



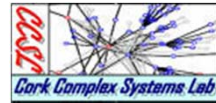
Data Warehouse Model to support Optimized Operation and Energy Savings in Buildings

**Paul Stack,
Brian Cahill,
Farhan Manzoor,
Prof. Karsten Menzel**





ICT for Optimised Building Operation (ITOBO)

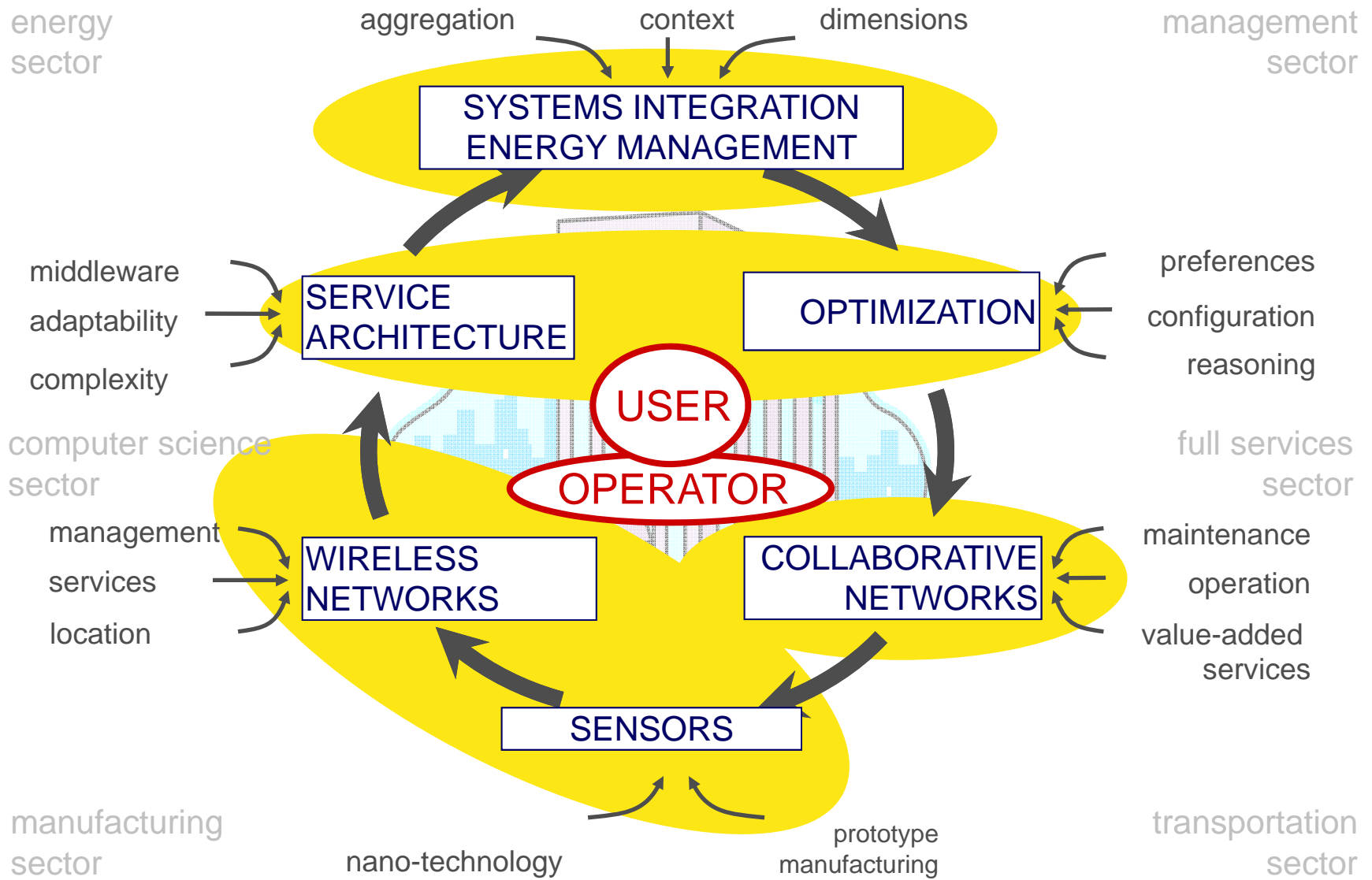




ITOBO
6 PI
18 Researchers
8 Technical Staff

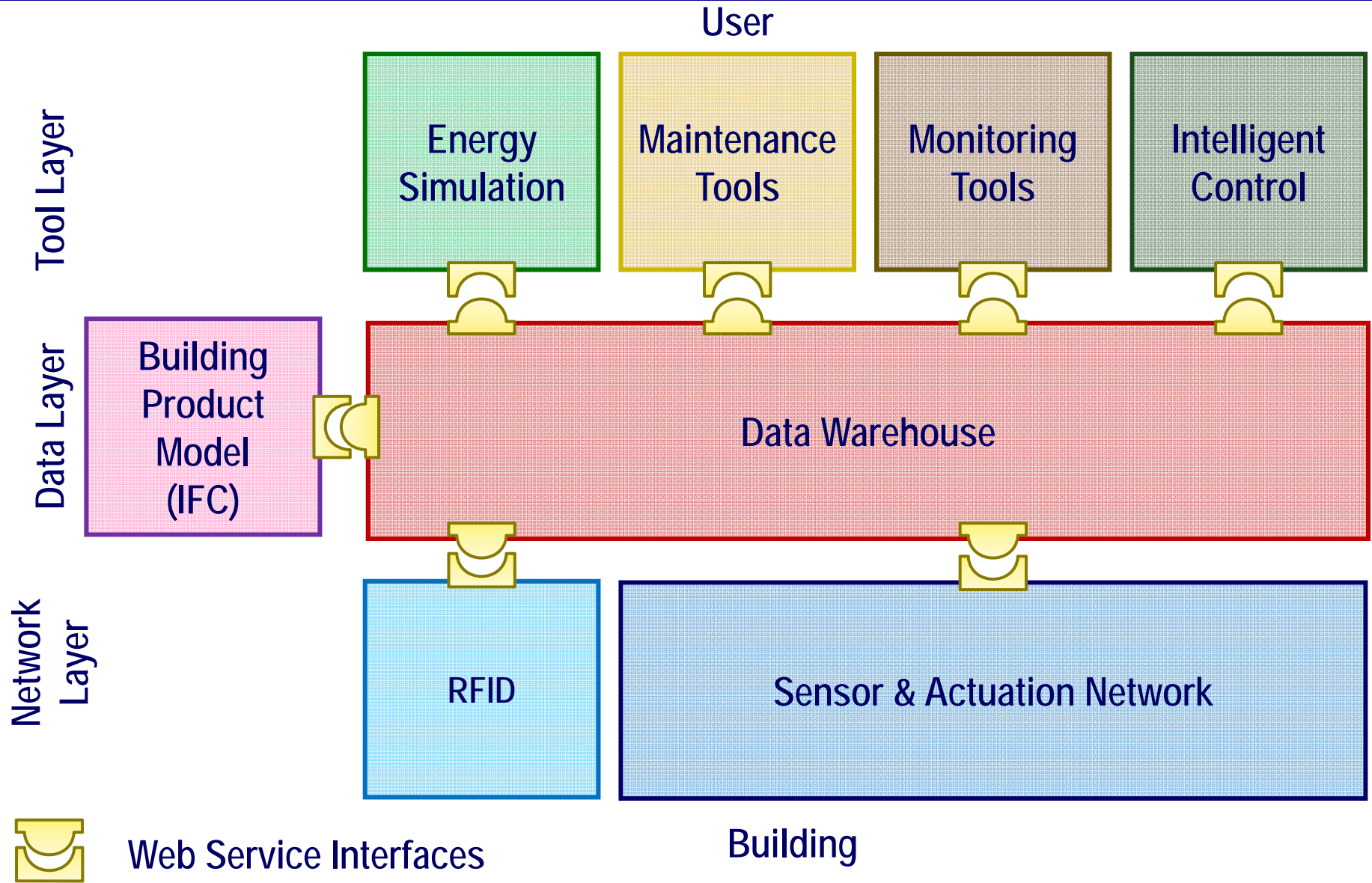


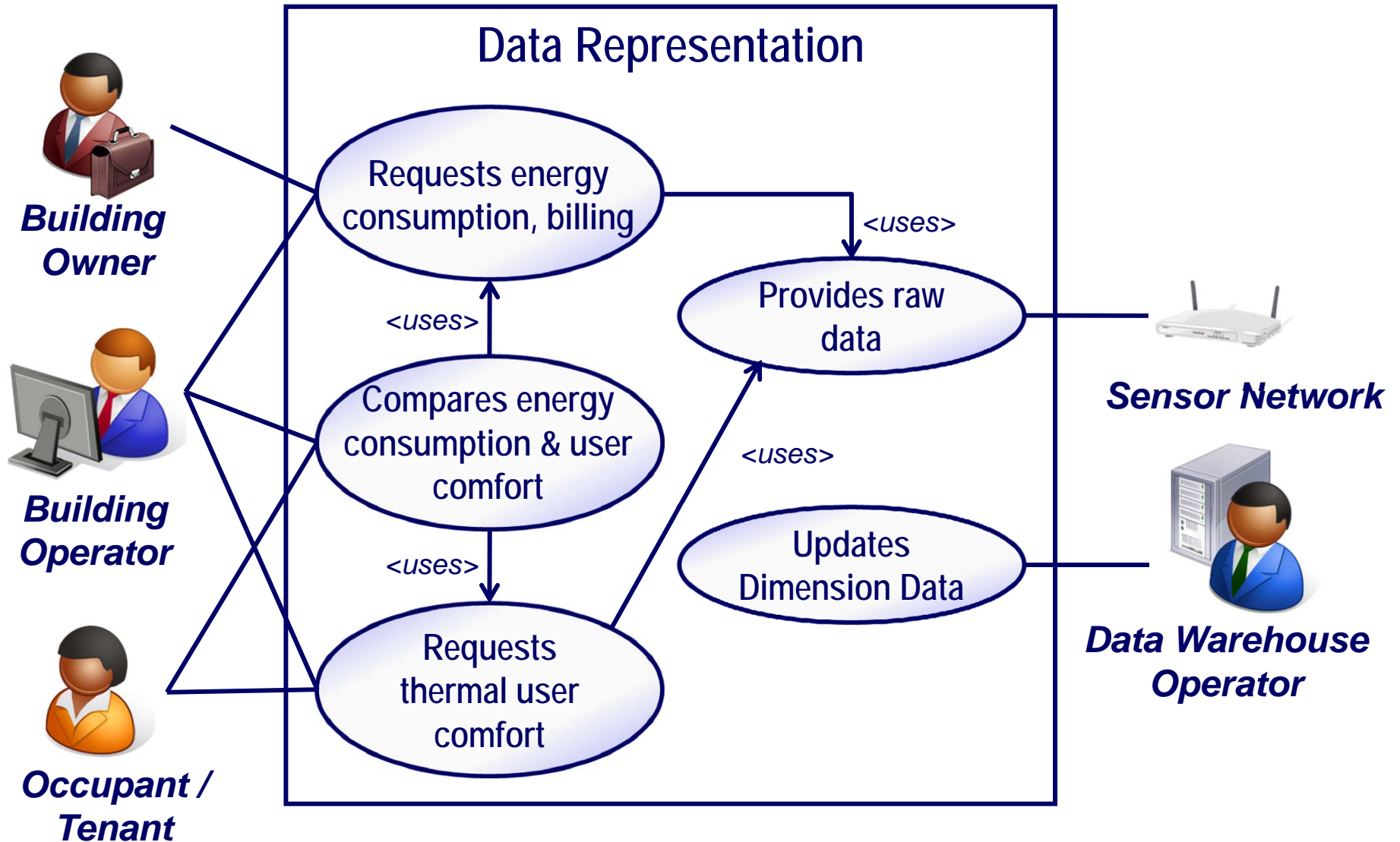






Energy Building Information Model (eBIM)










Building Owner




Building Operator

Occupant /Tenant

Measurements available

Available Room Environment Details

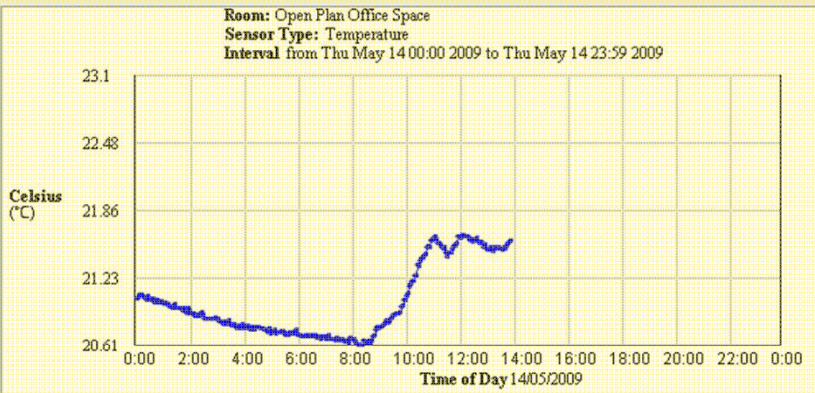
Show/Hide Current State

- Energy Consumption
- Temperature 22.53°C
- Humidity 54.450025200000006%
- Lighting 1.0360270072147726Lux
- CO2 Emission 247.3ppm

Graphical representation

Graphical Data Change Location Logoff

Room: Open Plan Office Space
Sensor Type: Temperature
Interval from Thu May 14 00:00 2009 to Thu May 14 23:59 2009



Time of Day 14/05/2009

<< Previous Day

Time Selection

Comfort Level

Please select Comfort Level

<p>Temperature</p> <ul style="list-style-type: none"> <input type="radio"/> Too Hot <input type="radio"/> Adequate <input type="radio"/> Too Cold 	<p>Humidity</p> <ul style="list-style-type: none"> <input type="radio"/> Too Wet <input type="radio"/> Comfortable <input type="radio"/> Too Dry 	<p>Light</p> <ul style="list-style-type: none"> <input type="radio"/> Too Bright <input type="radio"/> Adequate <input type="radio"/> Too Dark
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Occupant Comfort Feedback






Stakeholder Interest Facility Management


Building Owner



Building Operator



Occupant /Tenant



Building, Zone, Organisation

Please select a Zone

Building:

Storey:

Room No:

Room Occupants & Organisations

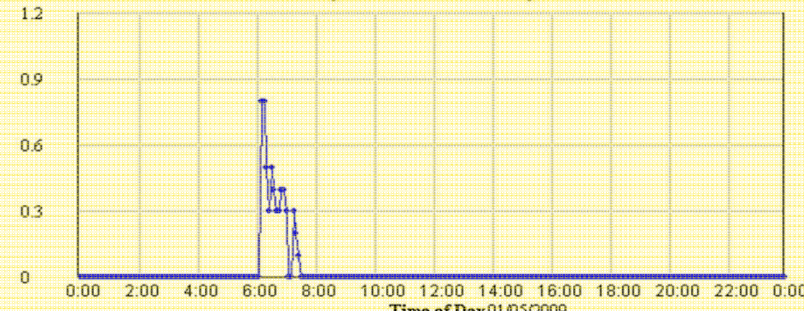
Available Measurements

- Heating Coils Pump F
- Heating Coils Pump P
- Heating Coils Pump P
- Immersion Frost Ther
- MCC-01 Total Power
- MCC-02 Total Power
- Main Power Board Pt
- Mains Water Flow Me
- Natural Gas(Boiler) F
- Natural Gas(Labs) Fl

Graphical representation

Graphical Data

Room: RoomX
Sensor Type: Gas
Interval from Fri May 01 00:00 2009 to Sun May 03 23:59 2009



Time of Day 01/05/2009

Date Selection

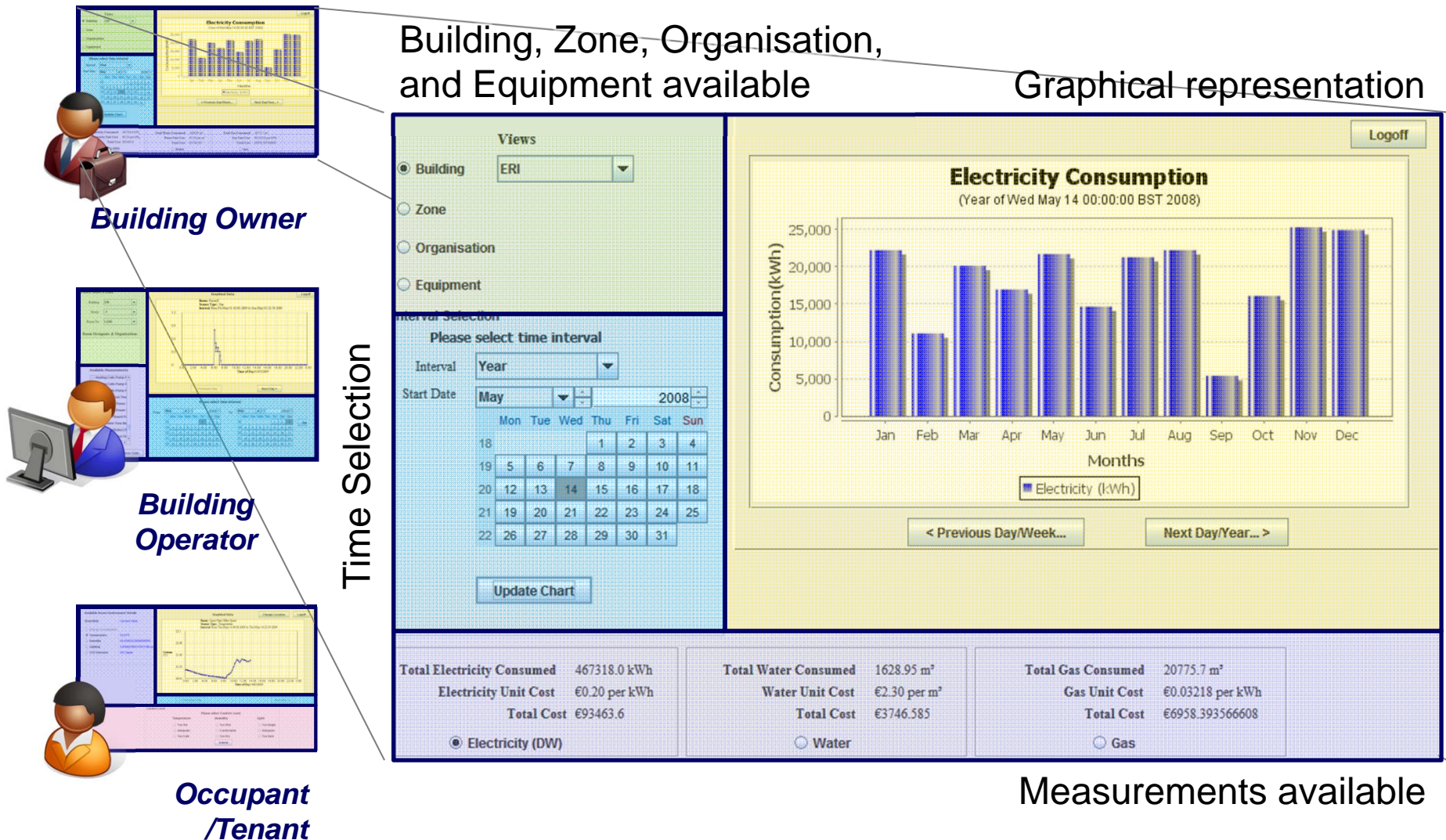
Please select time interval

From: May 2009 To: May 2009

Mon	Tue	Wed	Thu	Fri	Sat	Sun
18				1	2	3
19	4	5	6	7	8	9
20	11	12	13	14	15	16
21	18	19	20	21	22	23
22	25	26	27	28	29	30
						31

Measurements available

Time Selection



Building Owner

Building Operator

Occupant /Tenant

Building, Zone, Organisation, and Equipment available

Graphical representation

Time Selection

Measurements available

Views

- Building: ERI
- Zone
- Organisation
- Equipment

Interval Selection

Please select time interval

Interval: Year

Start Date: May 2008

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18				1	2	3	4
19	5	6	7	8	9	10	11
20	12	13	14	15	16	17	18
21	19	20	21	22	23	24	25
22	26	27	28	29	30	31	

Electricity Consumption
(Year of Wed May 14 00:00:00 BST 2008)

Consumption(kWh)

Months

Electricity (kWh)

< Previous Day/Week... Next Day/Year... >

Total Electricity Consumed 467318.0 kWh
Electricity Unit Cost €0.20 per kWh
Total Cost €93463.6

Total Water Consumed 1628.95 m³
Water Unit Cost €2.30 per m³
Total Cost €3746.585

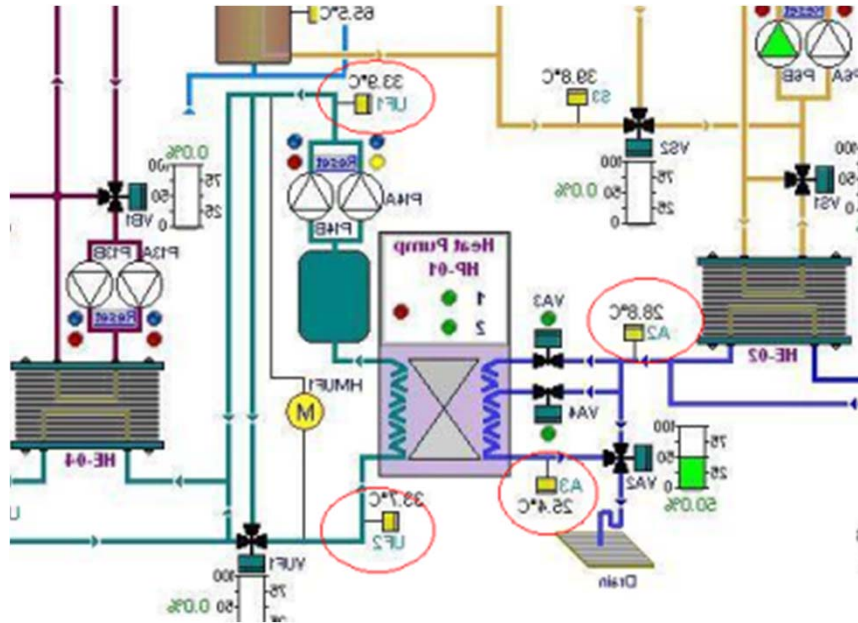
Total Gas Consumed 20775.7 m³
Gas Unit Cost €0.03218 per kWh
Total Cost €6958.393566608

Electricity (DW) Water Gas



ITOBO DEMONSTRATOR BUILDINGS

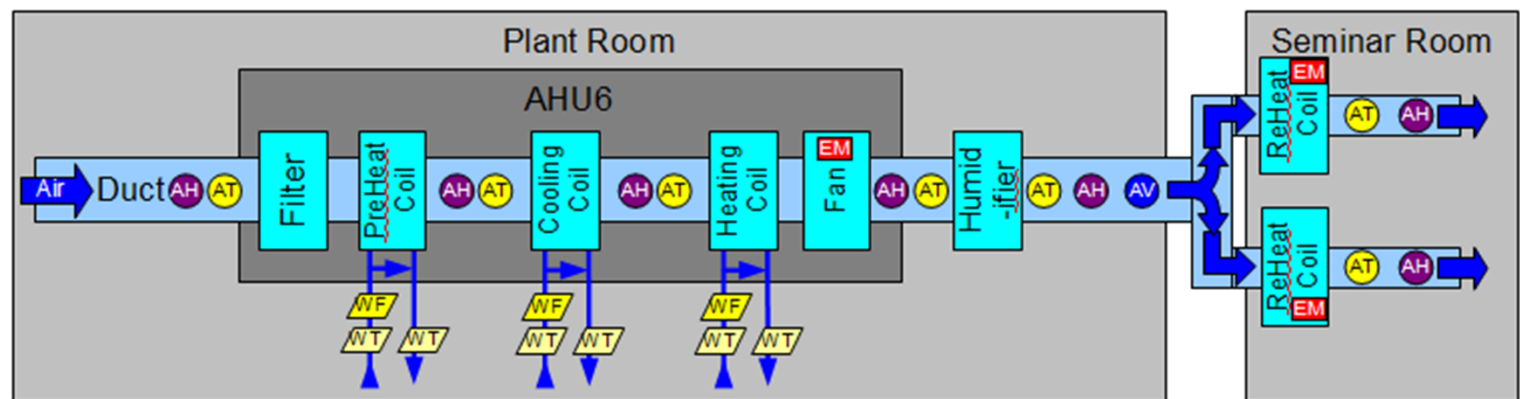
ERI
Cork



ARUP
London



HSG
Frankfurt



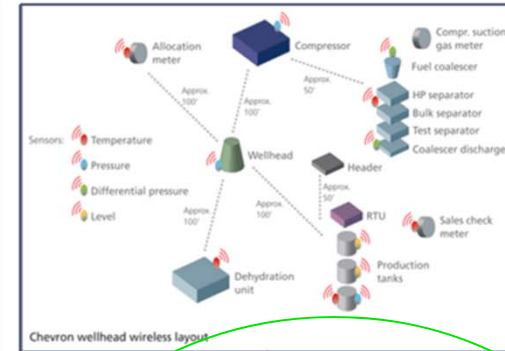
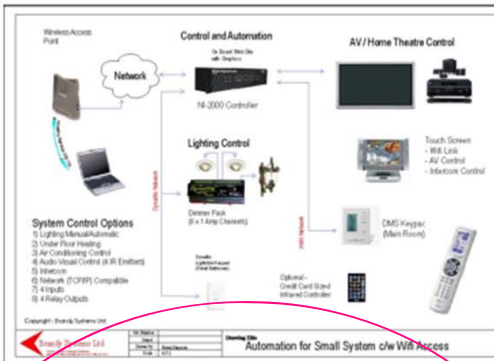
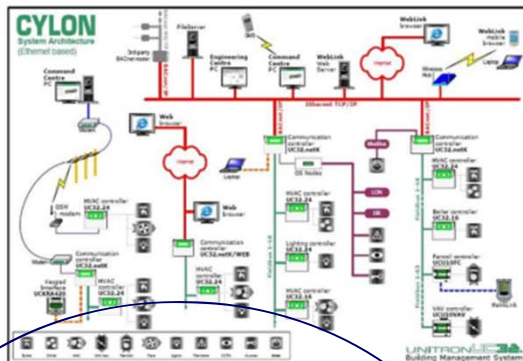


ERI (UCC, CORK, IRELAND) BUILDING MANAGEMENT SYSTEMS (BMSs)

Cylon BMS for HVAC Systems
(Earliest Data: Feb 2007)

Phillips BMS for Lighting System
(Data for 6 month intervals)

ITOBO Wireless Sensor Network
(Initial deployment Feb 2008)



226 Data Points
Including sensors,
meters and
actuators

150 Data Points

74 Data Points
Including sensors
and meters

ERI BMS systems





- **Sensor reading data available.**
- **Data processing through data warehousing.**
- **Enables sensing of large volumes of information on building operation over time.**

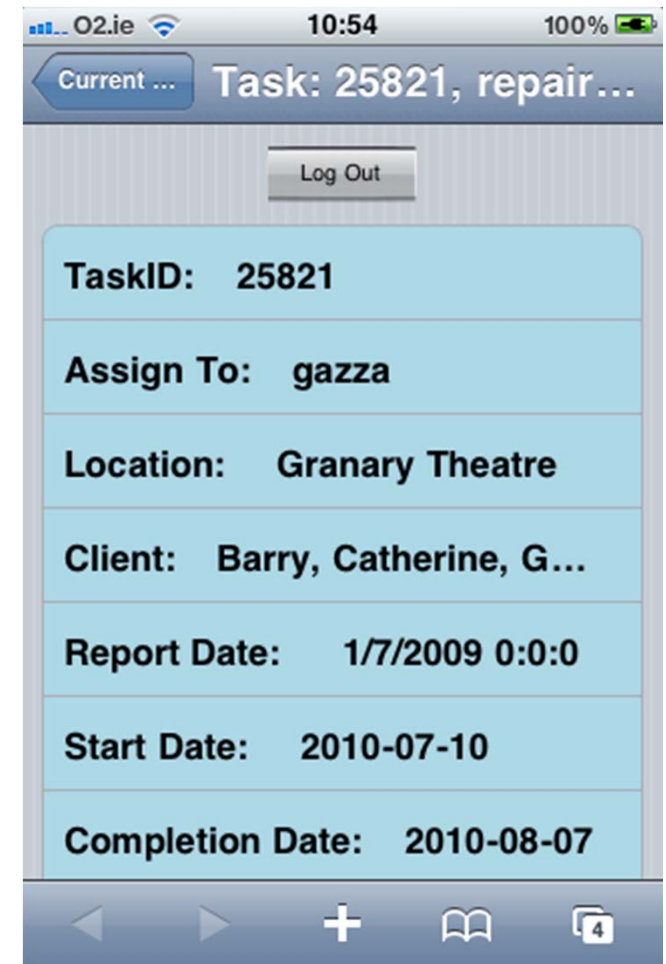
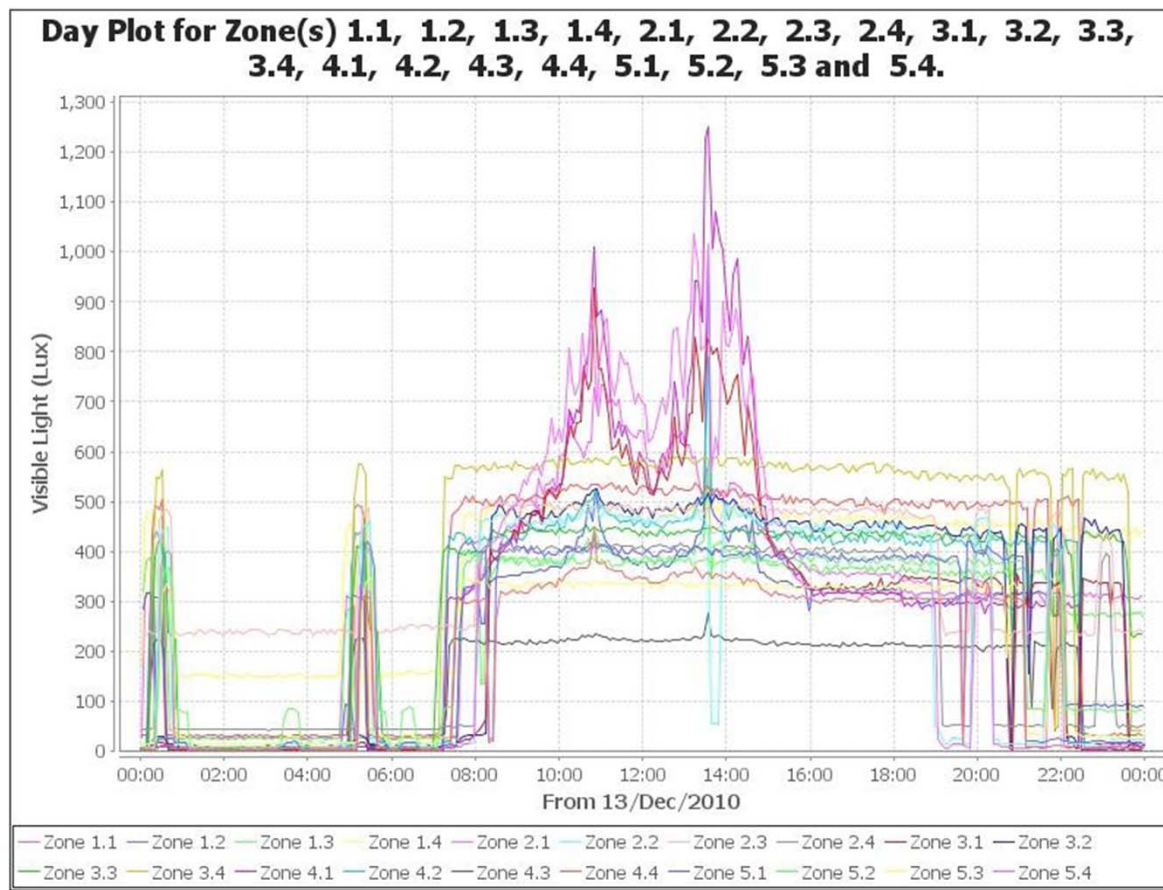
Building	#Devices	#Data Streams	Interval (s)	#Readings per Day (86400s)
ERI WSN	92	796	720	95520
ERI BMS	217	217	300 (7) 900 (210)	22176
ARUP WSN	20	340	720	40800
HSGZander WSN	36	415	720	49800
Total				208296





o End-user application

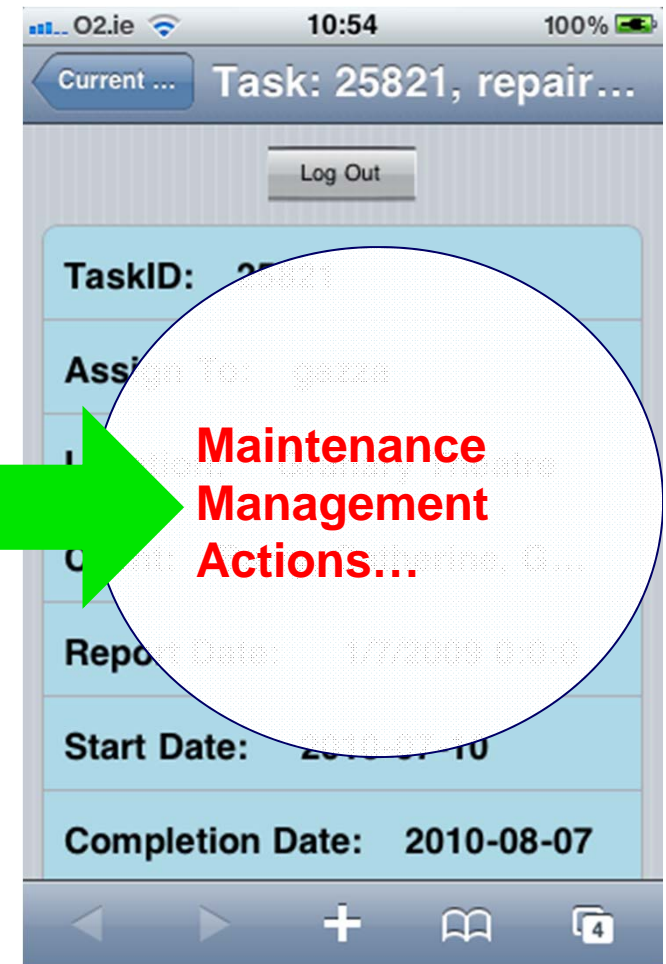
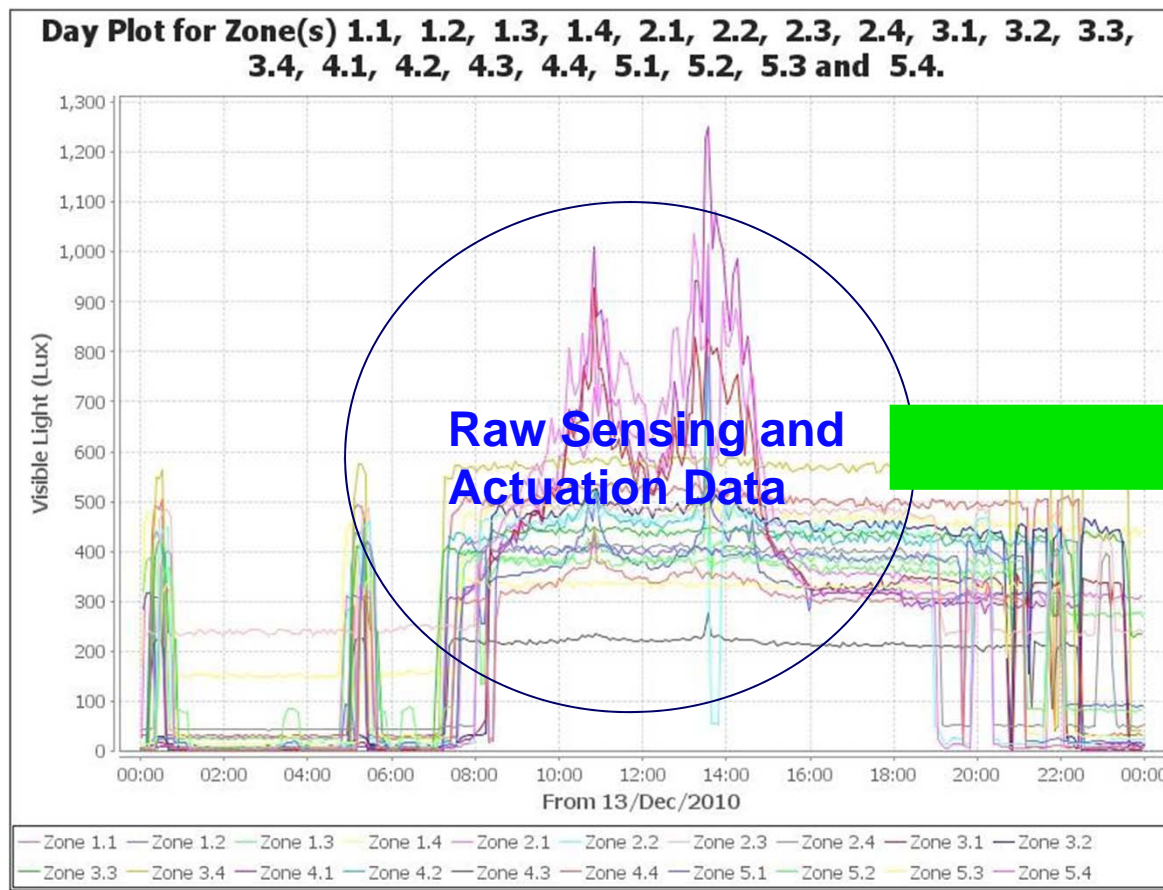
- Formatting of data for a intuitive and responsive presentation of building performance data.





o End-user application

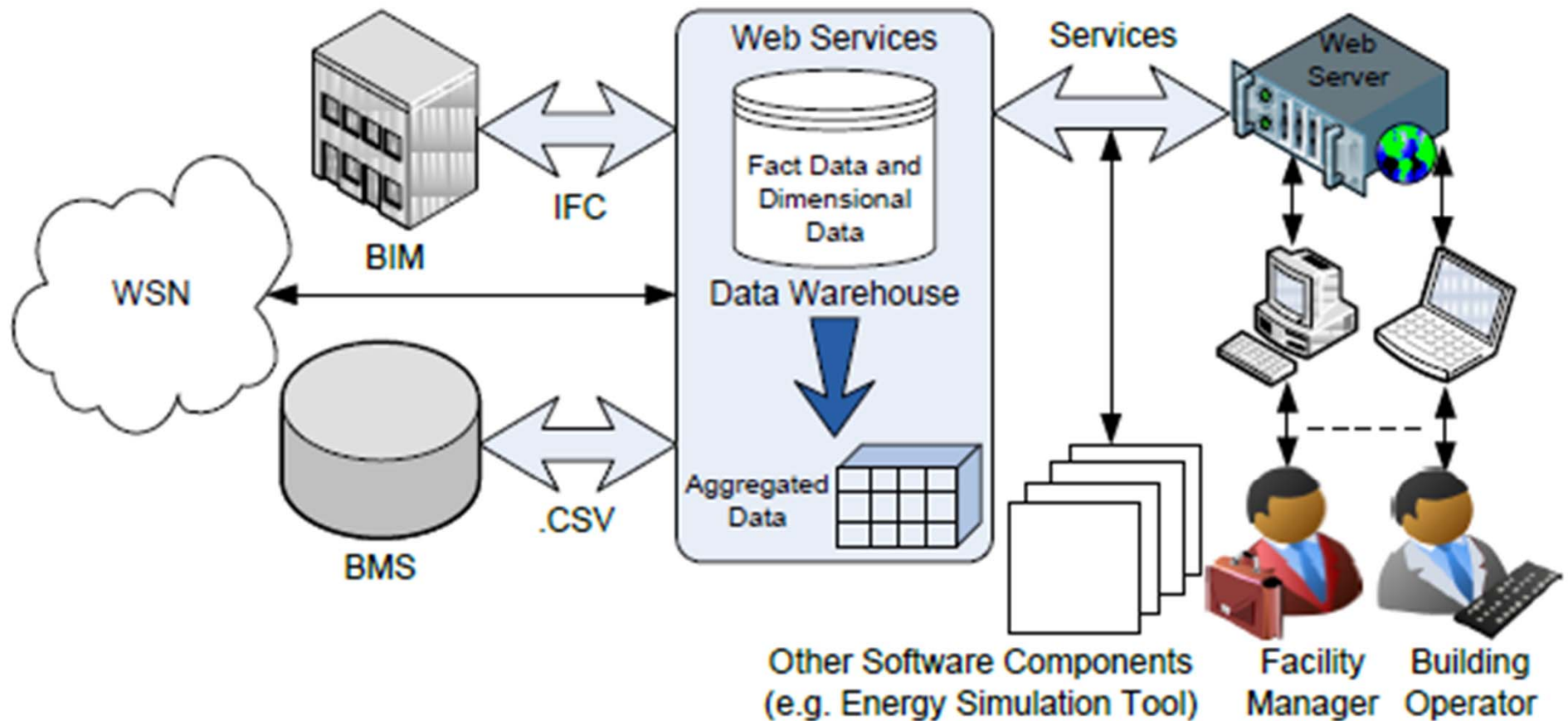
- Formatting of data for a intuitive and responsive presentation of building performance data.

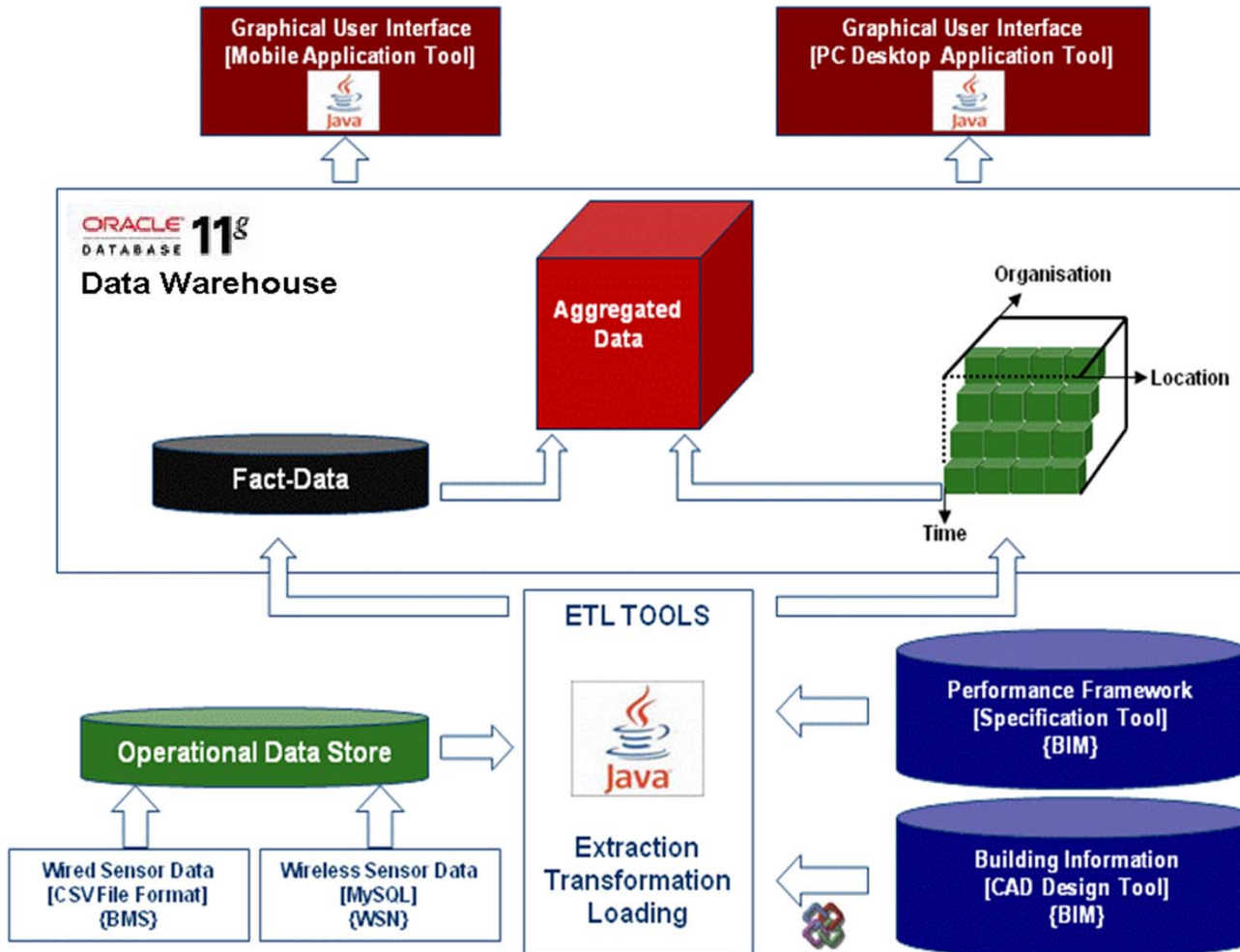




SIMPLIFIED MAINTENANCE MANAGEMENT SYSTEM FRAMEWORK

- o Data collection, data warehousing and end user maintenance management services.



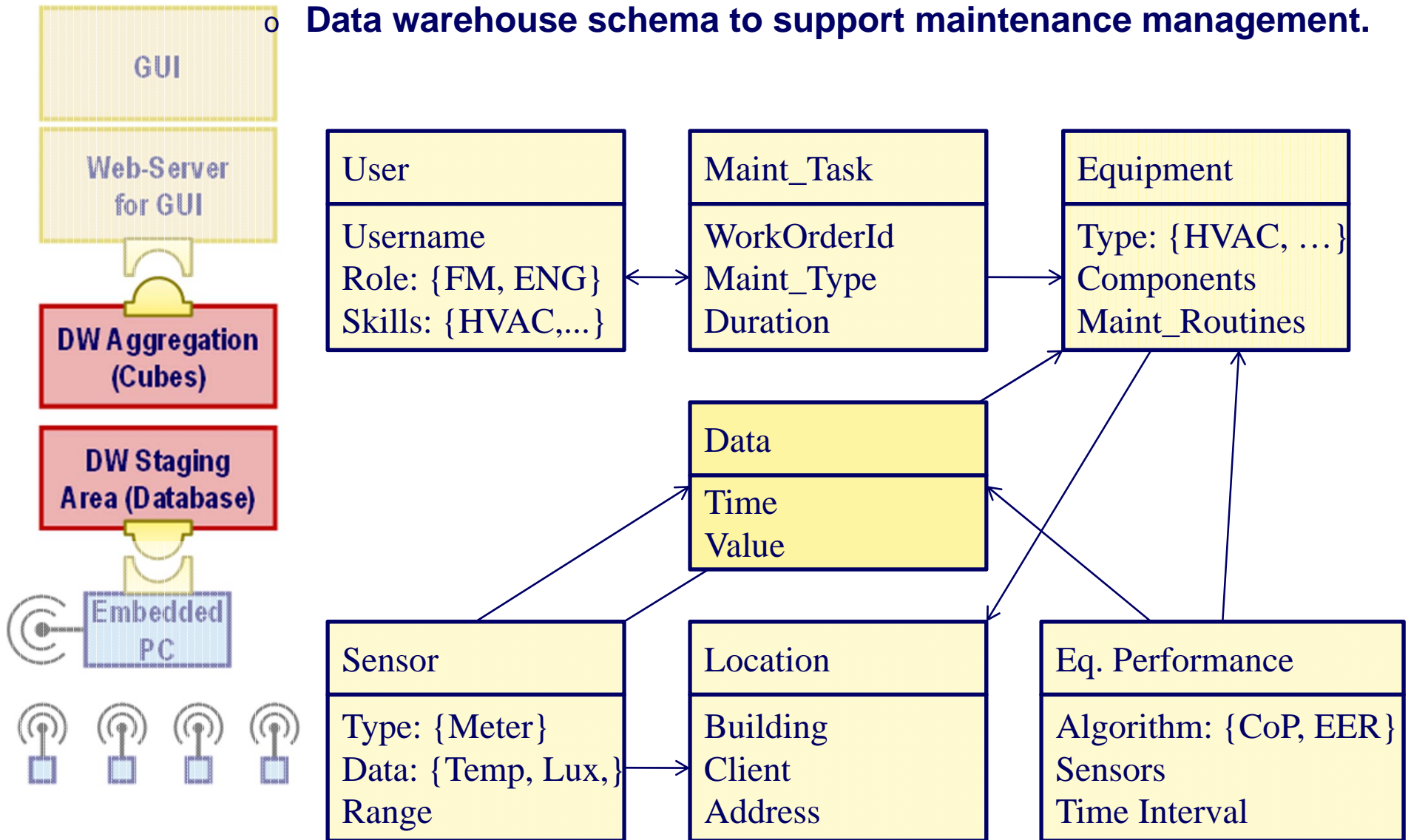


A DW is subject oriented, integrated, non-volatile, and time variant collection of data in support of management's decisions





o Data warehouse schema to support maintenance management.





o Electricity Consumption Service Average Performance For Data Retrieval Over Wireless Broadband

Data Access Type	Weekly (s)	Monthly (s)	Quarter (s)	Year (s)	Multiple Years (s)
Data Warehouse	0.2939	0.2727	0.3344	0.2894	0.2884
Database	0.8936	0.599	0.5031	1.2809	0.606
DW : DB	1 : 2	1 : 7	1 : 5	1 : 18	1 : 9



o Electricity Consumption Service Average Performance For Data Retrieval Over Local Area Network

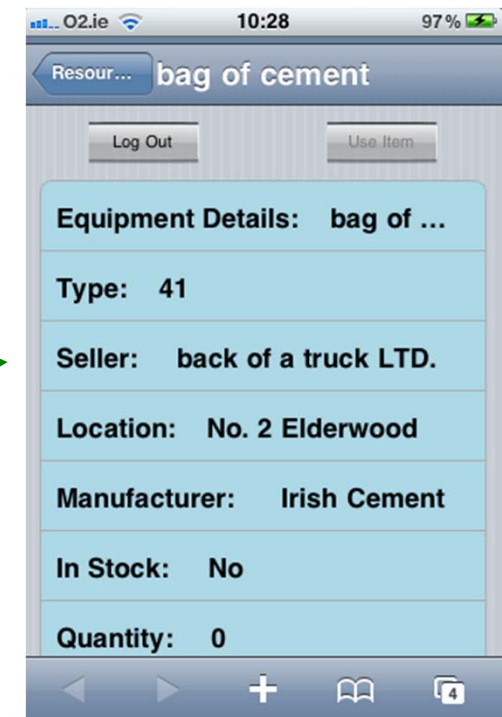
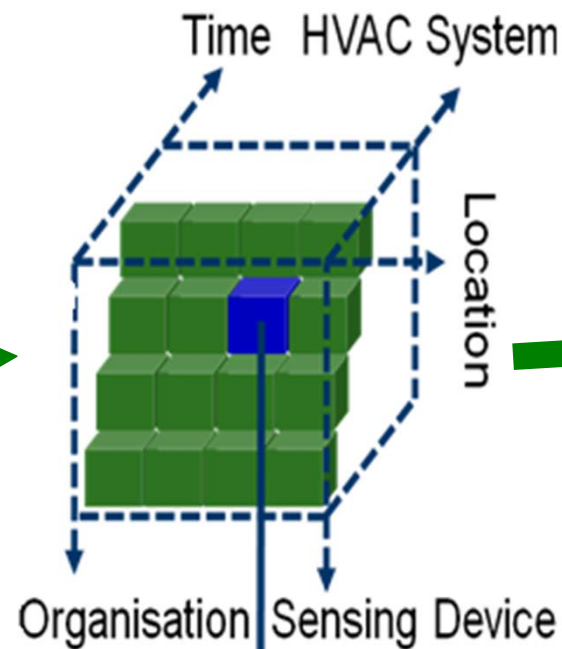
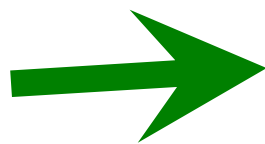
Data Access Type	Weekly (s)	Monthly (s)	Quarter (s)	Year (s)	Multiple Years (s)
Data Warehouse	0.1796	0.0344	0.0374	0.0327	0.0298
Database	0.3814	0.2515	0.1985	0.6126	0.2671
DW : DB	1 : 3	1 : 2	1 : 1.5	1 : 4	1 : 2





CONTEXT SENSITIVE MAINTENANCE CLIENT

- Context sensitive mobile client provides an effective methodology to support maintenance processes and maintenance engineer views.

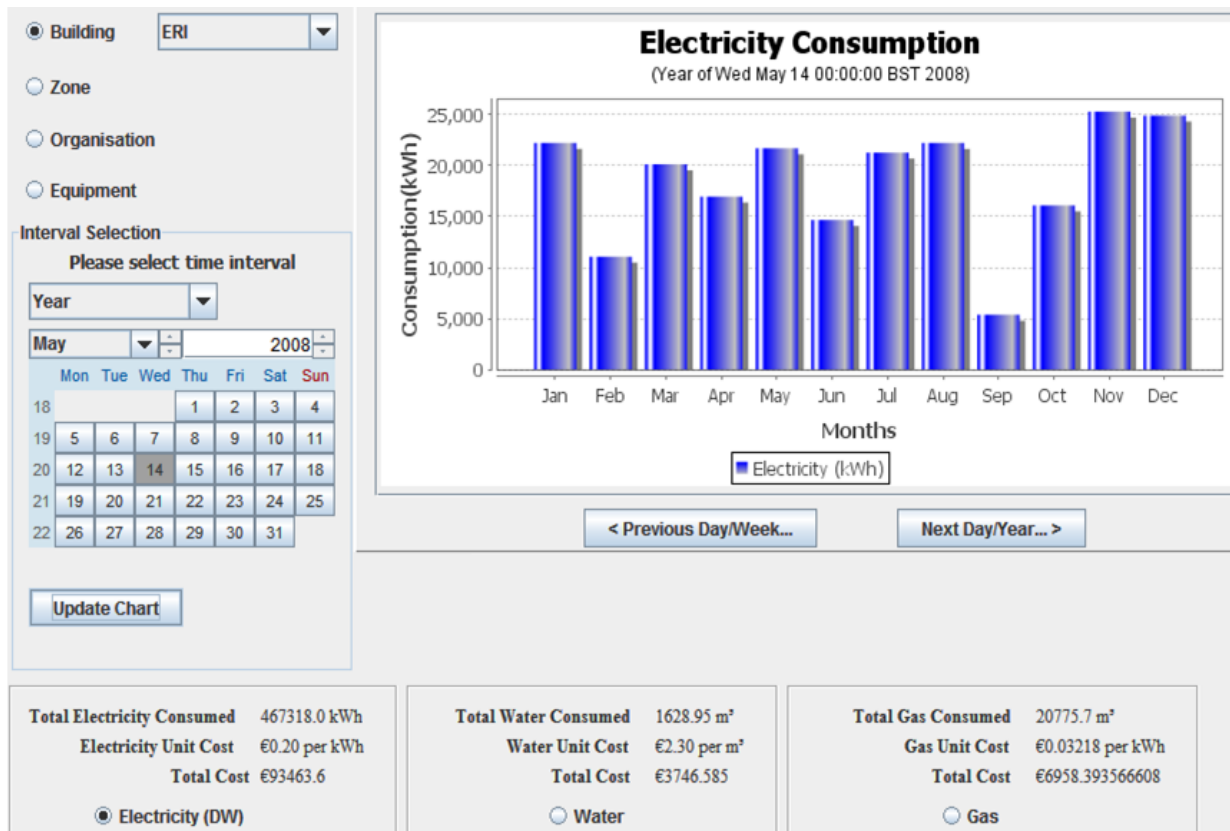




Solution

Monthly Energy Consumption per Building

Data can be aggregated per zone (room, floor, building,...), per user, or per time period (week, business year, etc...)



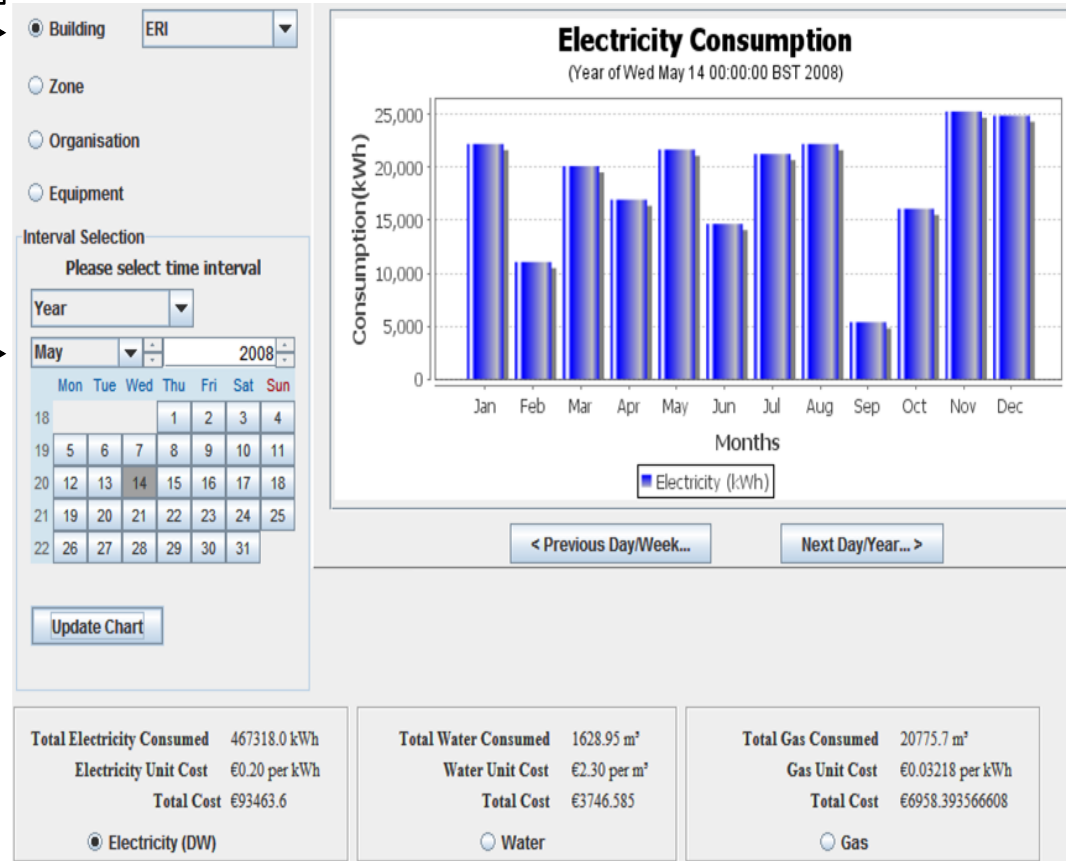
- Integrate & analyze building performance data.
- Create data aggregation, reports & actionable information.
- Provide a single repository for building monitoring data.



Data Warehouse Specifications Cube's Output

The Building Level on
the Zone Dimension

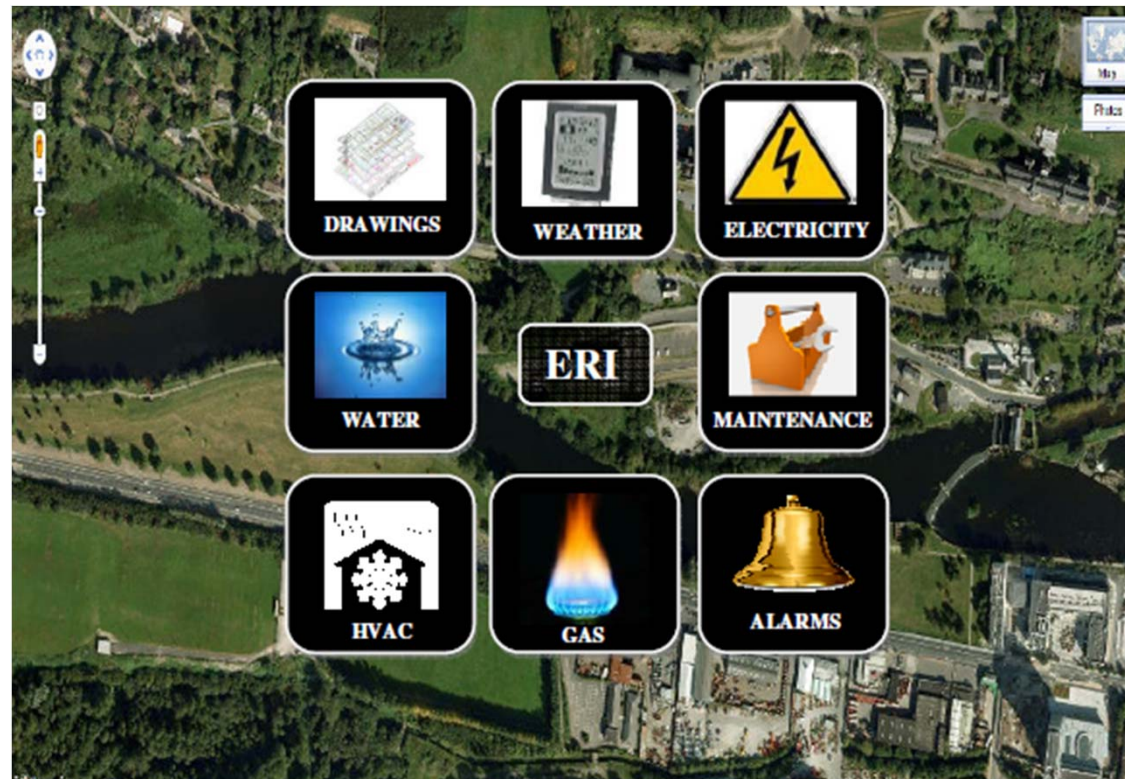
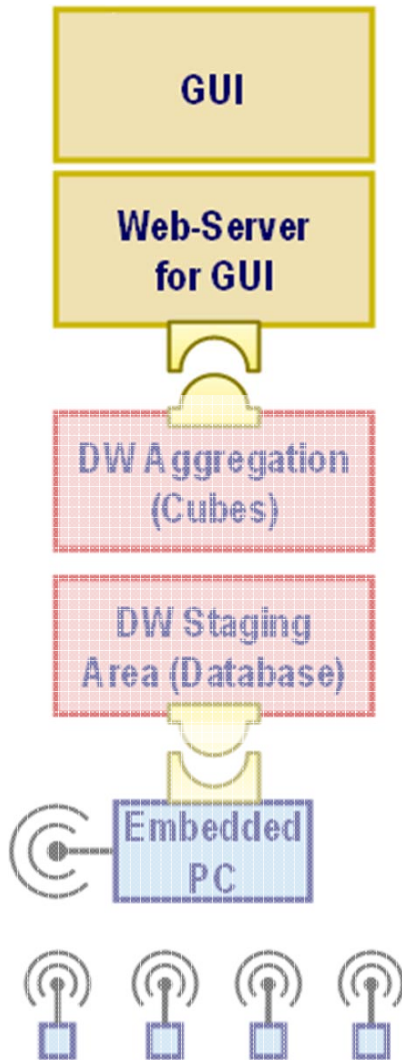
Data Aggregation



At the Month Level on
the Time Dimension

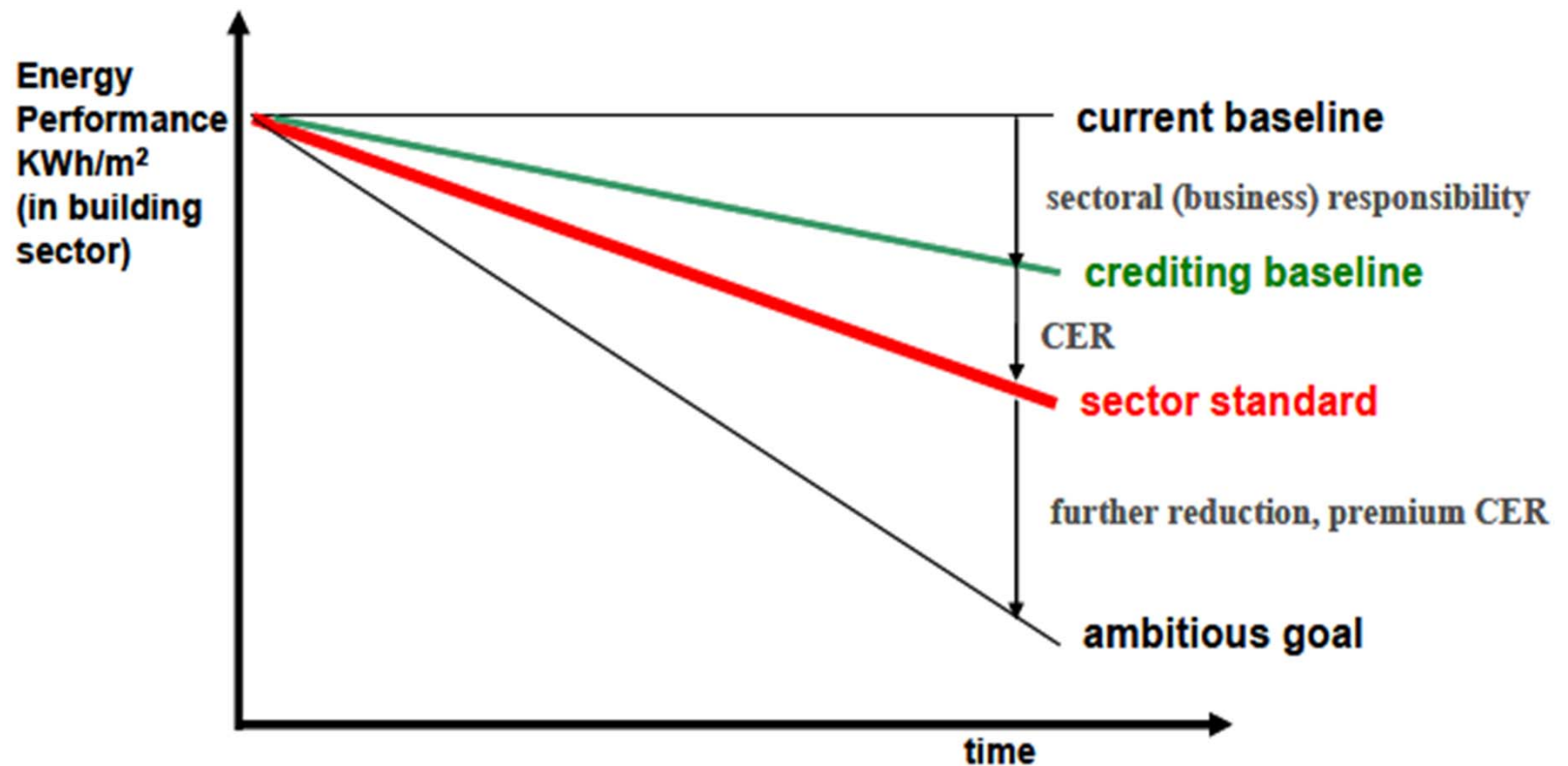


- Locate and interrogate building performance using 'home buttons'
- Interrogate room data





Kyoto Protocol Energy Reduction Credit Mechanism



Certified Emission Reduction - A lucrative incentive for Facility Management companies.

Ref: Cheng, C., Pouffary, S., Svenningsen, N., Callaway, M., "The Kyoto Protocol, The Clean Development Mechanism and the Building and Construction Sector" – A Report for the UNEP Sustainable Buildings and Construction Initiative, United Nations Environment Programme, Paris, France. ISBN: 978-92-807-2942-9, 2008.





Q & A

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