



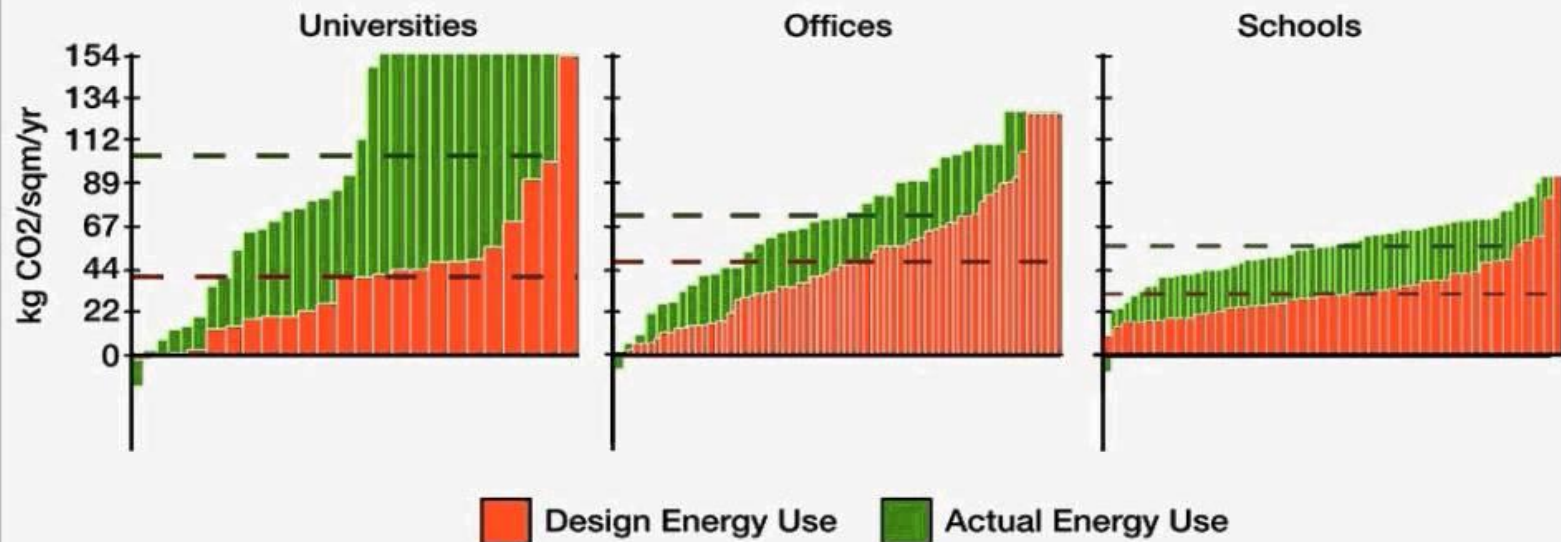
TOPAS





The Energy Performance Gap?

The performance gap : design + in use carbon figures



Source: 2Degrees - CarbonBuzz

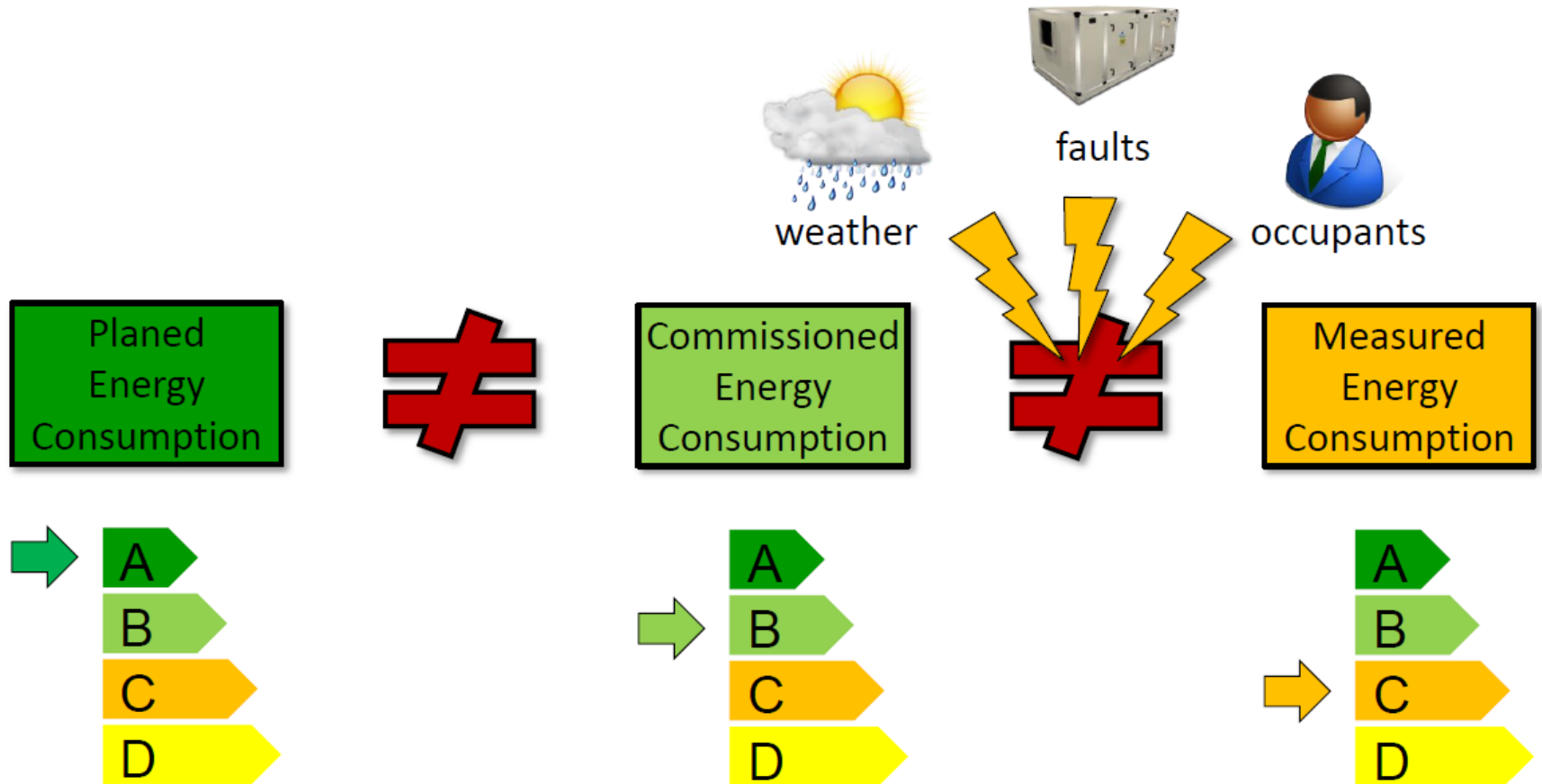
<https://www.youtube.com/watch?v=Xtqb190DQy8>

FeildenCleggBradleyStudios





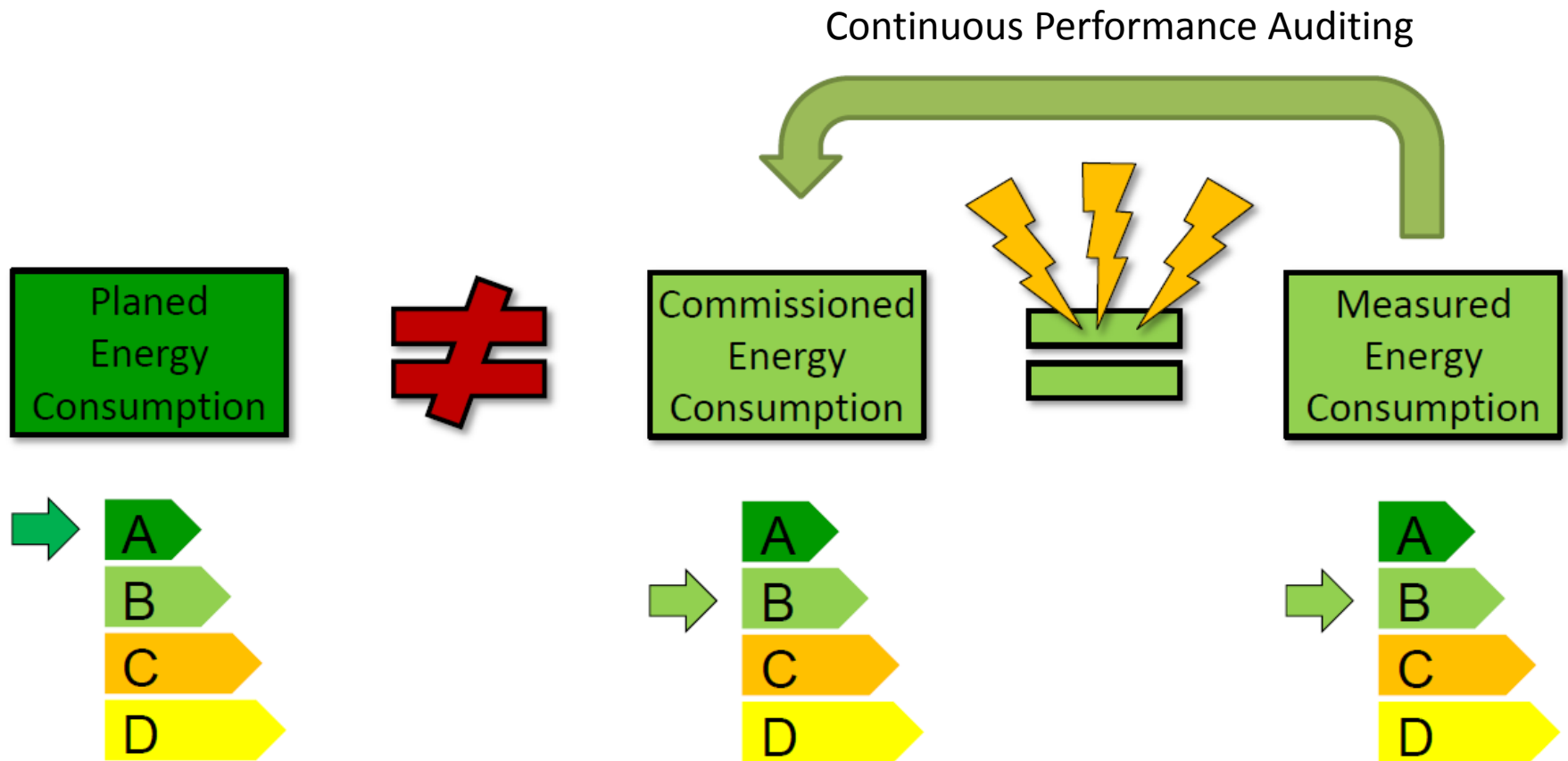
TOPAs Objectives



Building energy performance predictions show *major differences to measurements*.
This is even worse for building blocks.



Challenges to be overcome



Tools and methods for measuring and analysing real building energy performance for FM and ESCOs.

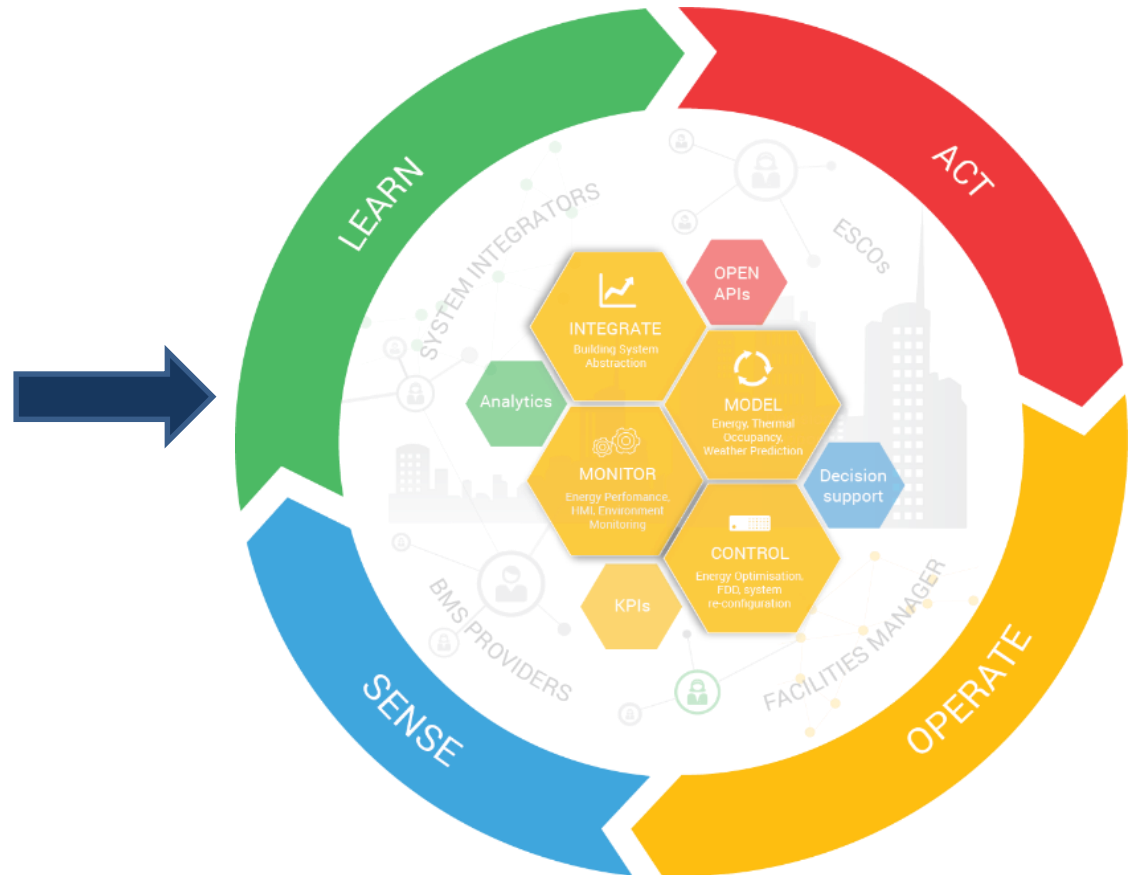


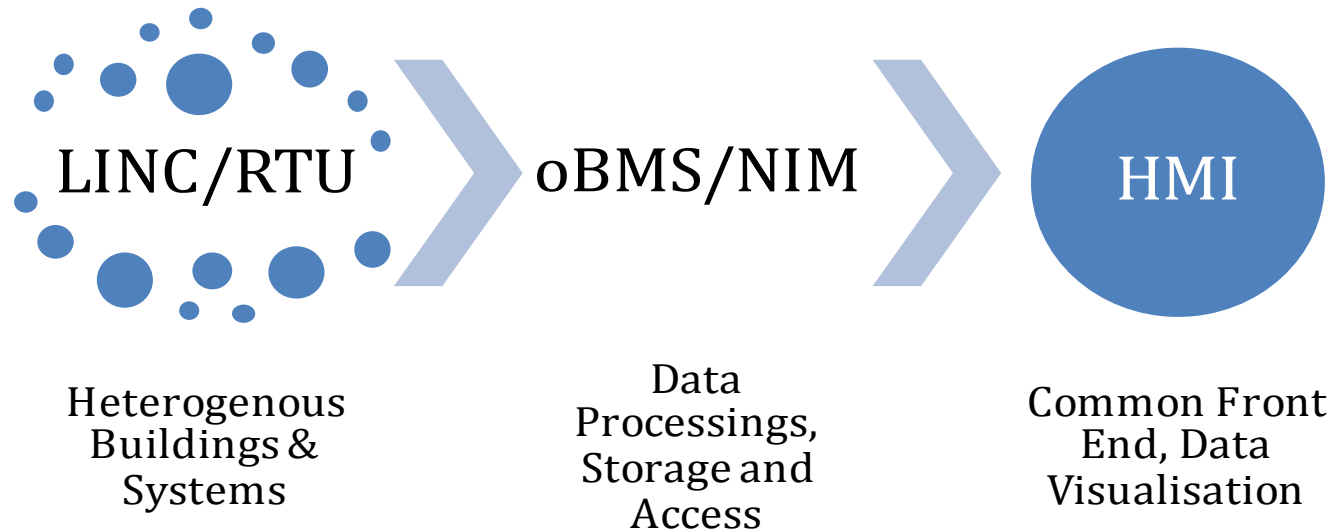
TOPAs Approach

TOPAs is a platform of tools and services that allows the coordinated management of blocks of buildings. It continuously performs energy audit based on:

- **SENSE:** Device/System connection, data is abstracted from the environment
- **LEARN:** Big data analytics leveraging IoT technologies to transform data into actionable insights
- **ACT:** Transform analysis to actions
- **OPERATE:** Better utilize assets and manage blocks of buildings, create human value

TOPAs Cognitive Loop





TOPAs Core System - components across the TOPAs three-tiered architecture (edge, platform, and enterprise). The primary focus being data-abstraction using LINC (Connectors & Resources), RTU (secure host at the edge), oBMS (Watson IoT, OpenAPI), NIM (meta-model) and HMI for data visualisation.



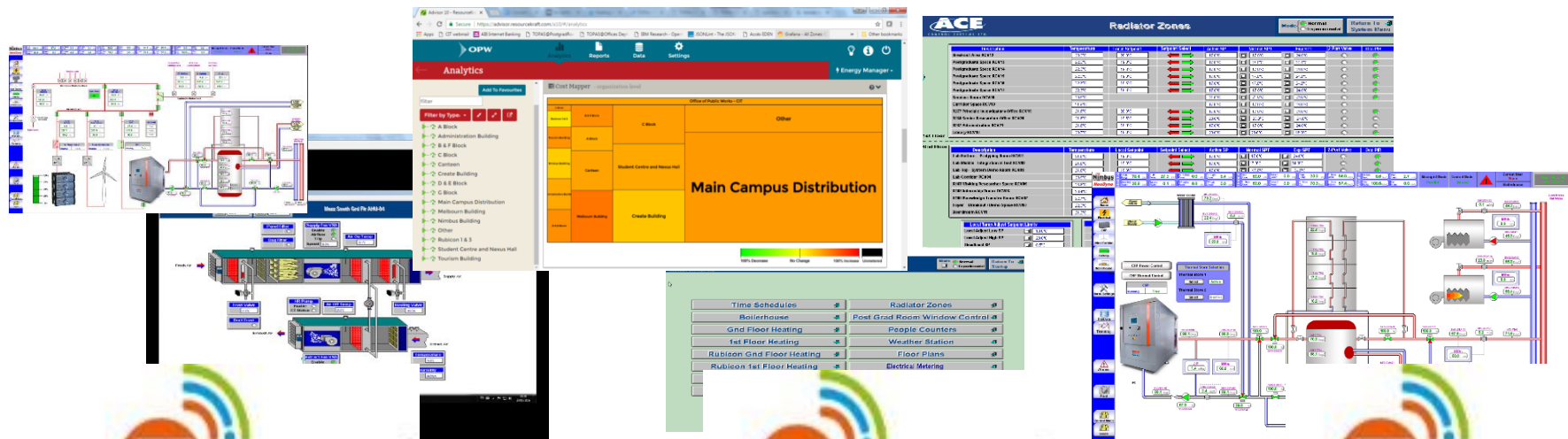
Getting Building Data



North



URBAN
POWER



Sustainable Places 2018, June 27th, 2018

<https://www.topas-eeb.eu>



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676760.



Getting Building Data



LINC



+ LINC

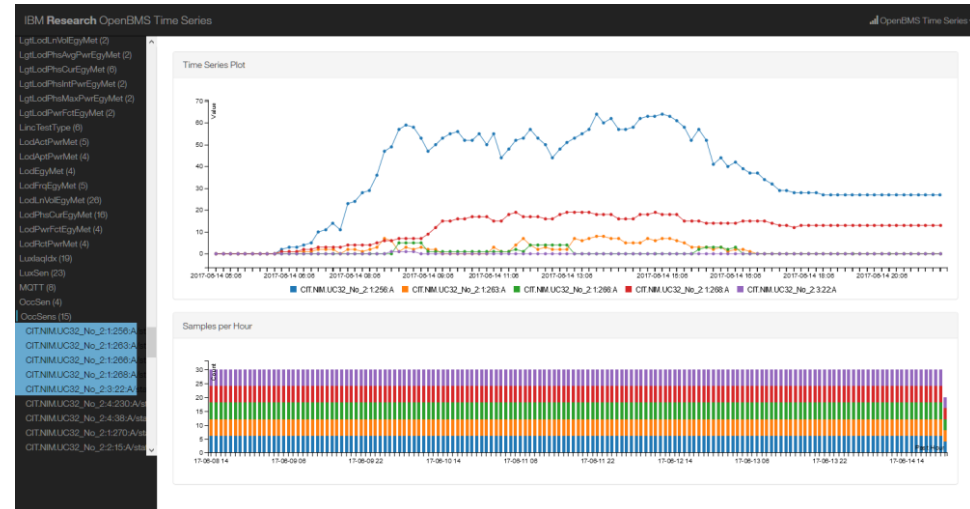
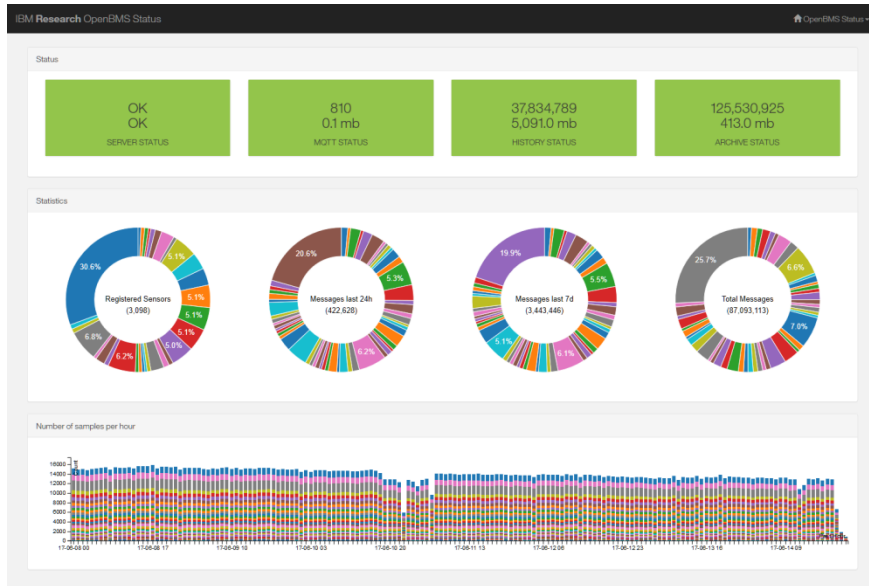


+ LINC

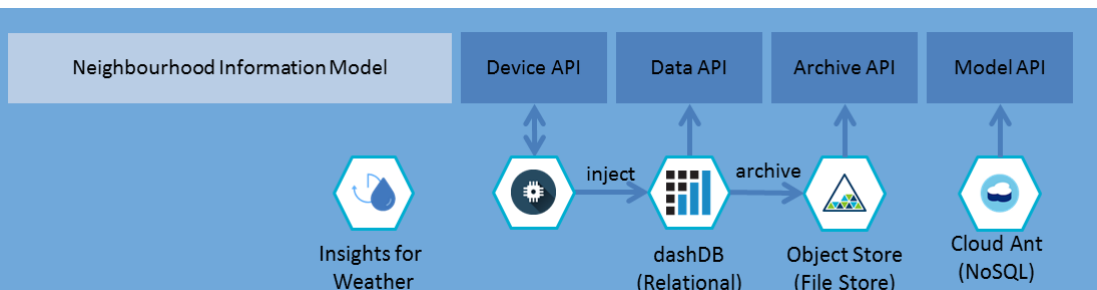
- Secure RTU H/W
 - Platform that integrates wired and wireless communication channels
- LINC Middleware
 - Local storage of data for redundancy
 - Auto restart if connection lost
 - Mail alerts sent on errors
 - Remote monitoring with Web tools
 - Transparent management of communication links



Manage Data (oBMS)



- OpenBMS platform
 - IoT Watson for stream analytics
 - Model storage
 - Brick standard
 - OpenAPI
 - Scalable Cloud Infrastructure





Neighbourhood Information Model

swagger <https://topas1.eu-gb.bluemix.net/tudstore/lim/swagger.json> [api_json](#) [Explore](#)

widgets [Show/Hide](#) [List Operations](#) [Expand Operations](#)

GET	addWidgetToDevice	Add a new device to an existing location
GET	addWidgetToDataPoint	Add a new input datapoint to an existing device
GET	addWidgetToOutDataPoint	Add a new output datapoint to an existing device
GET	addWidgetToDataPointNames	Get the names of all datapoints of an existing project
GET	addWidgetToDeviceNames	Get all known devices of a project
GET	addWidgetToLocationNames	Get all location names of a project
GET	addWidgetToLocations	Get all locations of a project
GET	addWidgetToProjects	Get All Projects
GET	addWidgetToDataPointLocation	Get the location to a specific datapoint
GET	addWidgetToDataPointPropertyList	Get all property keys of a specific datapoint
GET	addWidgetToDataPointPropertyValue	Get datapoint property value by key
GET	addWidgetToDeviceDataPointNames	Get the names of all datapoints of an existing project
GET	addWidgetToDeviceDataPoints	Get all datapoints of some existing device
GET	addWidgetToDeviceLocation	Get the location of some existing device
GET	addWidgetToDevicePropertyList	Get all property keys of a specific device
GET	addWidgetToDevicePropertyValue	Get device property by key
GET	addWidgetToDeviceState	Get the state of some existing device
GET	addWidgetToDeviceLocation	Get the devices contained in a location
GET	addWidgetToElementsByPropertyKey	Get all devices, datapoints and locations of a project which do have the named property
POST	addWidgetToElementsByPropertyValue	Get all devices, datapoints and locations of a project which do have the named property set with the given value
GET	addWidgetToLocationByName	Get a specific location by its name
GET	addWidgetToLocationDeviceNames	Get the device names contained in a location
GET	addWidgetToLocationPropertyList	Get all property keys of a specific location
GET	addWidgetToLocationPropertyValue	Get location property value by key
GET	addWidgetToParentLocation	Get the parent location name of an existing location
GET	addWidgetToProjectByName	Get Projects by name
GET	addWidgetToProjectNames	Get Projects by name
GET	addWidgetToProjectProperties	Get Project properties
GET	addWidgetToProjectPropertyByKey	Get Project property by key
GET	addWidgetToProjectPropertyList	Get all property keys of this project
GET	addWidgetToProjectPropertyValue	Get Project property by key
GET	addWidgetToProjectPropertyList	Get all projects which do have the named property
POST	addWidgetToProjectPropertyValue	Get all projects which do have the named property set with the given value
GET	addWidgetToPublicLocationsOfLocation	Get all child-locations of a location name
GET	addWidgetToProjectByFormalName	Get projects in XML-formal by name
GET	addWidgetToHasDataPointProperty	Check if a property exists for a datapoint
GET	addWidgetToHasDeviceProperty	Check if a property exists for a device
GET	addWidgetToHasLocationProperty	Check if a property exists for a location
GET	addWidgetToHasProjectProperty	Check if a property exists for a project
DELETE	addWidgetToRemoveDataPointProperty	Remove a property from a datapoint
DELETE	addWidgetToRemoveDeviceProperty	Remove a property from a device
DELETE	addWidgetToRemoveLocationProperty	Remove a property from a location
DELETE	addWidgetToRemoveProjectProperty	Remove a property from a project
POST	addWidgetToDataPointProperty	Add a new property to a specific device
POST	addWidgetToDeviceProperty	Add a new property to a specific device
GET	addWidgetToDeviceState	Get the state of some existing device
POST	addWidgetToLocationProperty	Add a new property to a specific location
POST	addWidgetToProjectProperty	Add a new property to a project

[weak ver. /tudstore/lim_api version 0.1.0] [Valid](#) [\[+\]](#)

GET **addWidgetToDevicePropertyValue** [Get device property by key](#)

GET **addWidgetToDeviceState** [Get the state of some existing device](#)

GET **addWidgetToProjectByName** [Get Projects by name](#)

GET **addWidgetToProjectNames** [Get Projects by name](#)

GET **addWidgetToLocationDeviceNames** [Get the device names contained in a location](#)

Response Class (Status 200)

Response Content Type **application/json**

Parameters

Parameter	Value
projectname	CIT_20180118
deviceName	CR_Energy_LGM4

Response Messages

HTTP Status Code	Reason
204	Success
400	Invalid param
404	Project or loc

Request URL

Request Body

```
{
  "deviceName": "CR_Energy_LGM4",
  "projectname": "CIT_20180118"
}
```

Response Code

Response Headers

```
{
  "x-backside-transport": "OK OK",
  "connection": "Keep-Alive",
  "transfer-encoding": "chunked",
  "content-language": "en-US",
  "content-type": "application/json",
  "data": "Fri, 18 May 2018 09:41:41",
  "x-global-transaction-id": "688"
}
```

Response Class (Status 200)

Response Content Type **application/json**

Parameters

Parameter	Value	Description	Parameter Type	Data Type
projectname	CIT_20180118	project name	query	string
locationname	RUBICON.First.RMC.9	location name	query	string

Response Messages

HTTP Status Code	Reason	Response Model	Headers
400	Invalid parameters supplied		

Request URL

Request Body

```
{
  "deviceName": "CR_Energy_LGM4",
  "projectname": "CIT_20180118",
  "locationname": "RUBICON.First.RMC.9"
}
```

Response Code

Response Headers

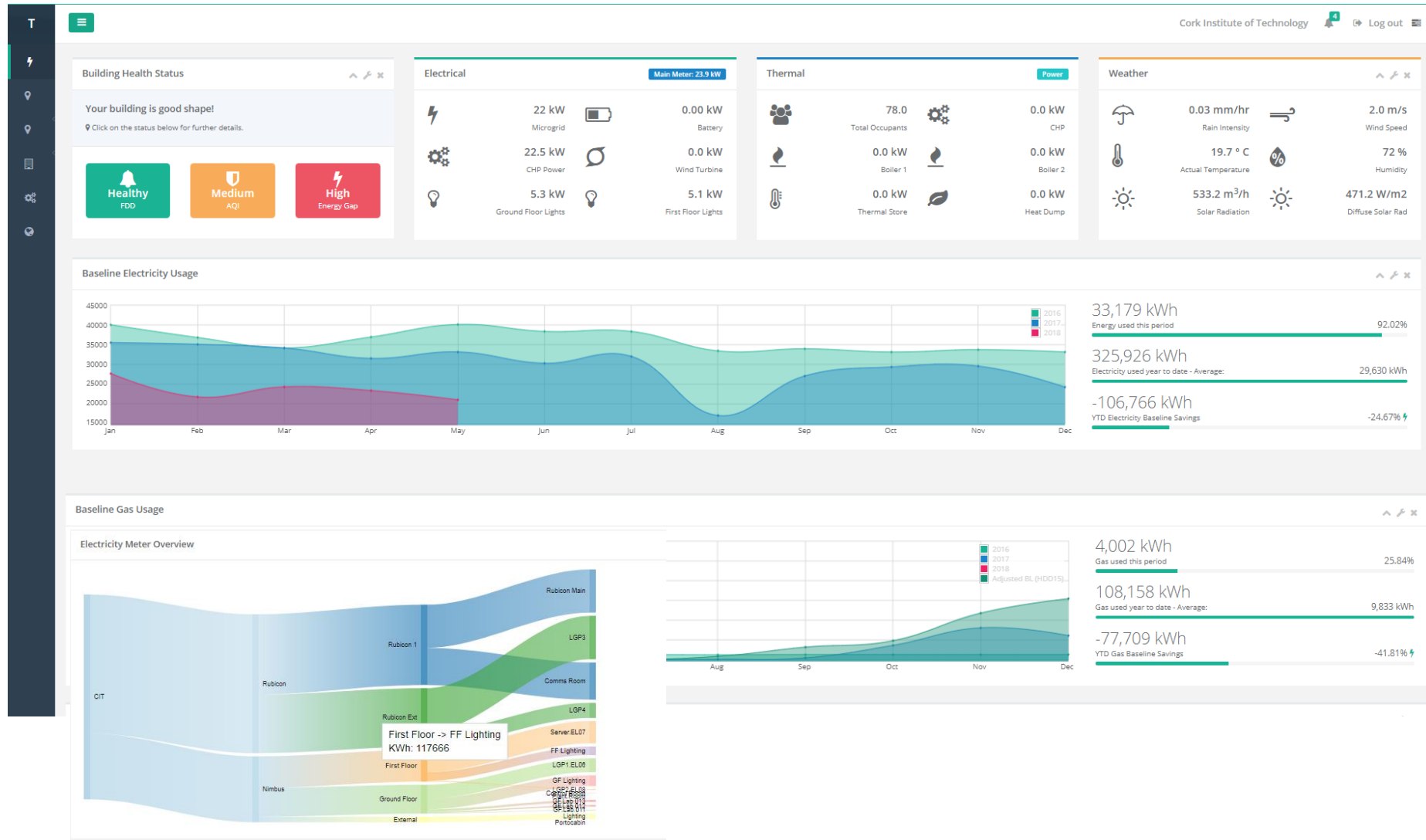
```
{
  "x-backside-transport": "OK OK",
  "connection": "Keep-Alive",
  "transfer-encoding": "chunked",
  "content-language": "en-US",
  "content-type": "application/json",
  "data": "Fri, 18 May 2018 09:41:41",
  "x-global-transaction-id": "114534"
}
```

- NIM is „address book“ for distributed building information
- NIM has 48 methods at RESTful-interface on BlueMix
- swagger-API and documentation for better usability
- backend is AUTERASStore from TUD
- building and device properties
- property-model is generic (model can be adapted for each user / building) – demo site data is very diverse
- links to oBMS via API IDs



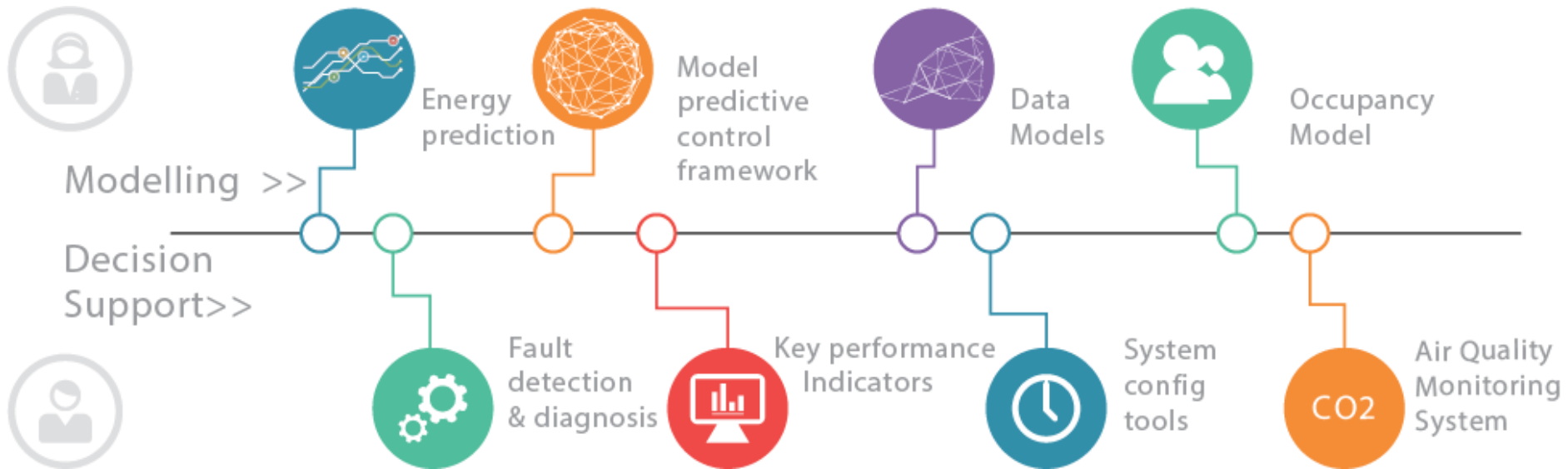


Common Front-end for Sustainable Energy Savings





TOPAs Add-On Services



Modelling Occupancy

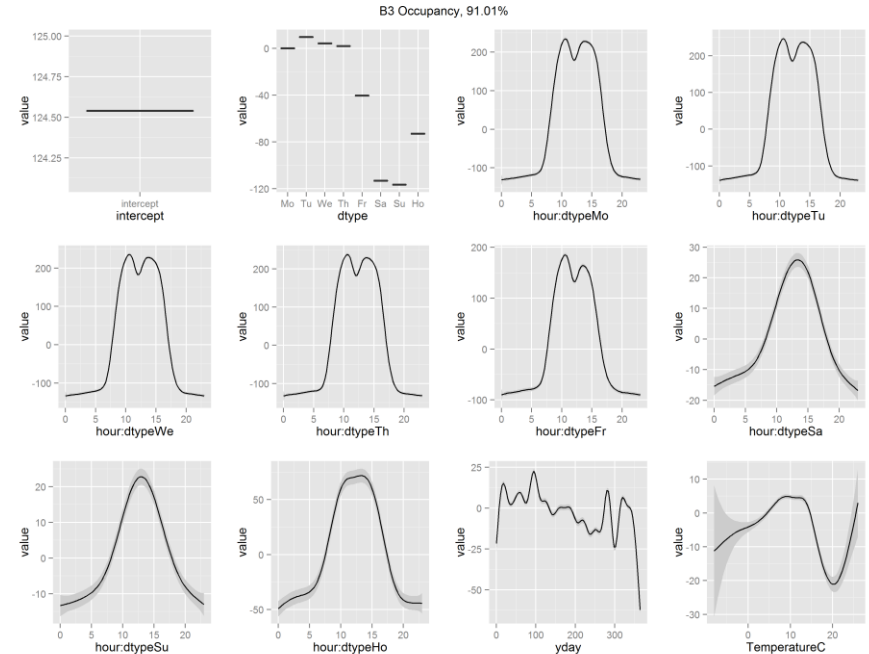
Occupancy models are used to predict and understand space usage. Occupancy is modelled together with its impact on energy using statistical machine-learning approaches that create interpretable models that explain occupancy by various influence.

Model for the occupancy

$$n_z(t) = n_0 + f^H(H_W(t)) + f^Y(D_Y(t)) + f^\vartheta(\vartheta_{oA}(t)) + f^\rho(\rho_{oA}(t)) + f^s(s_{oA}(t)) + \varepsilon_t$$

with

- $n_z(t)$ - Occupancy in a zone z at time t
- $f^H(H_W(t))$ - Function of time of day
- $f^Y(D_Y(t))$ - Function on day of year
- $f^\vartheta(\vartheta_{oA}(t))$ - Function on outside temperature
- $f^\rho(\rho_{oA}(t))$ - Function on outside humidity
- $f^s(s_{oA}(t))$ - Function on outside solar rad.

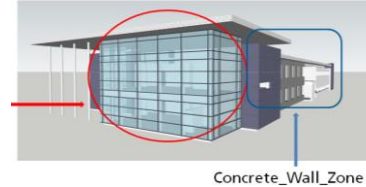


Modelling Methods

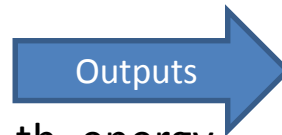
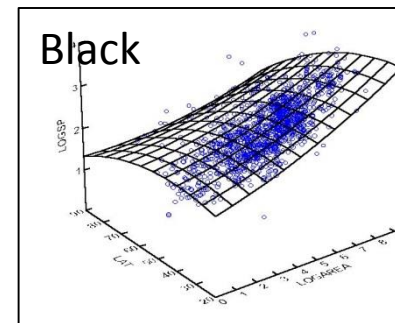
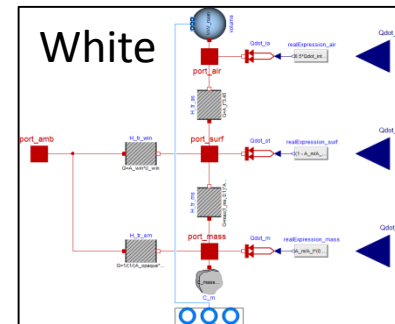
- White Box Models
 - Dynamic simulation (Dymola/Modelica)
 - Physical models
 - RC-networks
 - Characteristic curves

- Black Box Models
 - Gaussian Process Regression
 - Multi-Linear Regression
 - Support Vector Regression
 - Random Forests
 - K-nearest Neighbors

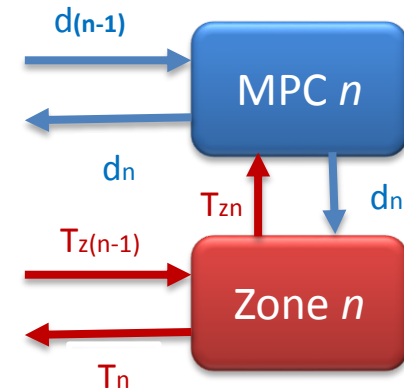
Parameters:
Building physics,
set points, ...

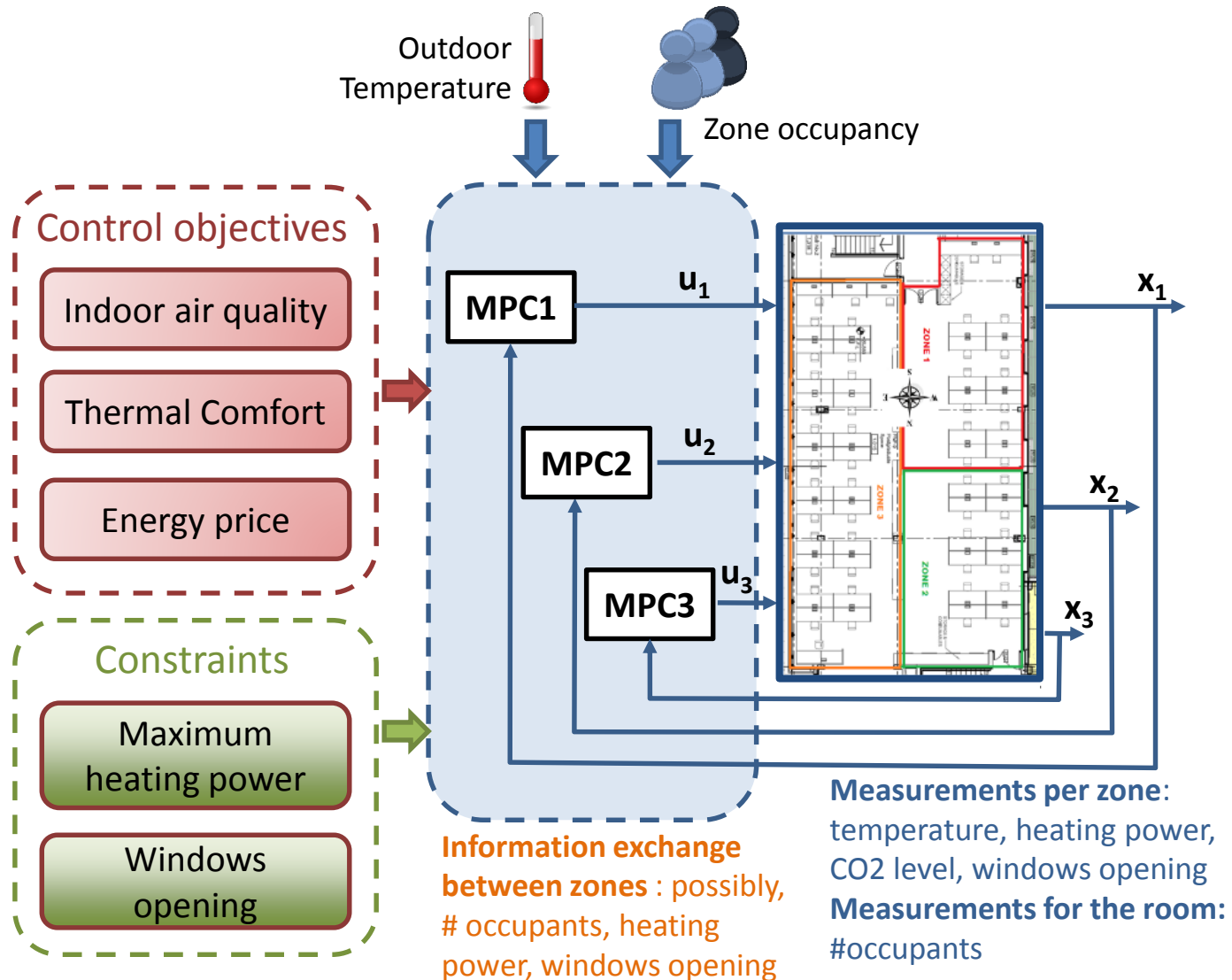


Weather
Occupancy
Windows
...



th. energy
el. energy
Comfort
...





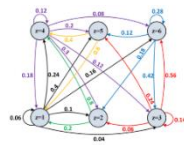
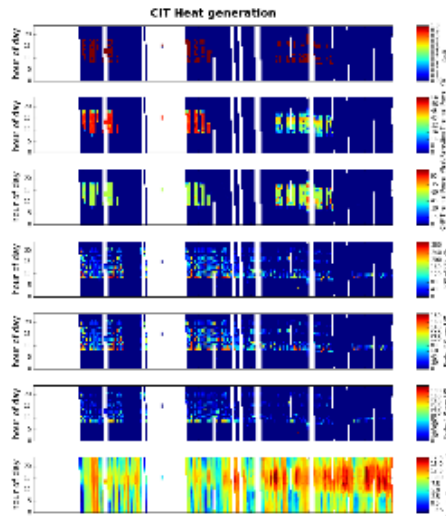


Decision Support Tools

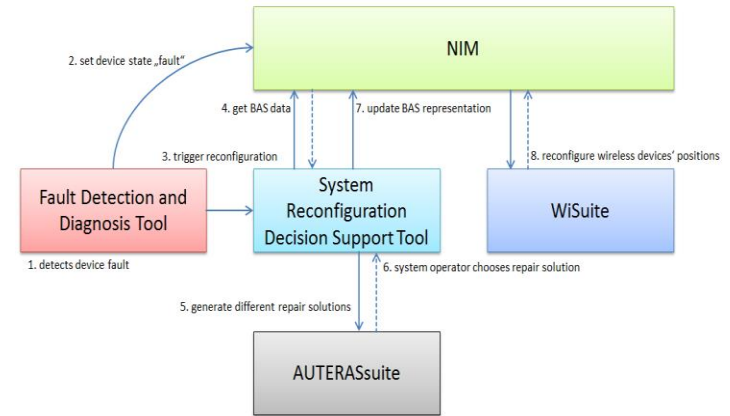
Decision Support Tools are developed to ensure a reduction in the gap prediction



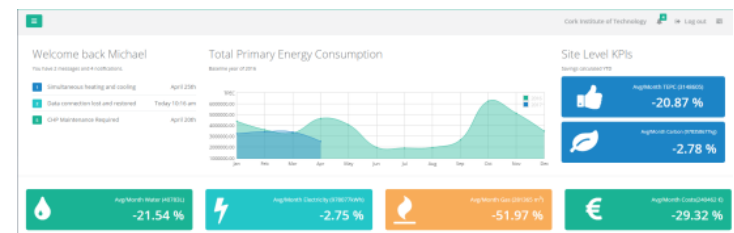
Monitoring sensors
IAQ calculation
Microbial assessment



Early faults detection and diagnosis



Support Tool for redesign of automation systems



Front end to support site specific energy analysis





- **Biggest Challenges**
 - CONSISTANT RELIABLE DATA!!!
 - Modelling is extremely challenging and time consuming
- **From Data to Decision**
 - Providing insight to stakeholders for appropriate decisions (KPIs)
- **Validation**
 - Real world validation and evaluation of energy savings