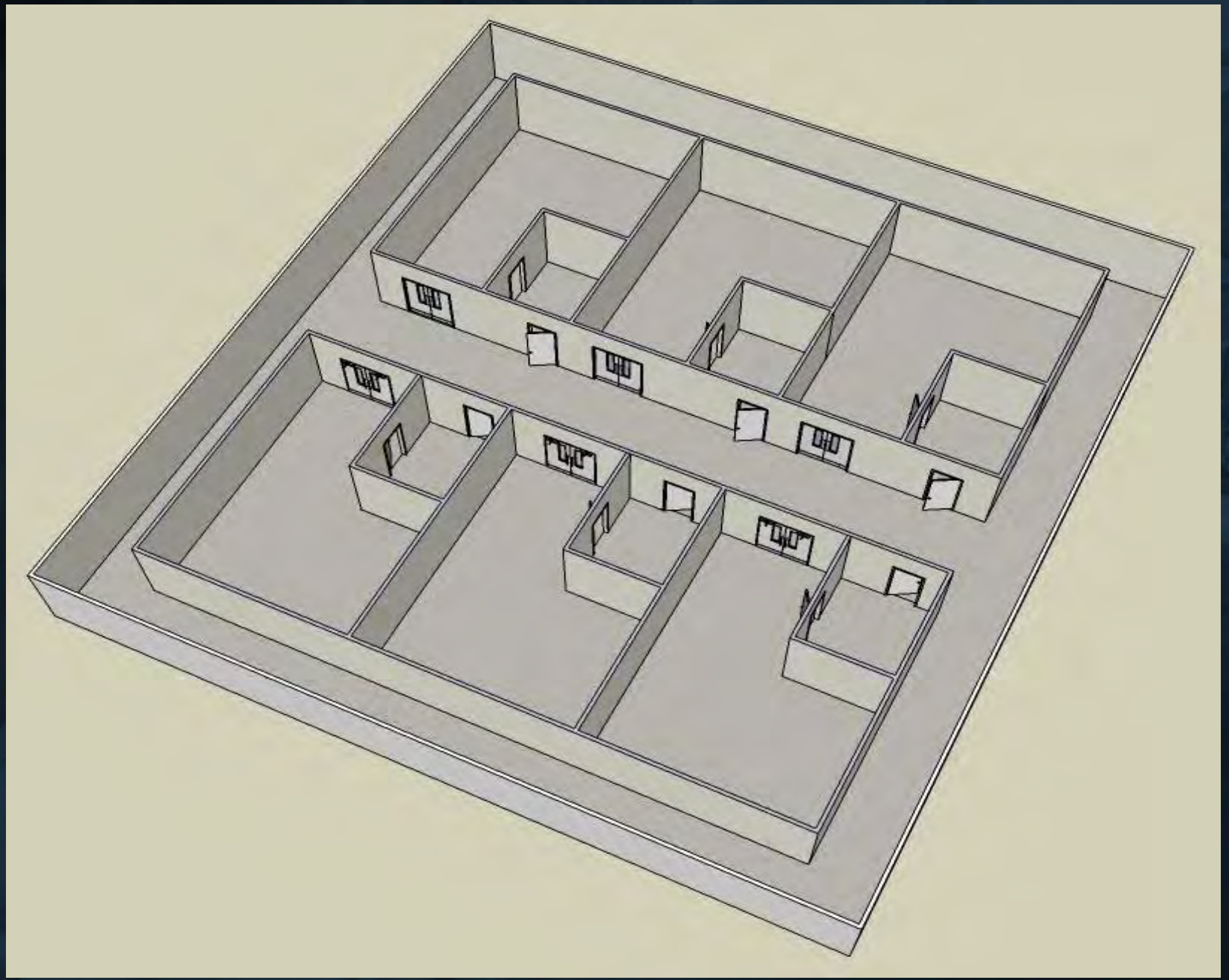
Innovative system design



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Spatial Innovation from other regions

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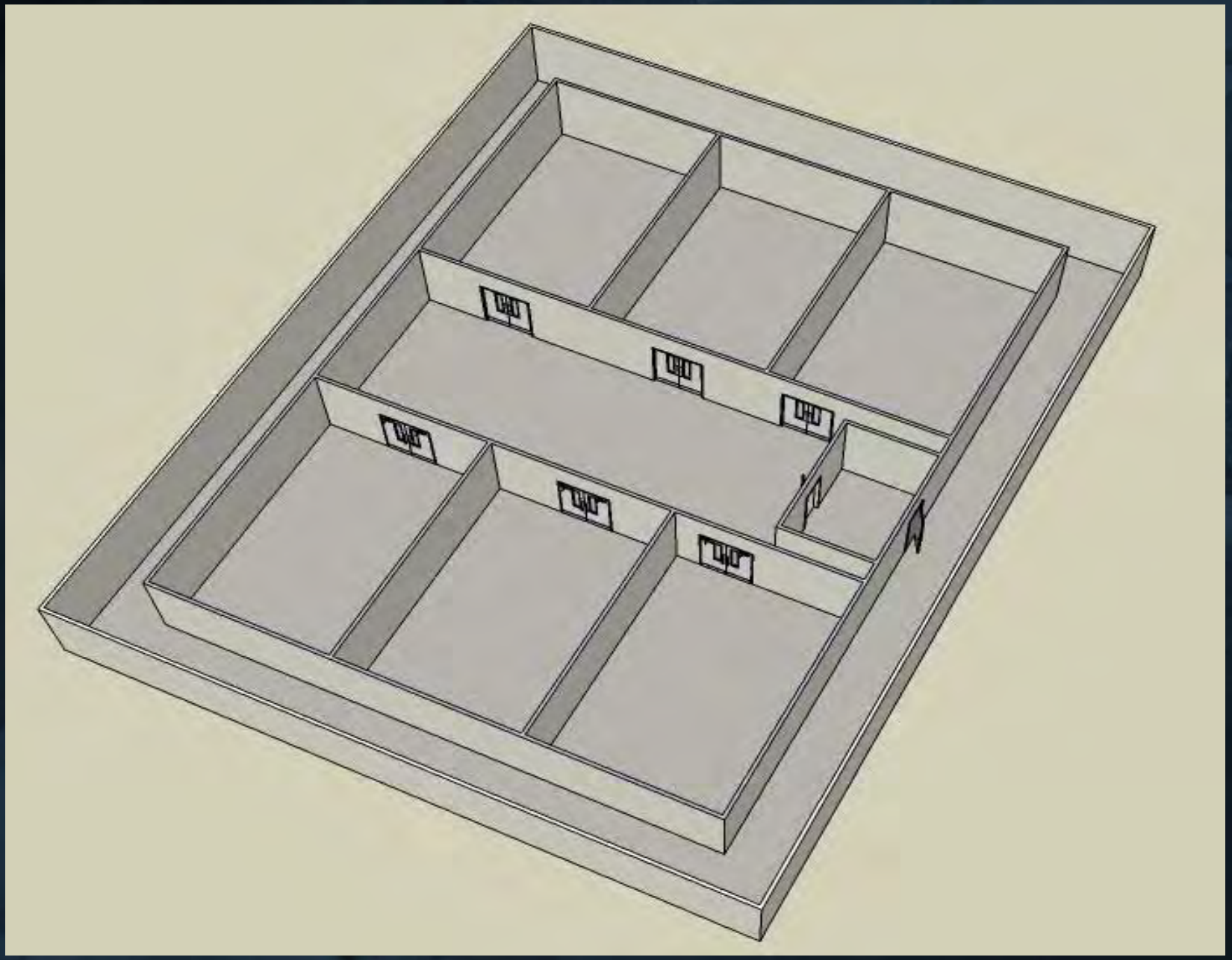
Innovative system design



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Barn theatre incorporating laminar flow units

Nightingale Architects

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Influencing Standards & guides

Natural lighting
Natural ventilation
View
Weather tightness
Energy conservation
Sound insulation
Security
Safety
Fire spread
Cleaning

Soaring hospital fuel costs could hit patient care

Jonathon Carr-Brown and Sarah-Kate Templeton

THE energy bills of some NHS hospitals have almost doubled as multinational oil and gas companies increase their prices to the health service by £120m a year.

The Department of Health said this weekend that the which represents health trusts, said: "These price increases could amount to several hundred thousand pounds for each hospital trust, which could be difficult to find in the middle of the year, given all the other financial commitments such as pay rises.

"Hospital trusts do not have a lot of money in reserve. They tend to spend money as they get

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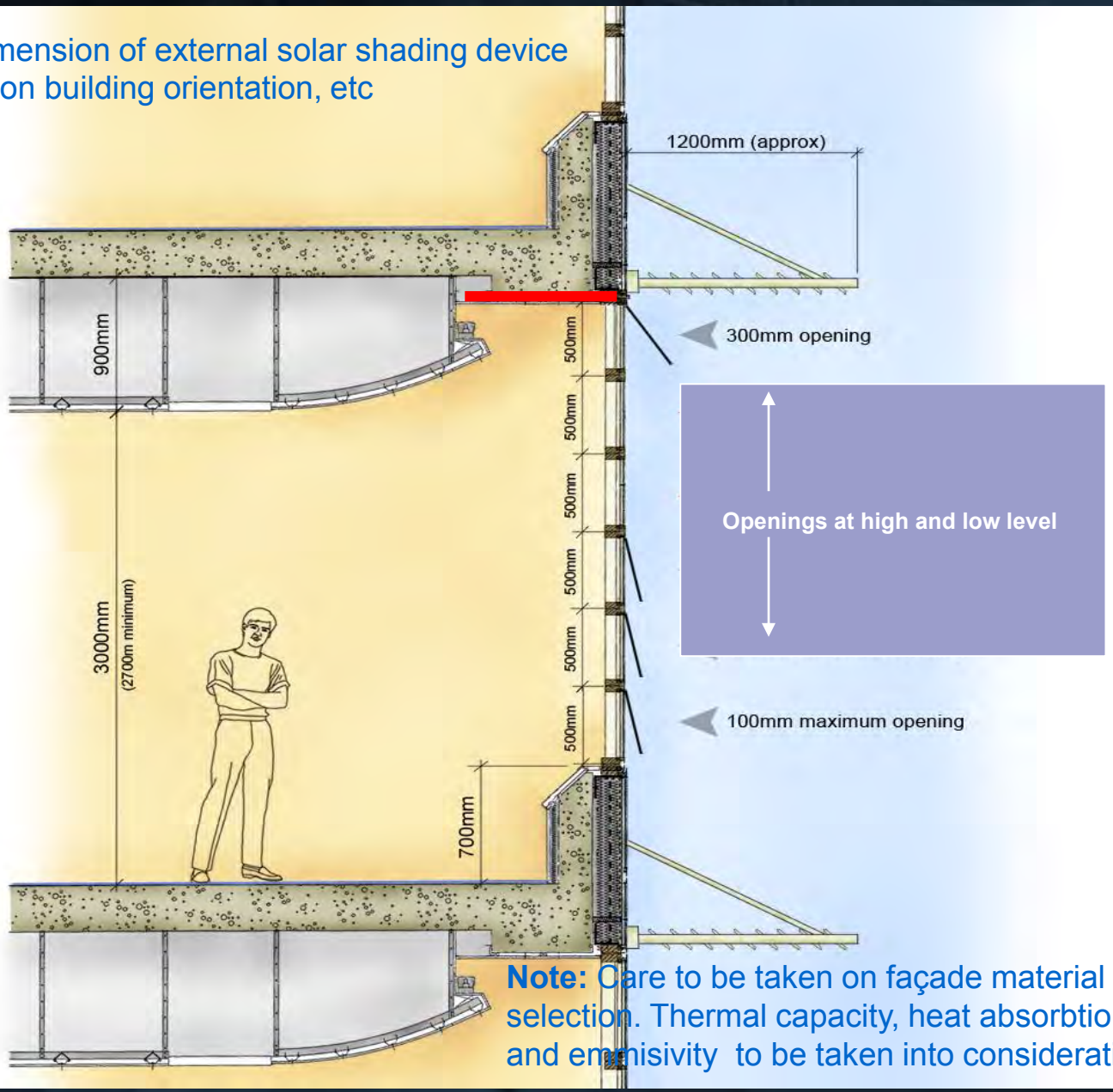
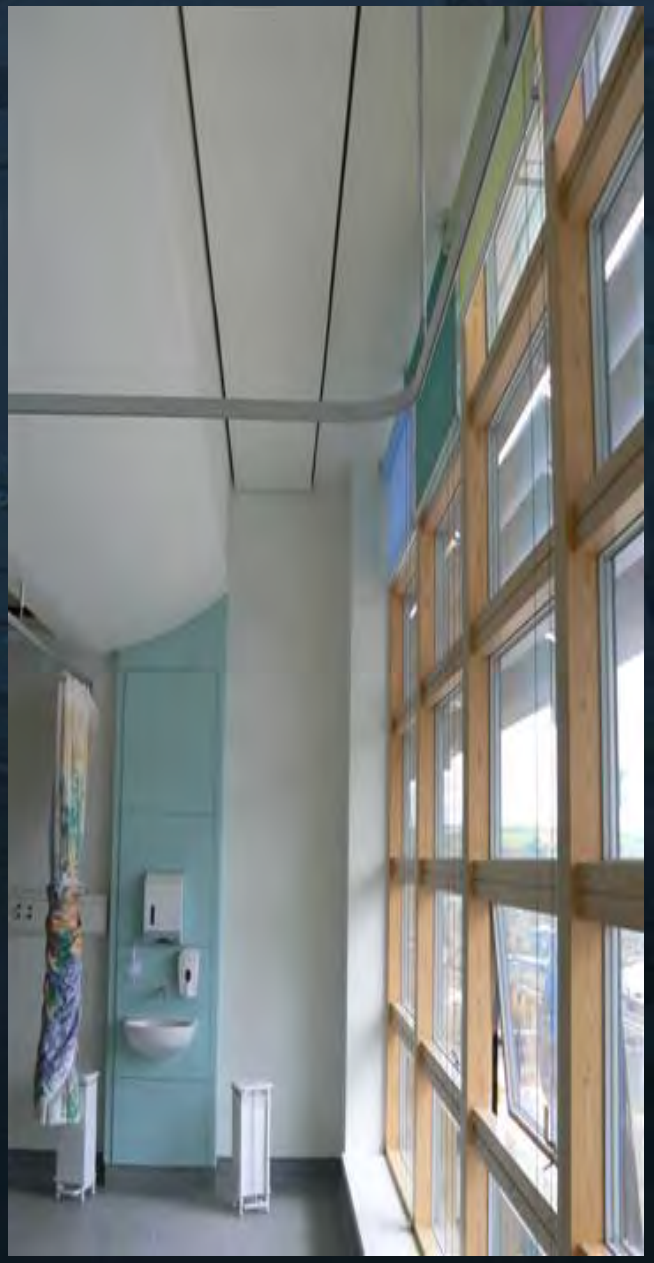
Exemplar window design

Note: Dimension of external solar shading device depends on building orientation, etc



Note: Care to be taken on façade material selection. Thermal capacity, heat absorbtion and emmisivity to be taken into consideration



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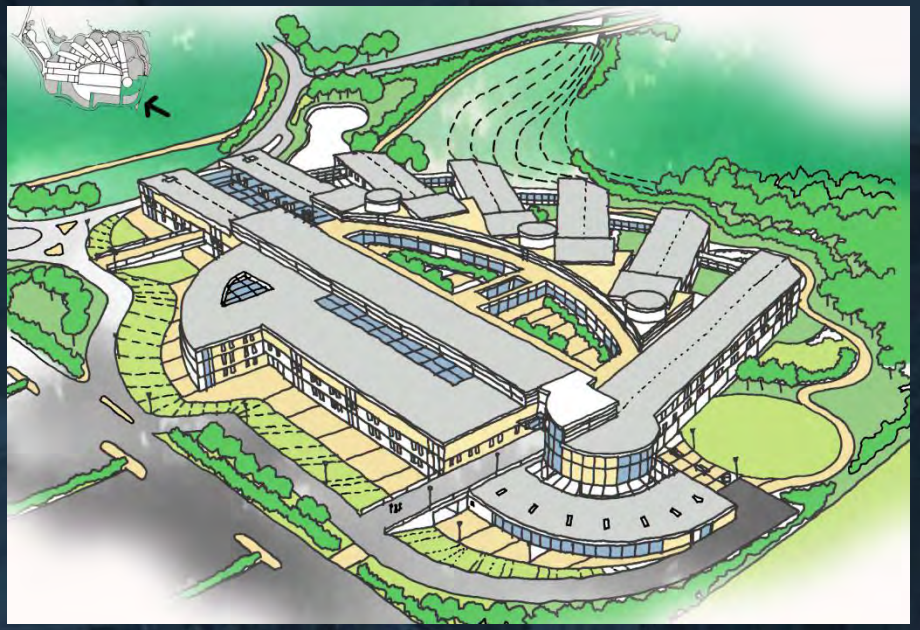
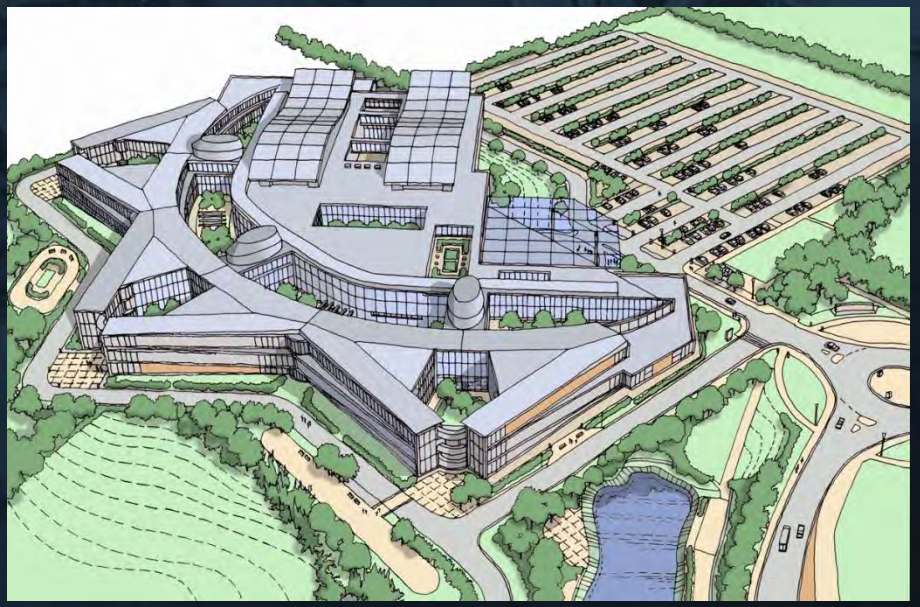


Typical master planning options



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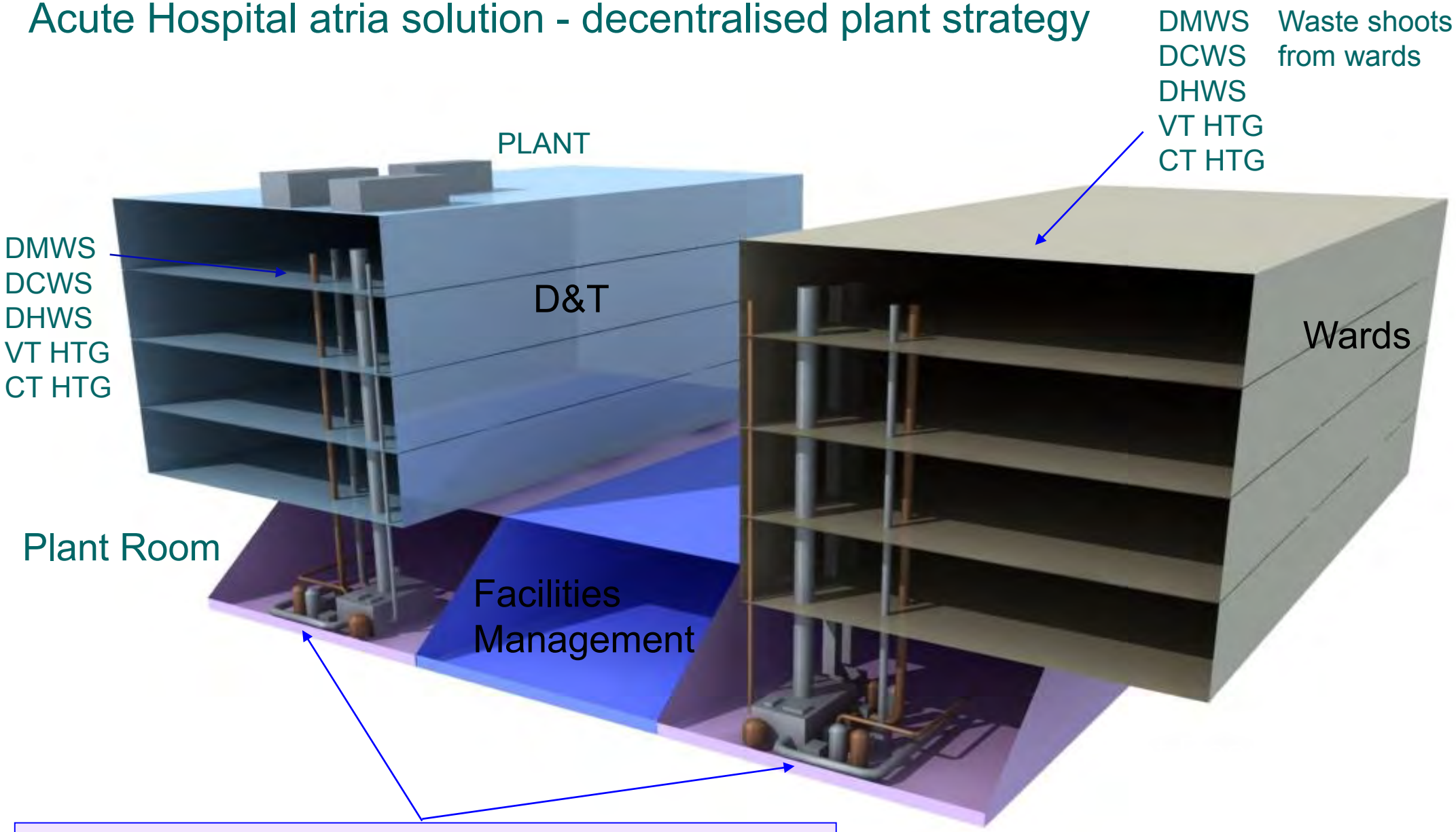
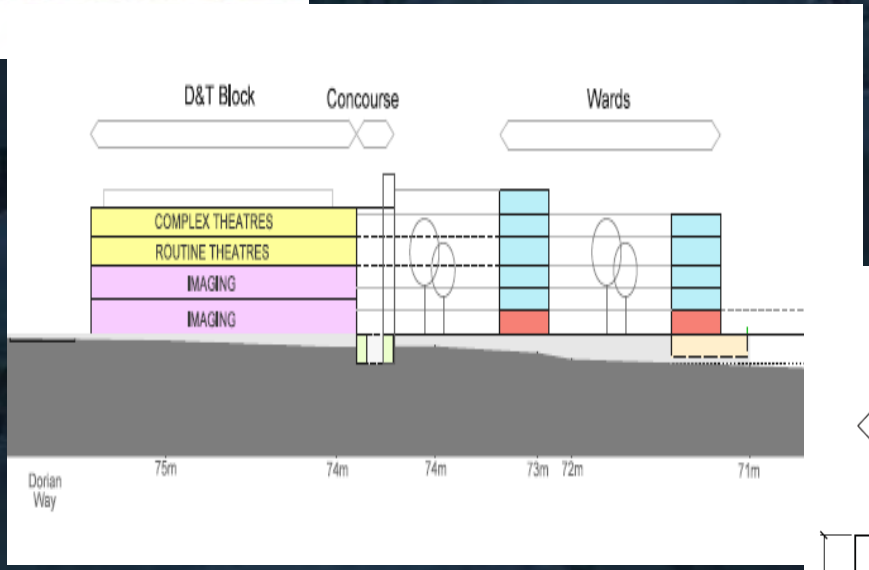
Acute Hospital atria solution - decentralised plant strategy

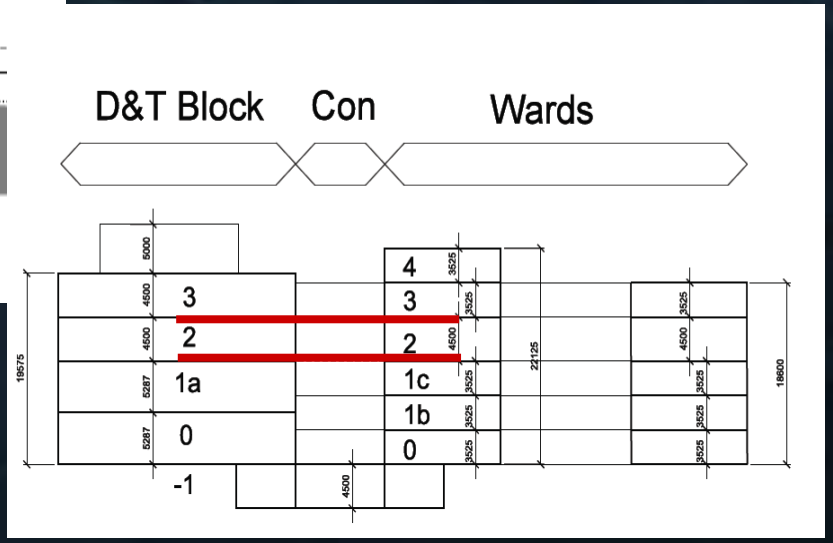


Medical gas manifolds
Primary pumps
Vacuum & compressed air
Pressurisation units
DHWS Booster

DCWS Booster
DHWS plate heat exchanger
Heating plate heat exchanger
CT Heating pumps
VT Heating pumps

Level conflicts





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STREAMER Research project

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CONSORTIUM:


TNO innovation for life
ipostudio
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DWA
installatie- en energieadvies
AEC 3
KIT
Karlsruher Institut für Technologie
de jong gortemaker algra
BOUYGUES CONSTRUCTION
NCC
Mostostal
WARSZAWA
DEMO
CONSULTANTS
beng
MAE
Rijnstate
ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS
The Rotherham
NHS Foundation Trust
NHS
Azienda Ospedaliero Universitaria Careggi
aouc
locum.
VÅRDEN FÖR VÅRDEN
CSTB
le futur en construction
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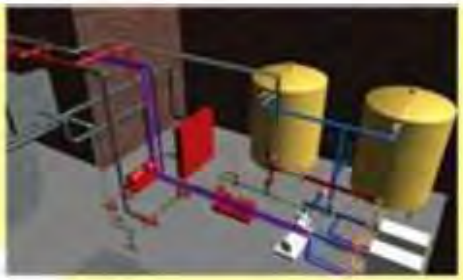
Strategic aim and project scope

Aim: 50% reduction of energy-use and CO2 emission of healthcare districts in 10 years.

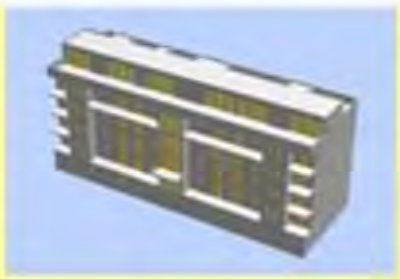
Scope: EeB design optimisation in 3 levels / areas:

1. **Building MEP systems** ↔ high-tech medical equipment
2. **Building envelope and spatial layout** ↔ new healthcare services
3. **Building energy systems** ↔ neighbourhood systems (grid, heat storage/exchange, etc.)

Medical equipment

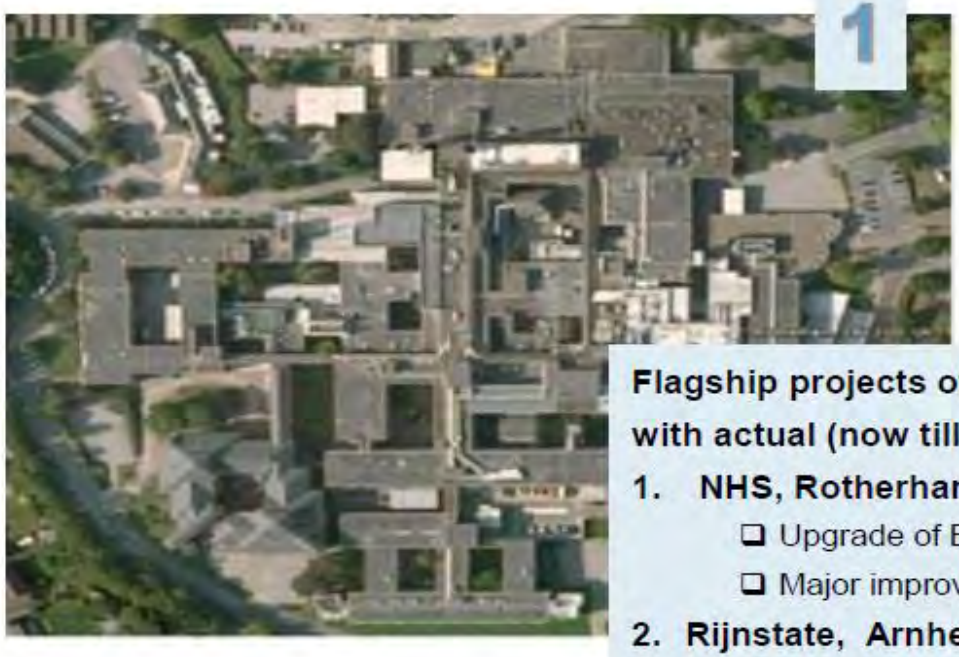


Energy and MEP systems



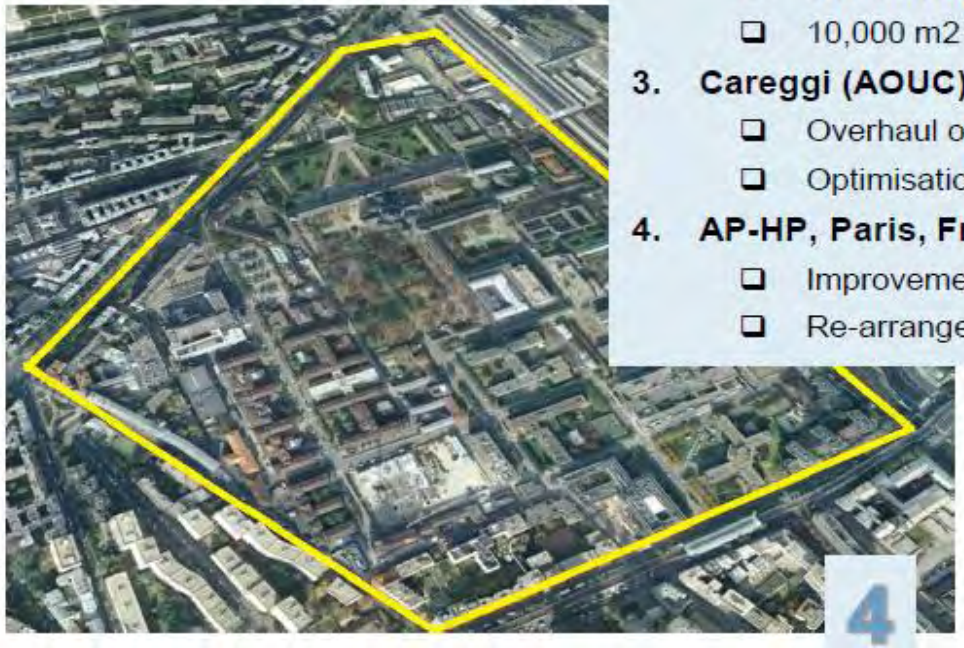
Building

Neighbourhood energy system

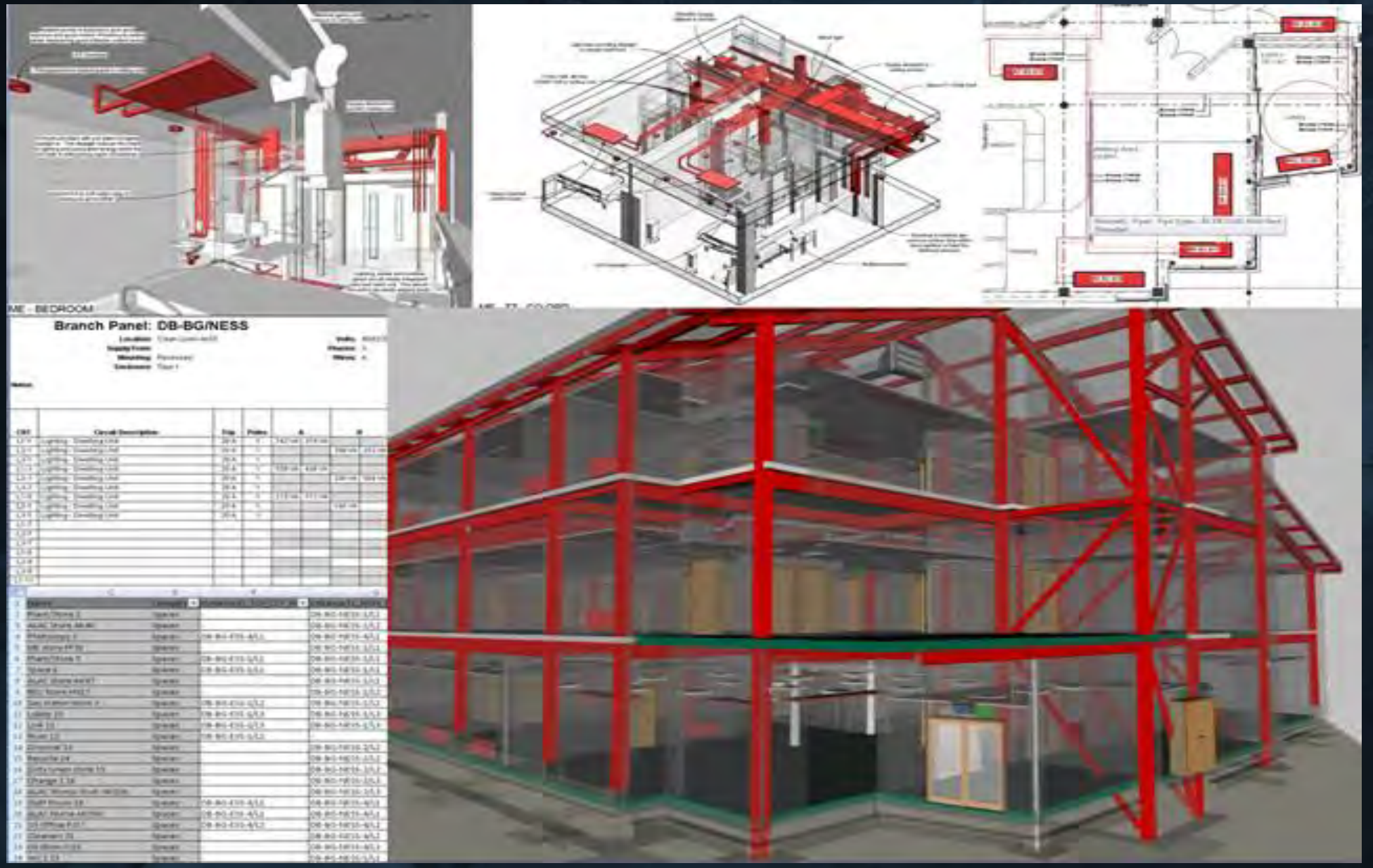


Flagship projects of 4 hospital districts with actual (now till 2020) EeB design plans:

1. **NHS, Rotherham, UK**
   - ❑ Upgrade of Building Management Systems
   - ❑ Major improvements in overall building fabric
2. **Rijnstate, Arnhem, NL**
   - ❑ Mid-life renovation to replace MEP systems
   - ❑ 10,000 m2 extension and new buildings
3. **Careggi (AOUC), Firenze, Italy**
   - ❑ Overhaul of electricity and heat distribution
   - ❑ Optimisation of inter-building functions
4. **AP-HP, Paris, France**
   - ❑ Improvement of logistic and waste systems
   - ❑ Re-arrangement of building spaces



Building Information Management - BIM



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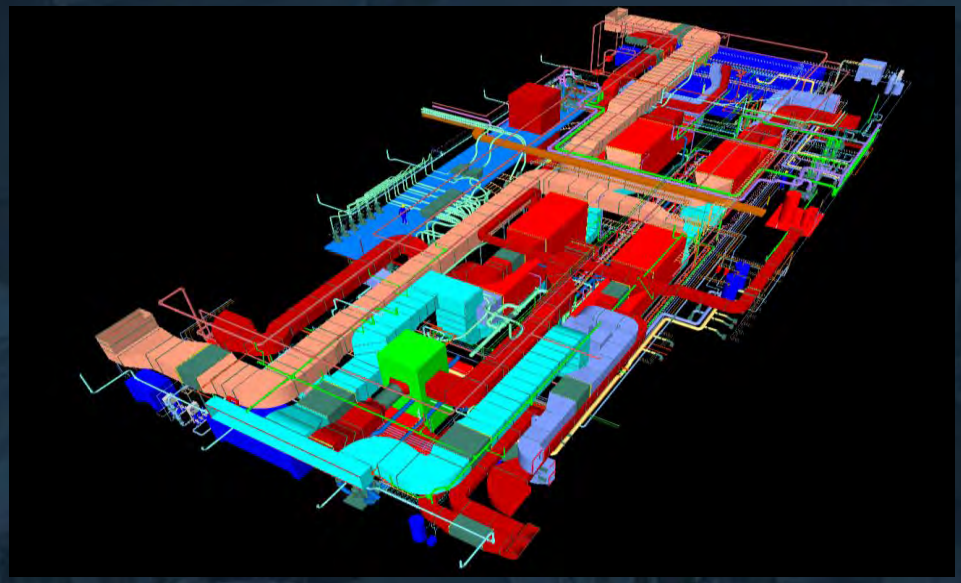
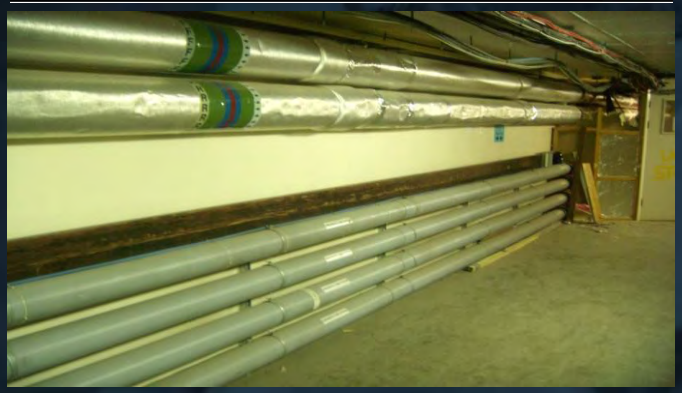
UCH MacMillan Cancer Centre - BIM





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