SMART CITIES

Urban Research: A Conversation: Measurements in the City

Gerhard Schmitt, Estefania Tapias, Danielle Griego, October 26, 2015

Smart Cities

1 GS: Introduction	2 GS: Urban Systems I	3 PJ: Urban Systems II	4 GS: Urban Systems III	5 GS: Urban Research	6 GS: Urban Science	7 GS: Complexity Science	8 GS: Urban Governance	9 GS: Responsive Cities	10 GS: Final Critique
Principles of Information Architecture and Urban Simulation	Smart Cities	Methods and Tools for Urban Design	Stocks and Flows in Urban Systems	A Conversation: Measurements in the City	A Conversation: Citizen Design Science	Cities as Complex Systems	Participatory Design and Management	Cognitive Design Computing	Presentation of Results from 3 Courses
Exercise 1: Examples of Smart Cities			Exercise 2: Data Collection and Specification			Exercise 3: Energy and Mobility Data			Certificates

The story so far:

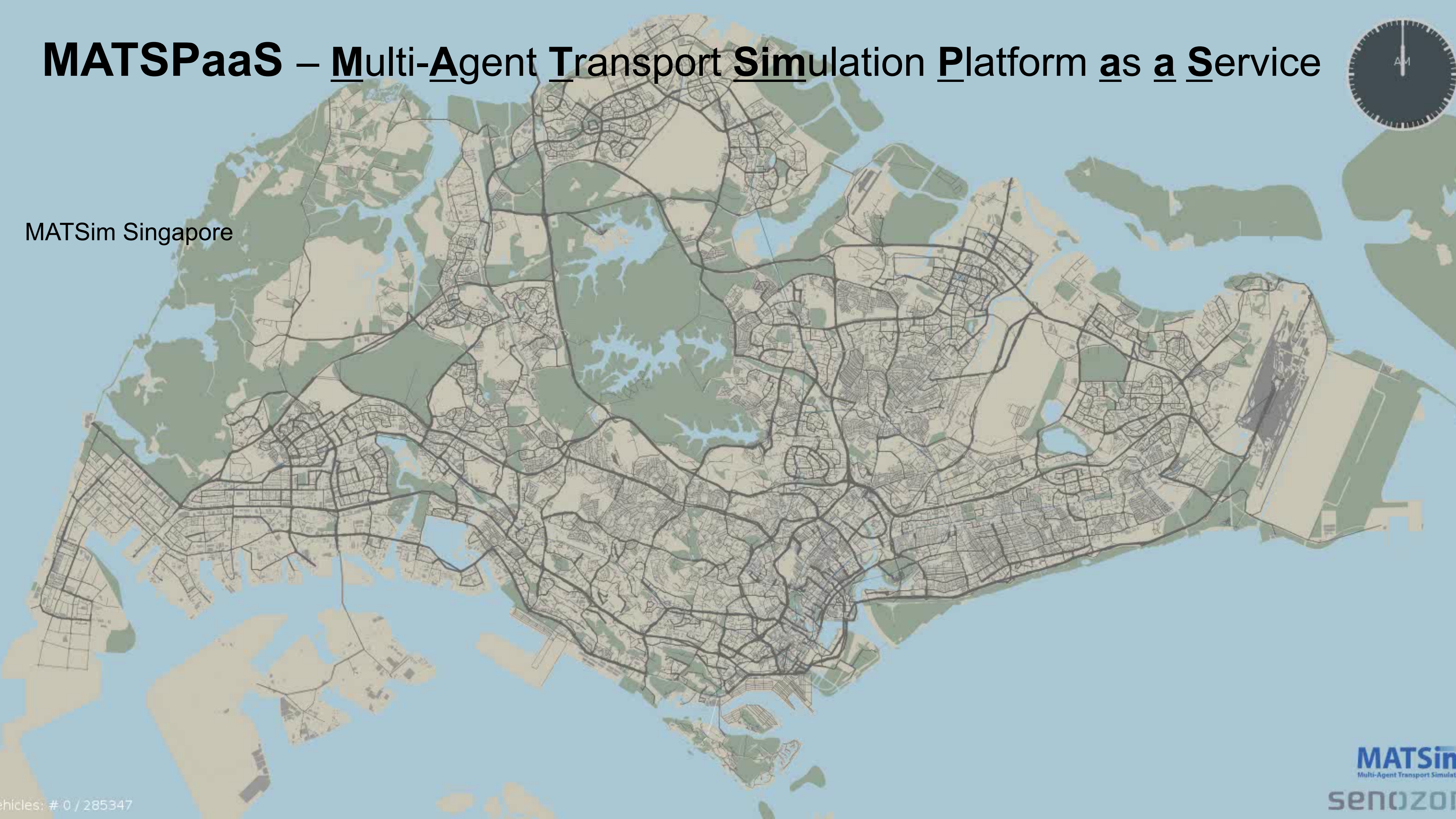
- 26.10.2015 Metrics of Smart Cities are basic instruments of urban research
- 12.10.2015 Stocks and Flows are fundamental concepts for understanding urban dynamics
- 5.10.2015 Methods and Tools for Urban Design can support the creative design process
- 28.9.2015 From smart houses to smart cities – emerging criteria for smart cities as urban systems
- 21.9.2015 Cities are complex systems. Ideally, they are sustainable, resilient, livable, smart, and finally responsive – from production machines to human habitat

Content

- Urban Research
- Metrics of Smart Cities
- A Conversation: Measurements in the City
- Questions regarding Exercise 2
- Conclusions

MATSPaaS – **M**ulti-**A**gent **T**ransport **Sim**ulation **P**latform **a**s **a** **S**ervice

MATSim Singapore



Urban Research:
Understanding Cities

„A City is not a tree“

The tree of my title is not a green tree with leaves. It is the name of an abstract structure. I shall contrast it with another, more complex abstract structure called a semilattice. In order to relate these abstract structures to the nature of the city, I must first make a simple distinction.

I want to call those cities which have arisen more or less spontaneously over many, many years *natural cities*. And I shall call those cities and parts of cities which have been deliberately created by designers and planners artificial cities. Siena, Liverpool, Kyoto, Manhattan are examples of natural cities. Levittown, Chandigarh and the British New Towns are examples of artificial cities.

It is more and more widely recognized today that there is some essential ingredient missing from artificial cities. When compared with ancient cities that have acquired the patina of life, our modern attempts to create cities artificially are, from a human point of view, entirely unsuccessful.

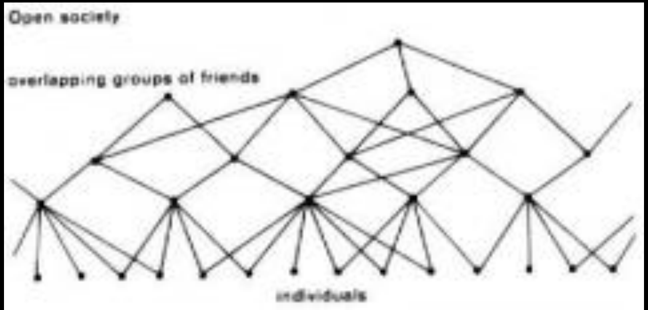
Both the tree and the semilattice are ways of thinking about how a large collection of many small systems goes to make up a large and complex system. More generally, they are both names for structures of sets.

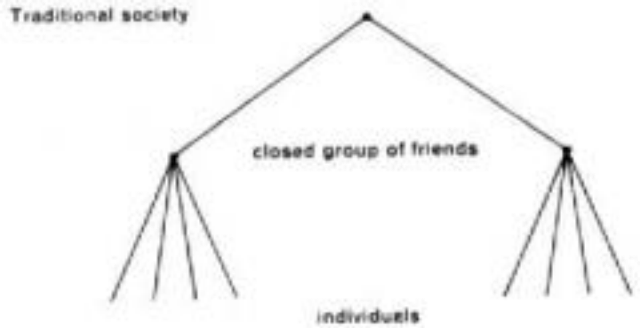
Christopher Alexander, http://www.rudi.net/pages/8755

„A City is not a tree”

In a traditional society, if we ask a man to name his best friends and then ask each of these in turn to name their best friends, they will all name each other so that they form a closed group. A village is made up of a number of separate closed groups of this kind.

But today's social structure is utterly different. If we ask a man to name his friends and then ask them in turn to name their friends, they will all name different people, very likely unknown to the first person; these people would again name others, and so on outwards. There are virtually no closed groups of people in modern society. The reality of today's social structure is thick with overlap - the systems of friends and acquaintances form a semilattice, not a tree (**Figure 10**).





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Quote from „The Responsive City“

“I have a rule of thumb: if you can’t measure it, you can’t manage it”

June 2014, Michael Bloomberg, Former Mayor of New York City

Quote from „http://www.watson.ch/!939330961?utm_source=ligatus&utm_medium=paid&utm_campaign=cmqi “

Ein spanischer Reisebus ist am Sonntagmorgen in der Nähe von Lille in einen zu niedrigen Tunnel gefahren. Dabei wurde das Dach abgerissen. 30 Personen wurden verletzt, vier von ihnen schwer. «Ich schlief, dann plötzlich dieser Krach, Rauch und zerbrochenes Glas und Blut», sagte ein Student, der nur leicht verletzt wurde. Der Bus hatte 59 Passagiere an Bord und war von Bilbao nach Amsterdam unterwegs. Offenbar war der Chauffeur mit GPS gefahren und hatte die Warschilder über die Tunnelhöhe übersehen. (kri)

Towards Smart Urban Systems

Example: Interaction between urban stock (tunnel ceiling) and urban flow (transportation)

Model → Measuring → Checking → Understanding → Warning → Action

Accident in Lille, France, July 2015. 59 people injured, 4 seriously

Evolène: un pan du Rocher du Mel de la Niva s'est détaché

Towards Smart Urban Systems

Example: From alpine stock (rock) to alpine urban flow (rock avalanche)

Model → Measuring → Checking → Understanding → Warning → Action

Rock avalanche in Evolène, October 22, 2015.

“Warning signs: To the local residents, Vesuvius was just a large hill. It was very fertile and would have been covered with vineyards and small villages. The volcano was lying dormant and had not erupted for hundreds of years.The first indication of the disaster ahead was in 62 AD. A destructive earthquake occurred which caused streams and wells to dry up, and damaged many buildings in Pompeii. A relief sculpture from the house of Lucius Caecilius Iucundus shows the Temple of Jupiter and its statues leaning heavily to the left after the earthquake. Major repair works had to be undertaken, including the Forum Baths and the Villa of Mysteries, where a pile of lime indicates that work had not finished by the time of the eruption 15 years later.” http://www.pompeii.co.uk/CDROM/DEST/1.HTM

Towards Smart Urban Systems

Example: interaction between territorial stock and flow (volcanic eruption) with urban stock and flow

Model → Measuring → **Checking** → Understanding → Warning → Action

“Warning signs: To the local residents, Vesuvius was just a large hill. It was very fertile and would have been covered with vineyards and small villages. The volcano was lying dormant and had not erupted for hundreds of years.The first indication of the disaster ahead was in 62 AD. A destructive earthquake occurred which caused streams and wells to dry up, and damaged many buildings in Pompeii. A relief sculpture from the house of Lucius Caecilius Iucundus shows the Temple of Jupiter and its statues leaning heavily to the left after the earthquake. Major repair works had to be undertaken, including the Forum Baths and the Villa of Mysteries, where a pile of lime indicates that work had not finished by the time of the eruption 15 years later.” http://www.pompeii.co.uk/CDROM/DEST/1.HTM

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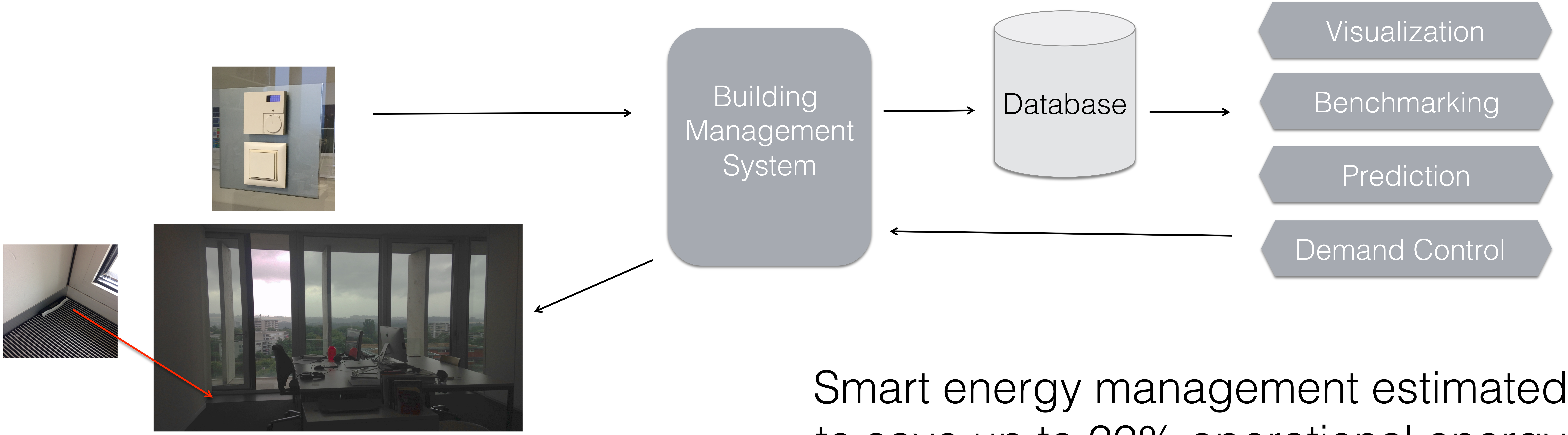
Measurements in the City

Building Stock: Energy Flows

- Data Collection: Buildings & Urban Climate
  - You cannot improve what you cannot measure
    - What type of data do we need?
    - What can we do with this data?

What can we do with building data?

When is it considered smart?



Smart energy management estimated to save up to 22% operational energy and $50 billion operational costs

Lucid, Connected Buildings: A disruptive new approach to Building Management, White Paper, (2015)

Campus Benchmarking

Historic data analysis

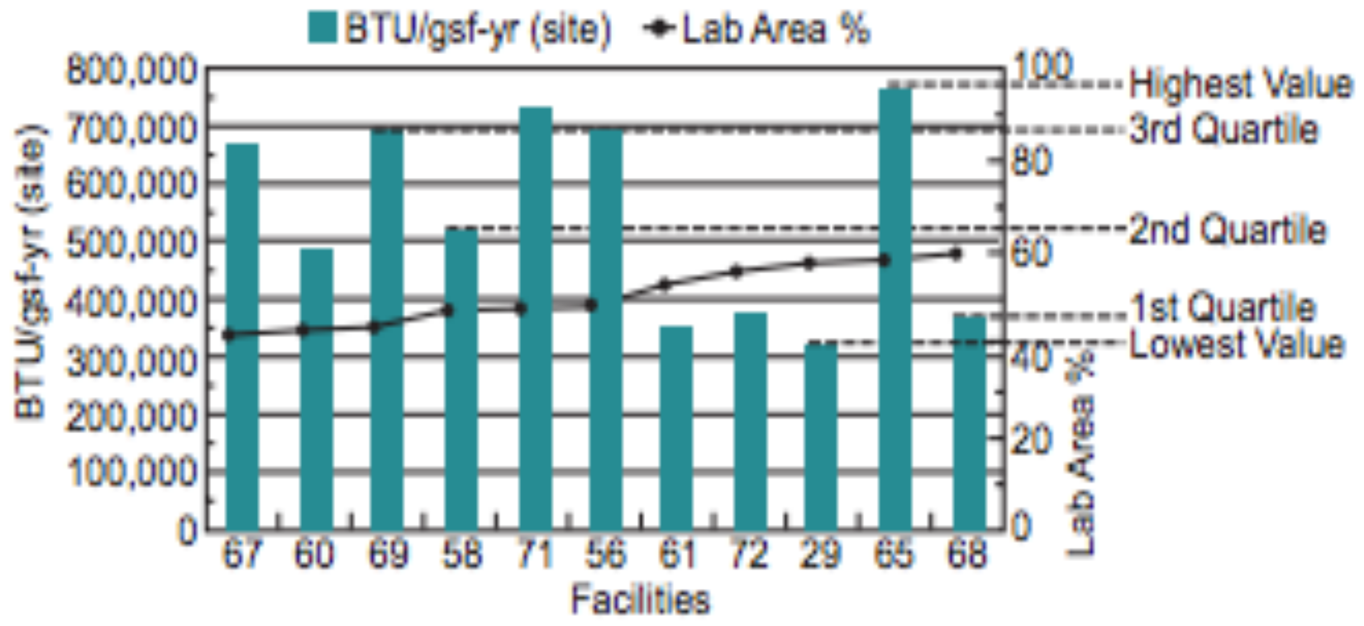
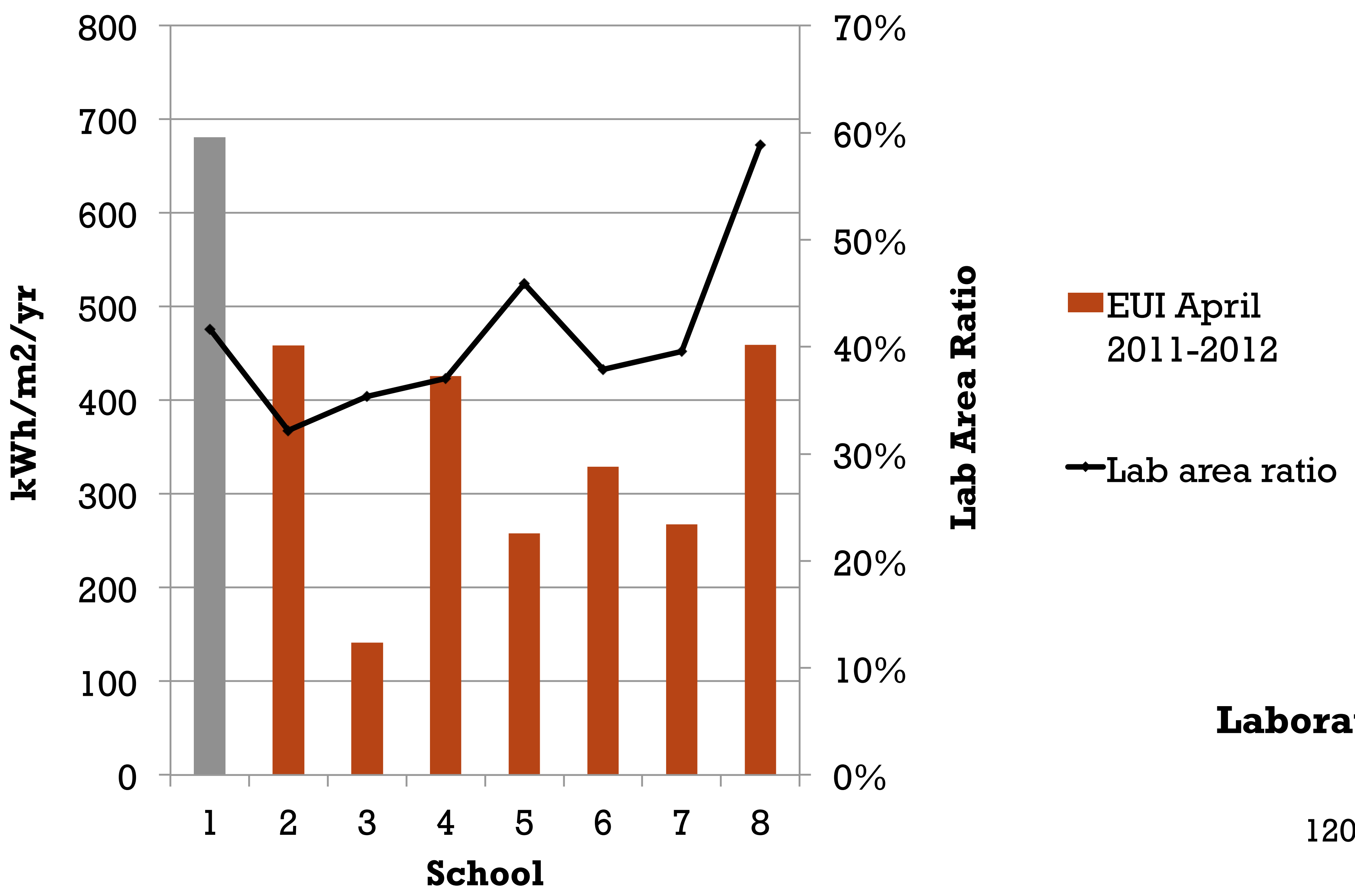
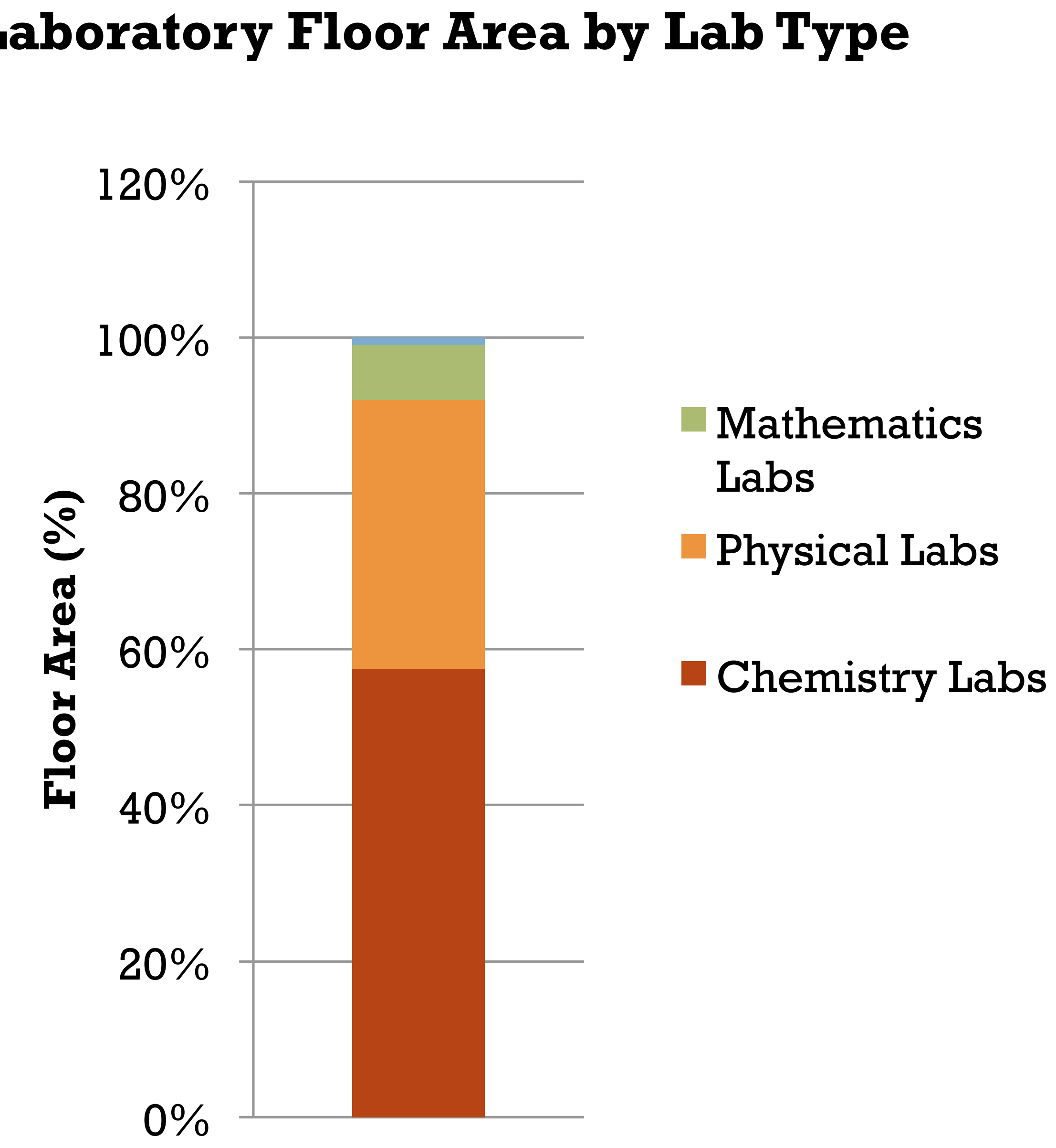


Figure 2. Empirical benchmarking data from Labs21 database for laboratories with lab area ratio between 0.4-0.6 and located in the warm marine climate zone (e.g., San Francisco).

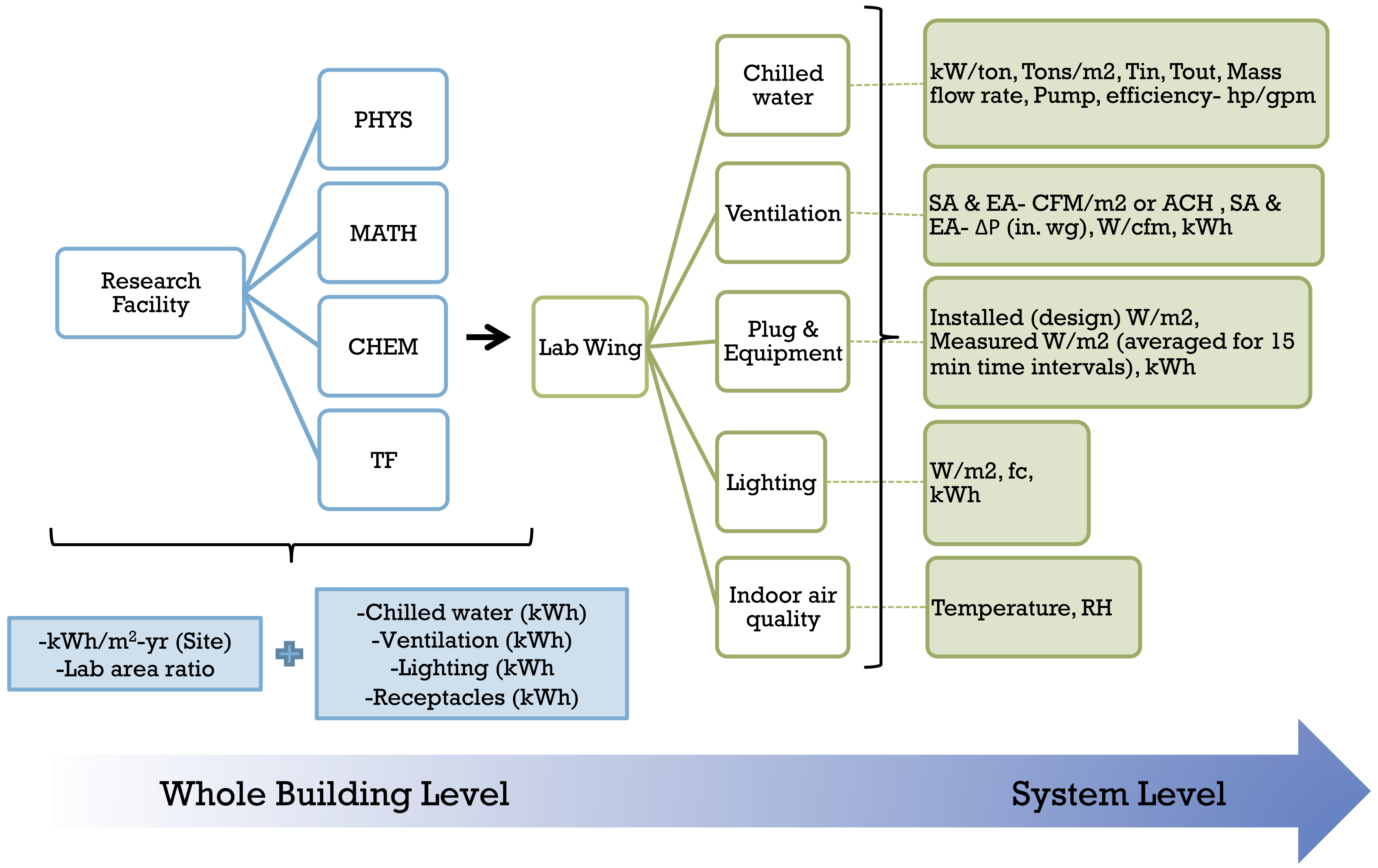
http://www.i2sl.org/documents/toolkit/bp_metrics_508.pdf

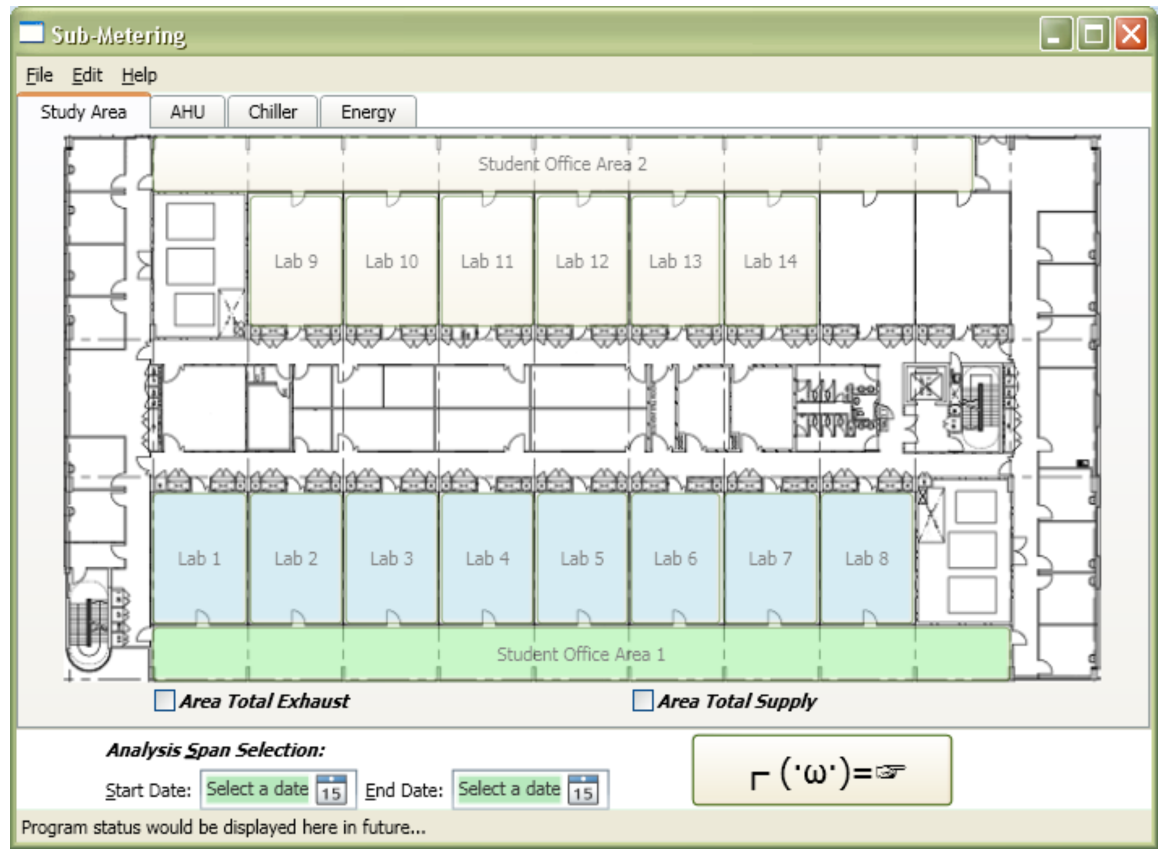




Sub-Metering System

Laboratory Energy Monitoring





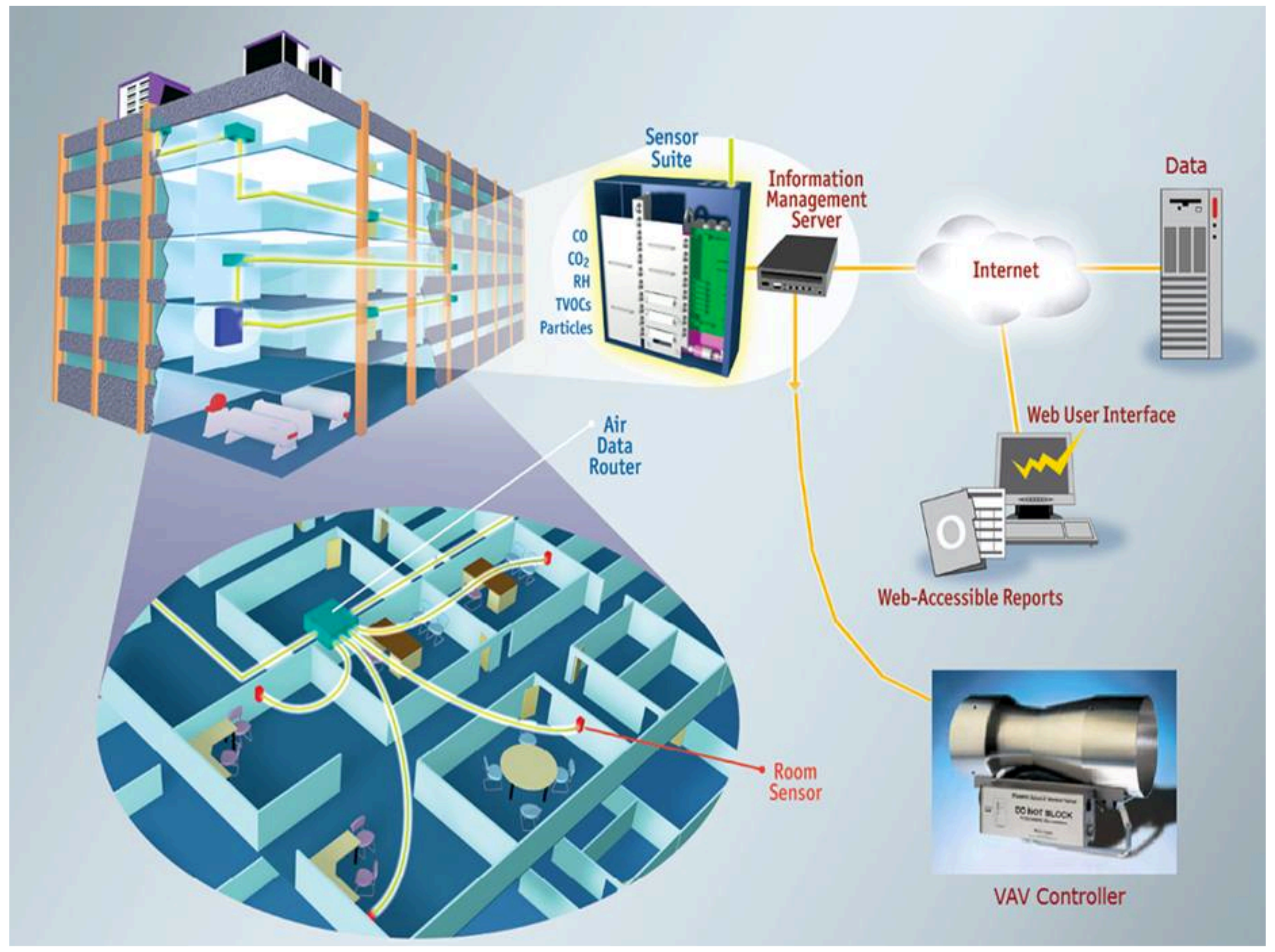
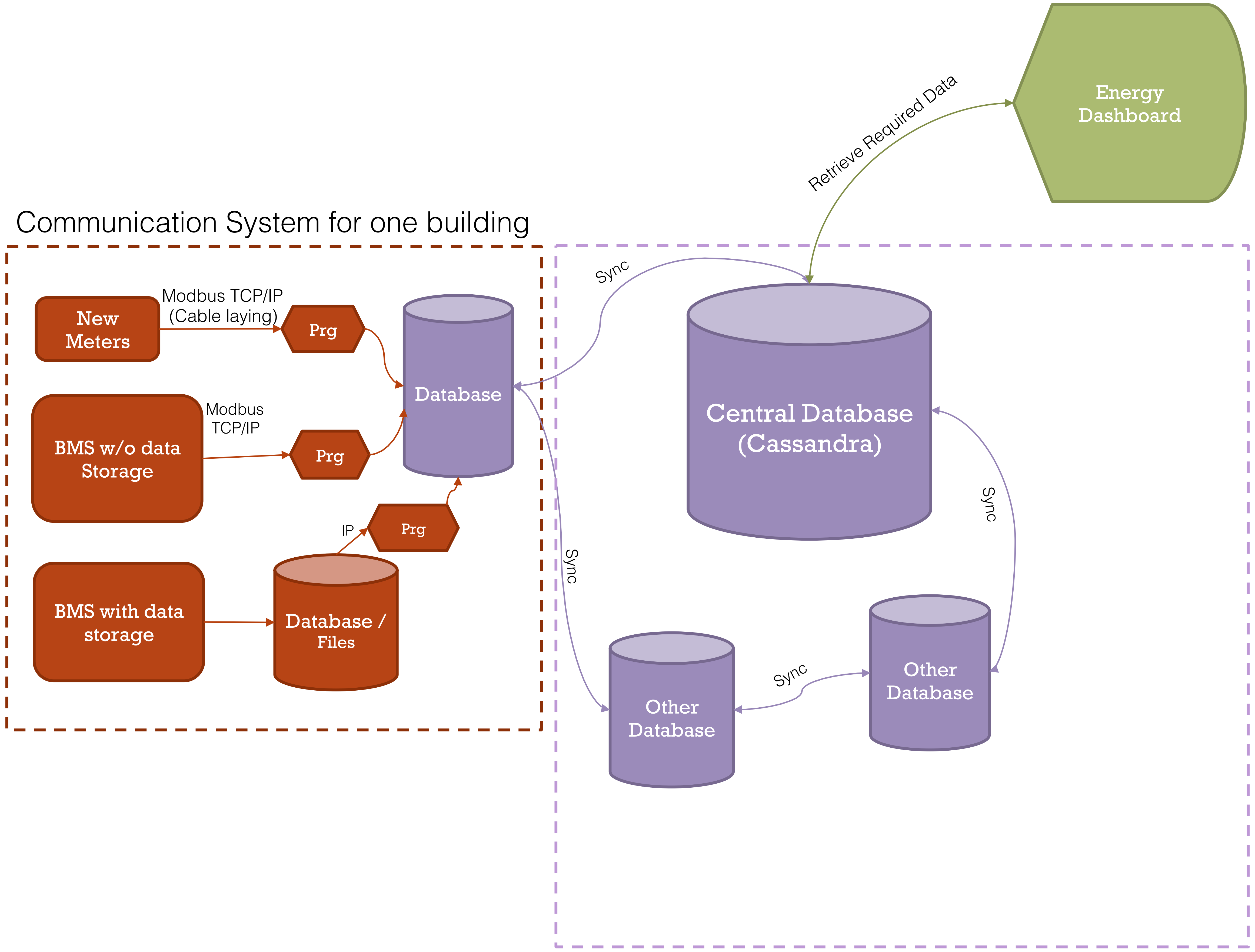


Image source: http://www.aircuity.com/technology/optinet-overview/

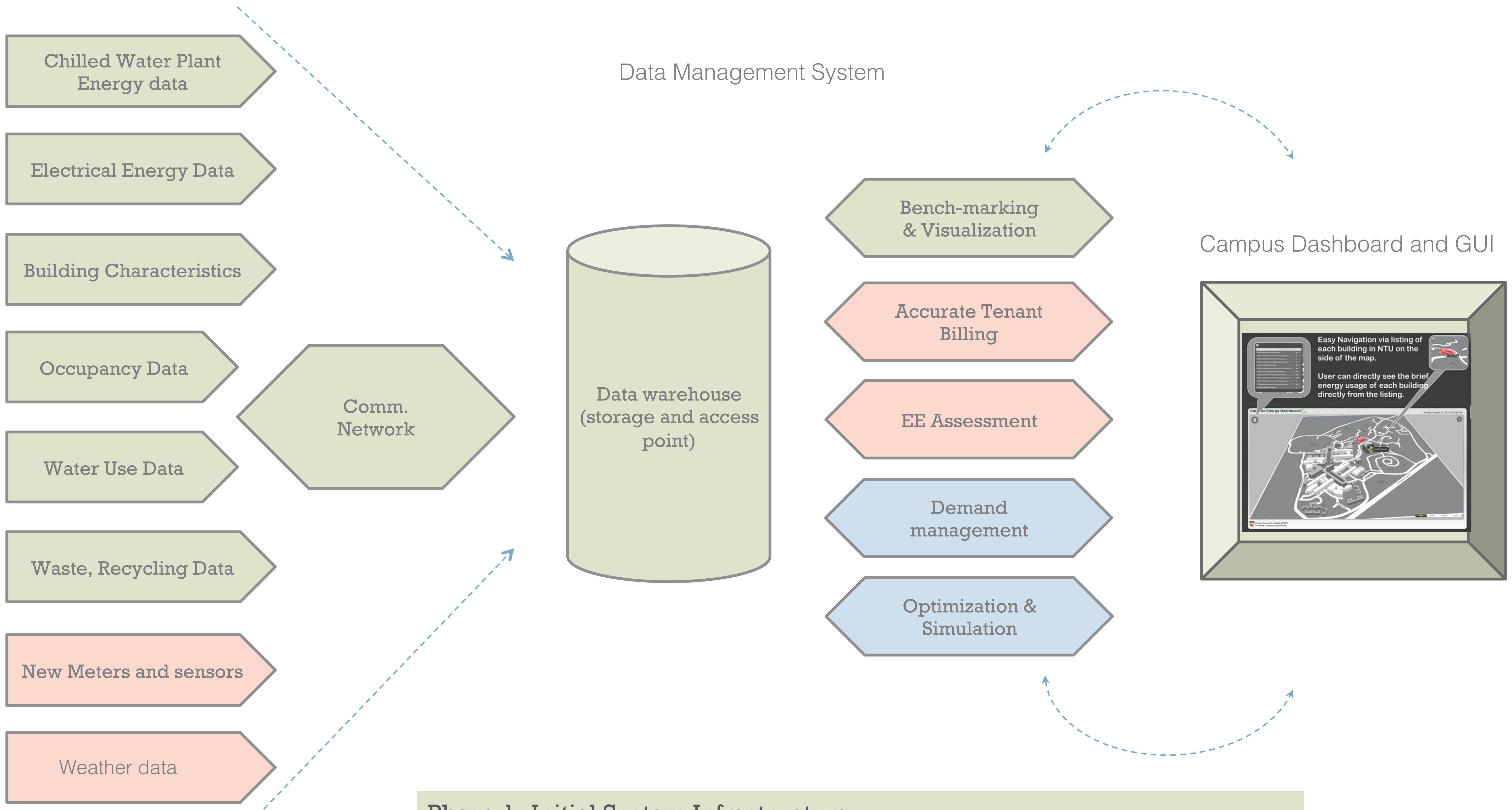
Campus Energy Information Management System

Proposed communication network



Campus Energy Information Management System

Schematic overview



Phase 1- Initial System Infrastructure

Phase 2- Sub-metering for accurate tenant billing

Phase 3- Connectivity for demand side management

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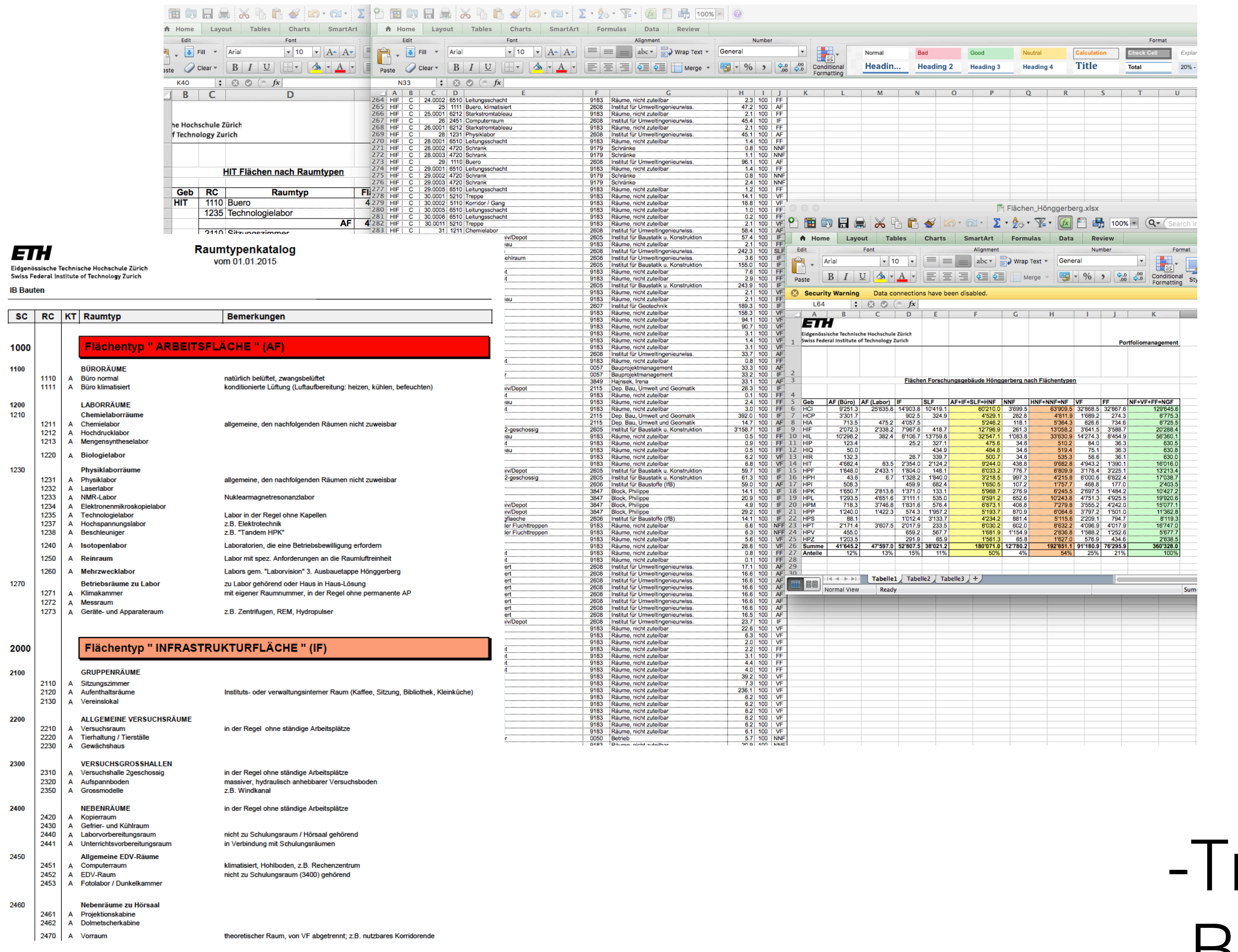
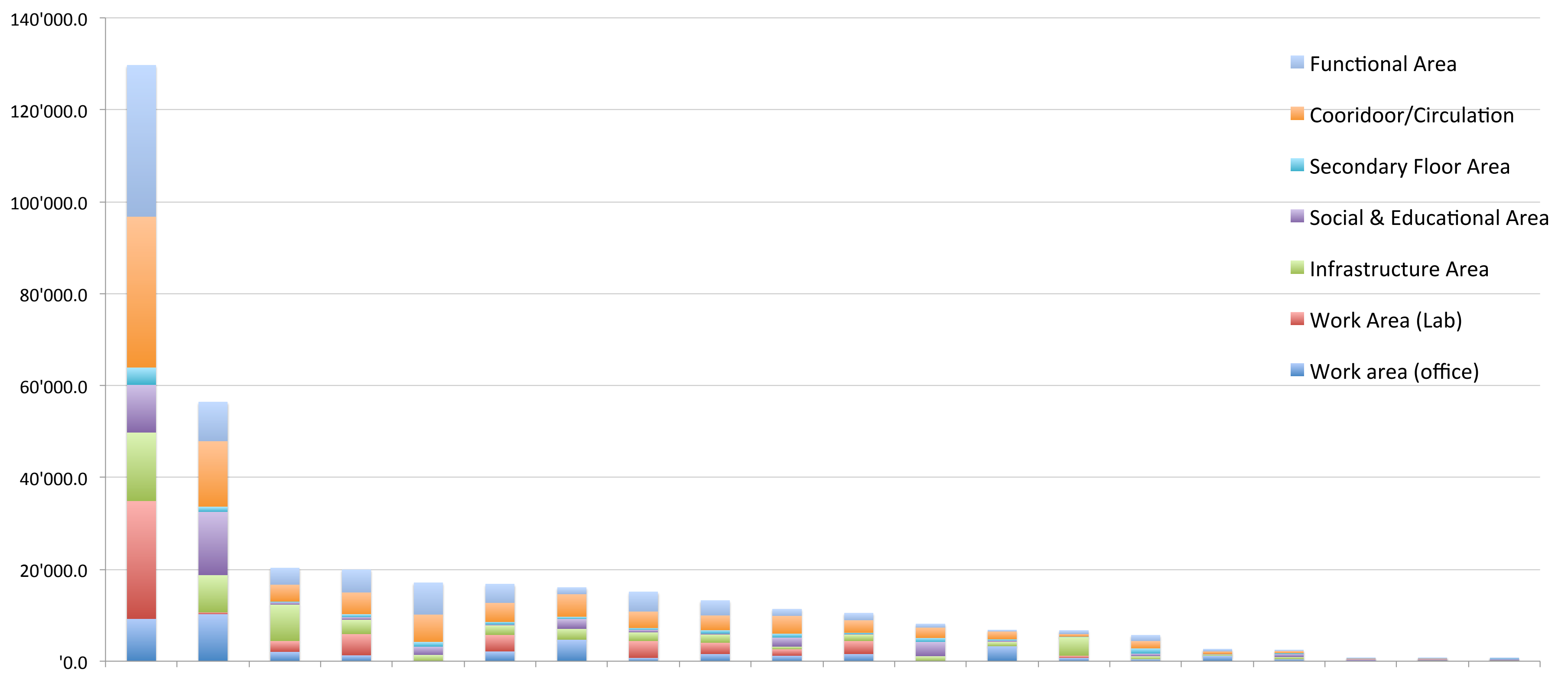
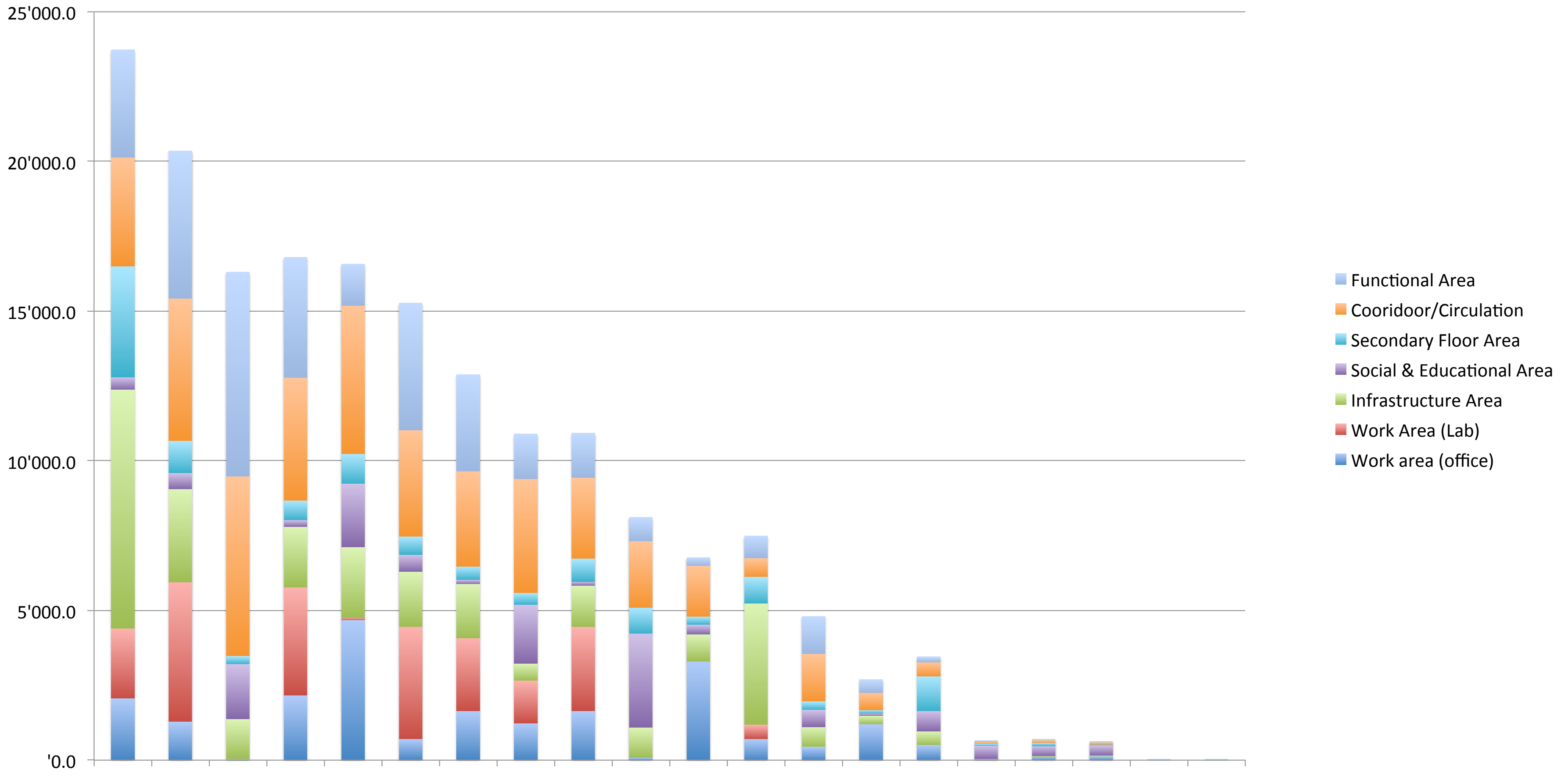
Additional Examples

Historic Data Analysis



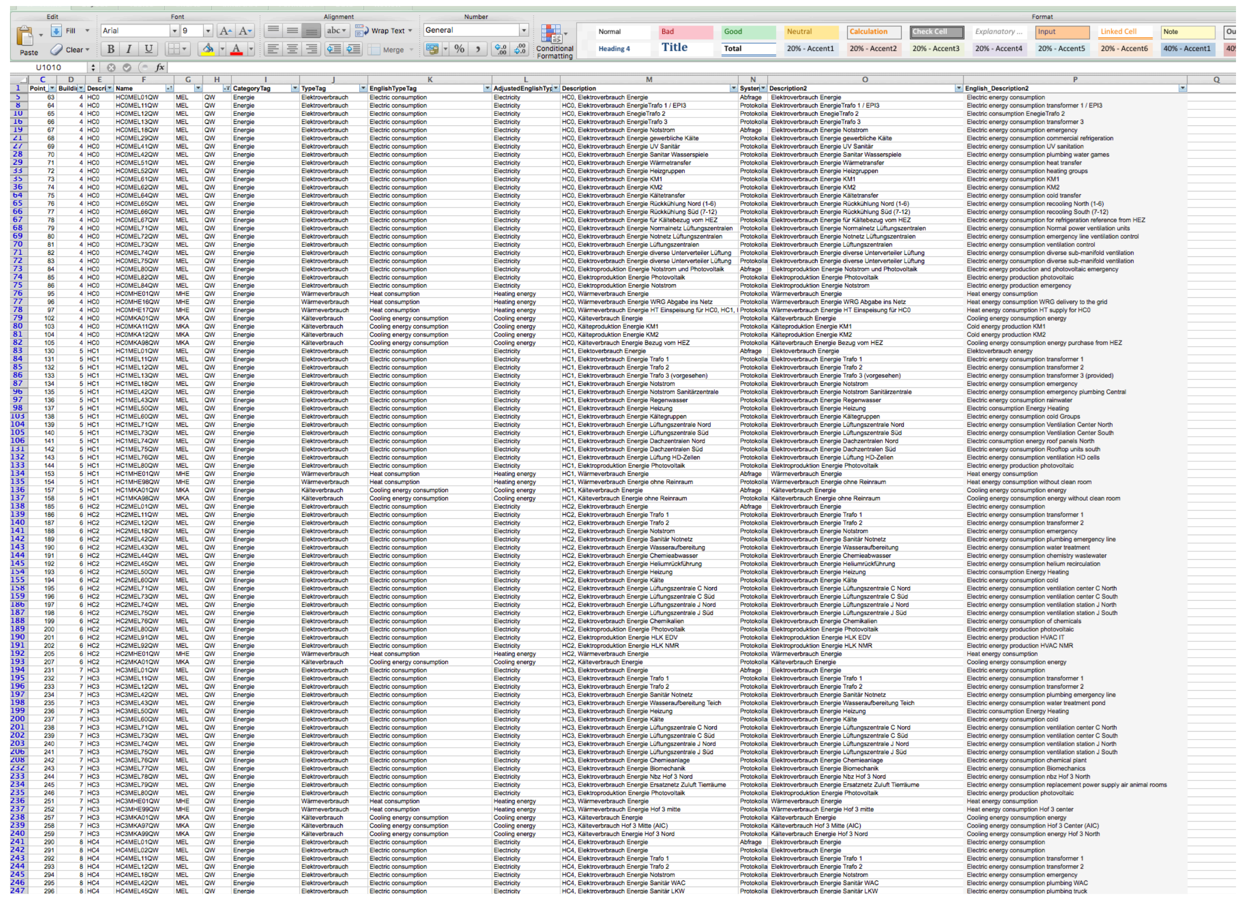




-Tracking
-Benchmarking
-Feasibility Assessments

Additional Examples

Time-series data analysis



- -Prediction
- -Diagnostics
- -Fault Detection

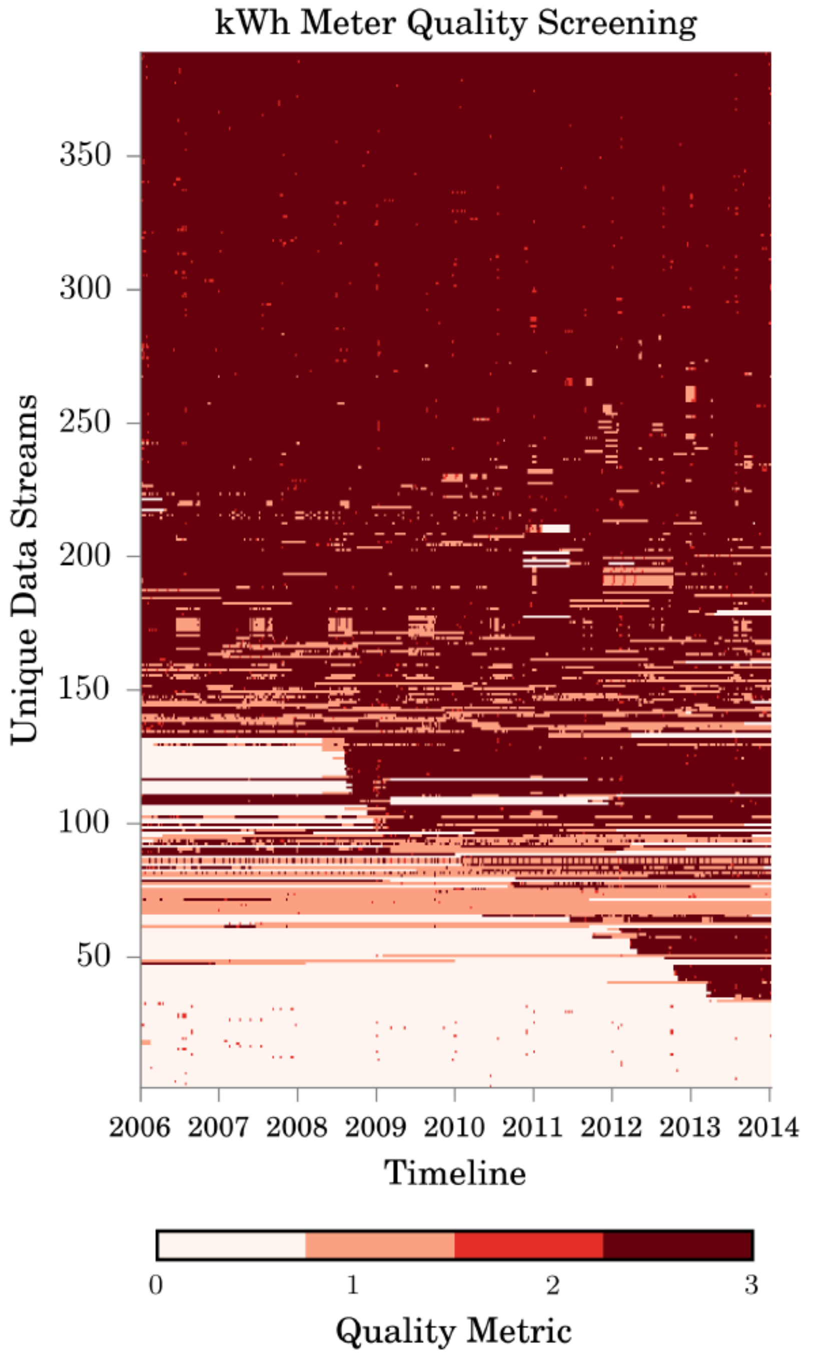


Figure 6. Data quality metrics map for campus sorted (bottom-to-top) according to increasing quality metric

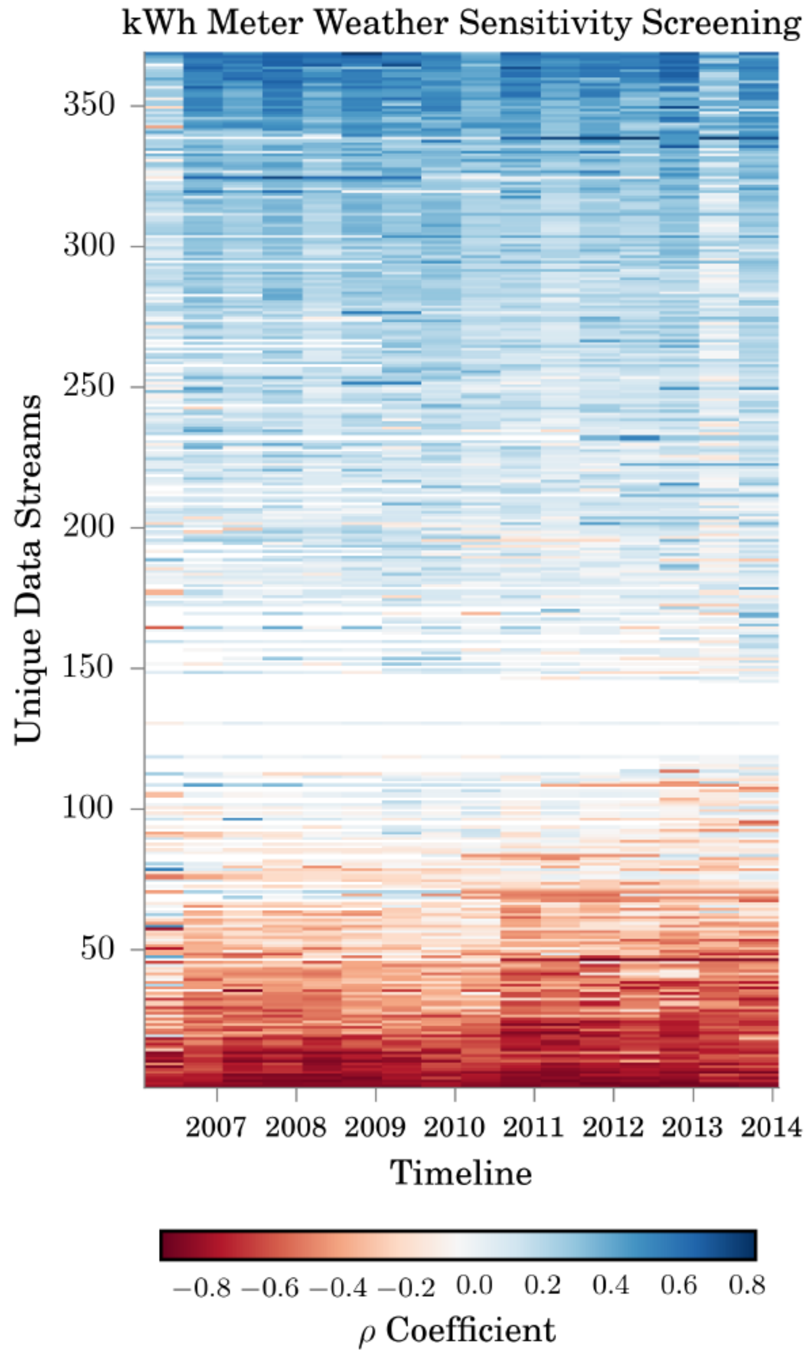


Figure 7. Weather sensitivity map sorted (bottom-to-top) from high negative to high positive ρ coefficient values

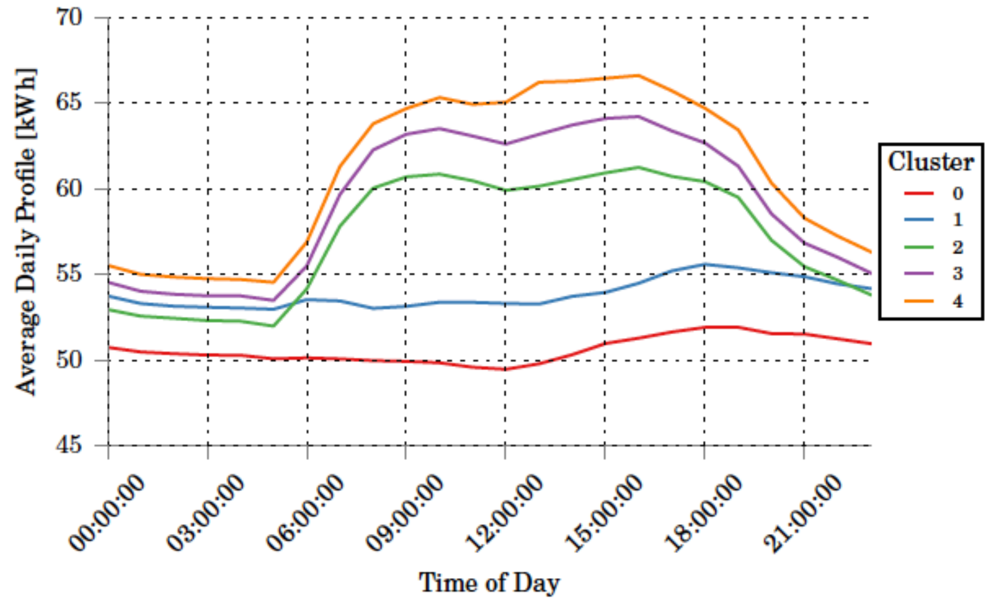


Figure 10. Example of a performance cluster profiles created by the typical profile creation process for a selected kWh meter from Region 4

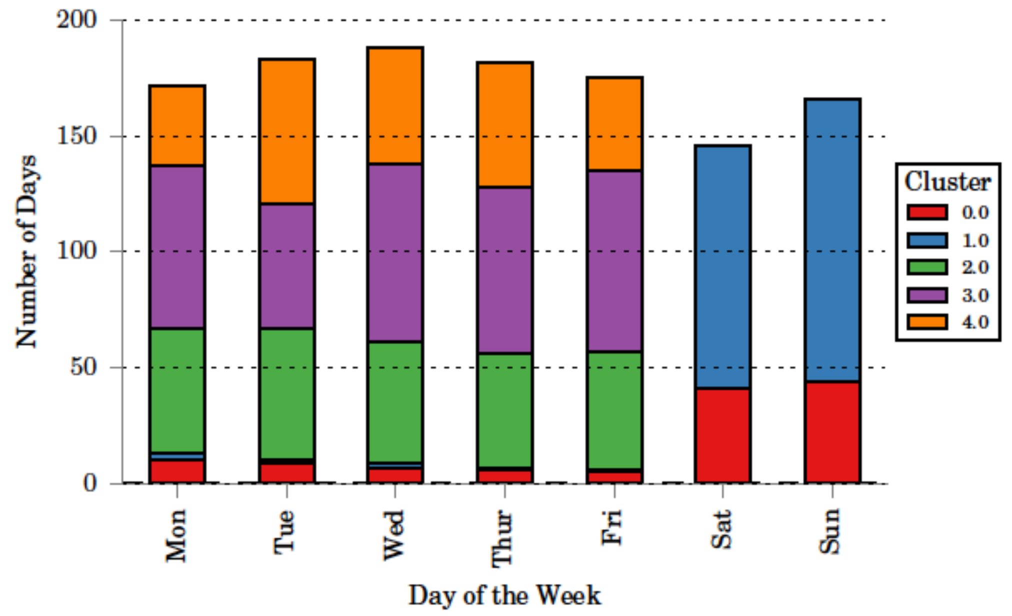


Figure 12. Number of instances of each performance cluster across the days of the week

Clayton Miller, Arno Schlueter. "Forensically Discovering Simulation Feedback Knowledge from a Campus Energy Info rmation System." *Symposium on Simulation for Architecture and Urban Design (SimAUD).* Washington DC, USA: Socie ty for Modelling and Simulation International (SCS) , 2015

Additional Examples

Spatial-Temporal Data Analysis

Fig. 8. Spatio-temporal energy map of space heating demand in buildings – peak period 04.01, 11-10am. This figure presents the peak space heating demand of buildings in four zones of the study area. The graphs embedded in the figure show the peak demand of every building in a specific zone. We highlight anchor loads or consumers with the highest demand in each zone. Both the height of and color code of buildings represent the relative demand level in relation to their associated zones. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

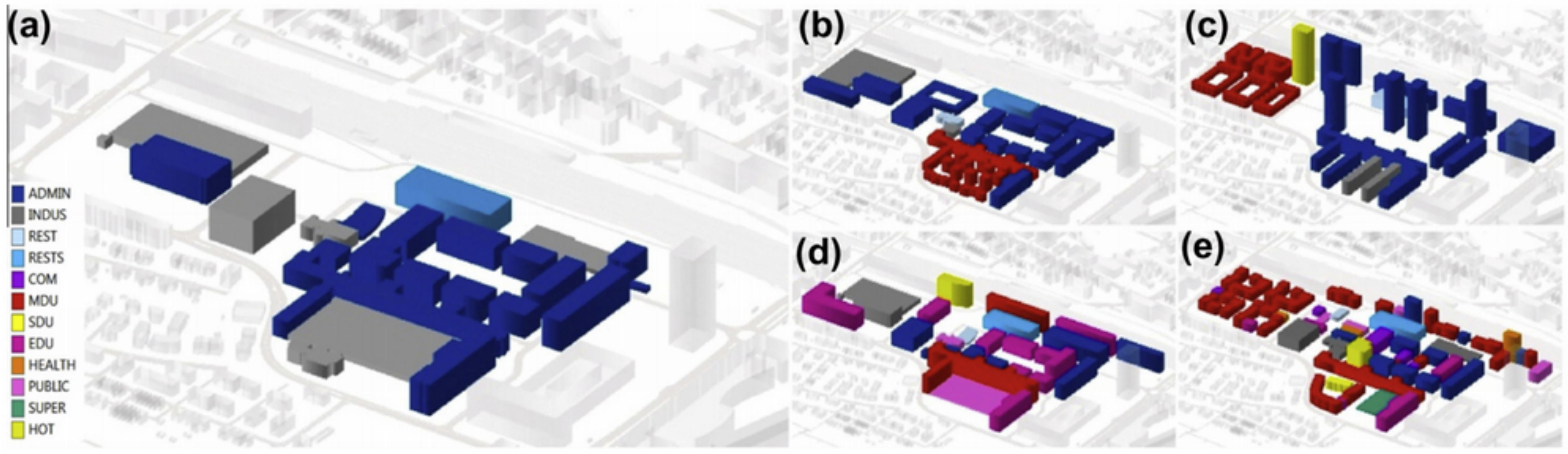


Fig. 19. Occupancy type in buildings in the zone of interest, (a) today's situation, (b) scenario S1, (c) scenario S2, (d) scenario S3 and (e) scenario S4.

Jimeno A. Fonseca, Arno Schlueter. (2014, December 27). *Integrated model for characterization of spaciotemporal building energy consumption patterns in neighborhoods and city districts.* Applied Energy 142, 247-266.

Conclusions

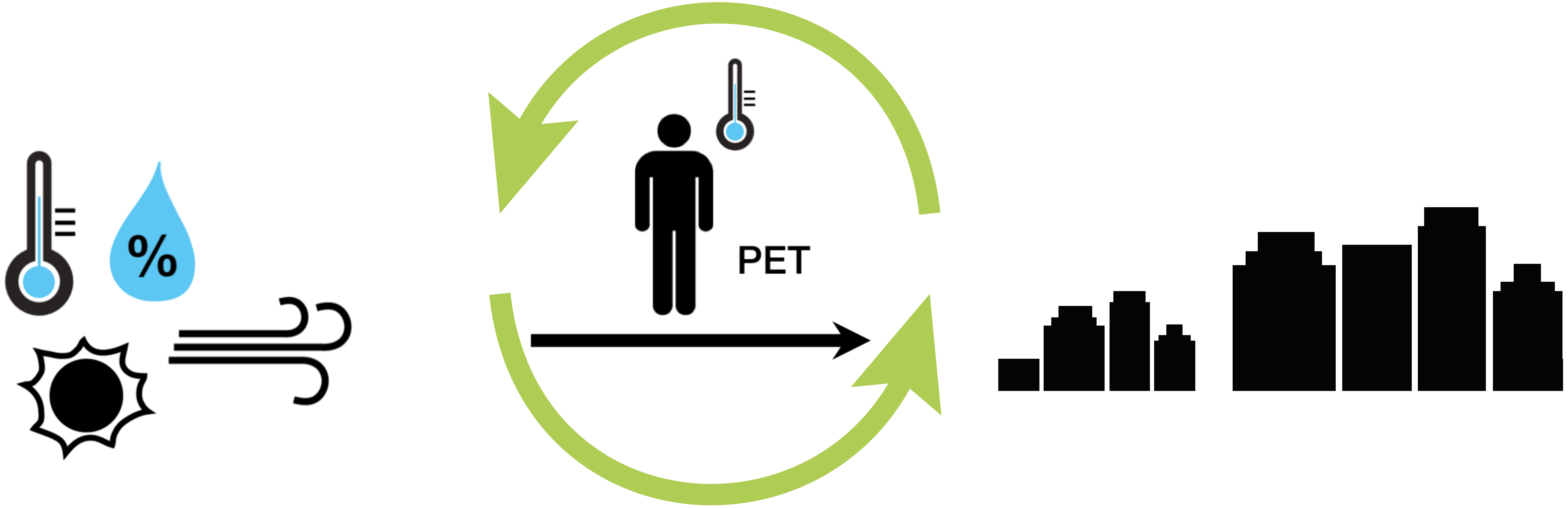
- Pretty much all buildings and campus facilities have meters and sensors for:
    - Billing purposes
    - Building systems control
- But that doesn't necessarily make them smart: data analysis, prediction and real-time demand-control & information dissemination make them "smart"

Climate-sensitive Urban Growth

Measurement Network – Barranquilla Colombia

__(i)__ enables the integration of microclimate data into the creation of new urban forms using outdoor thermal comfort as an indicator,

and __(ii)__ translates this knowledge into a parameterized design-feedback tool.



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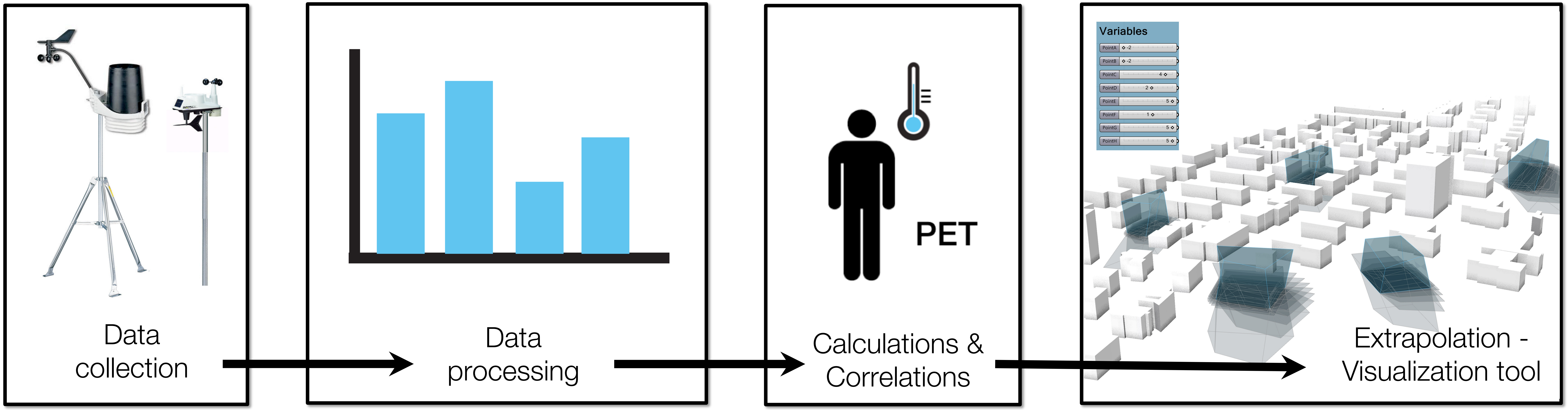

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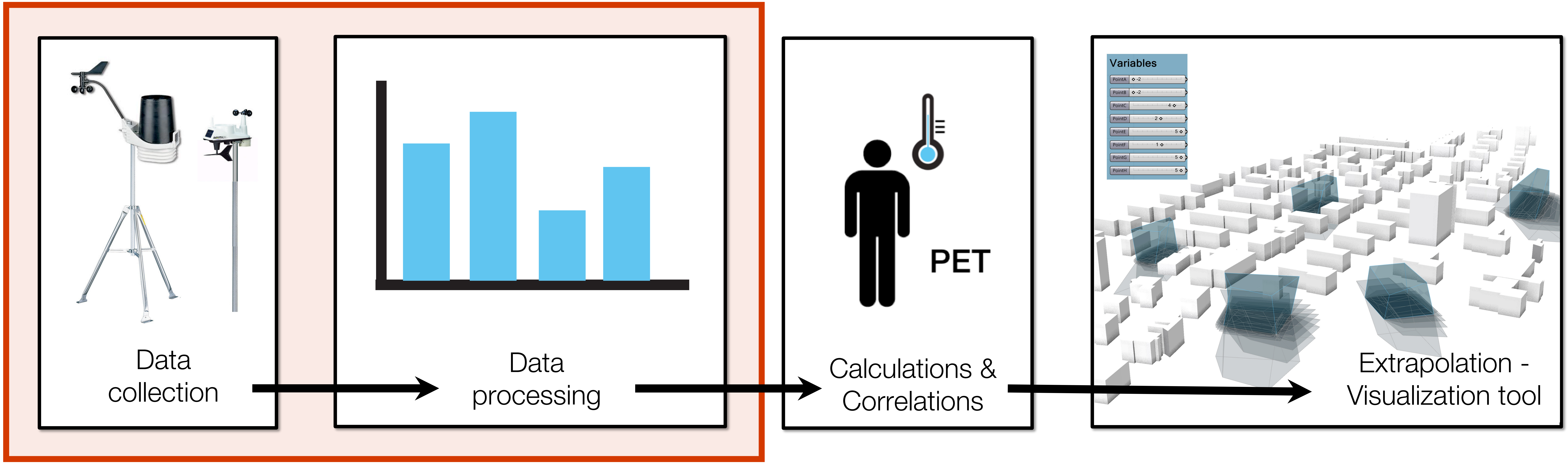
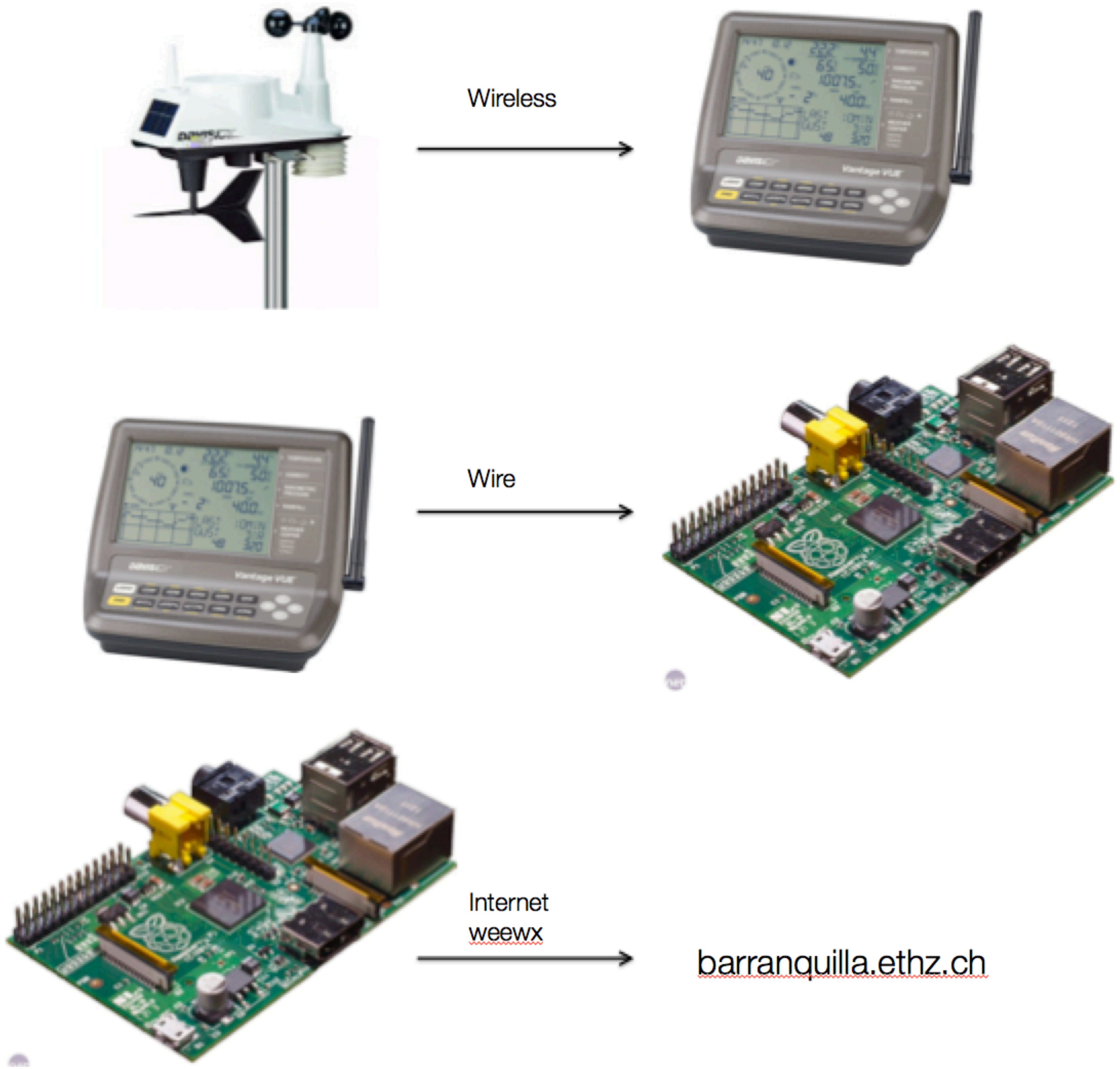


Climate-sensitive Urban Growth

Measurement Network – Barranquilla Colombia

Data collection



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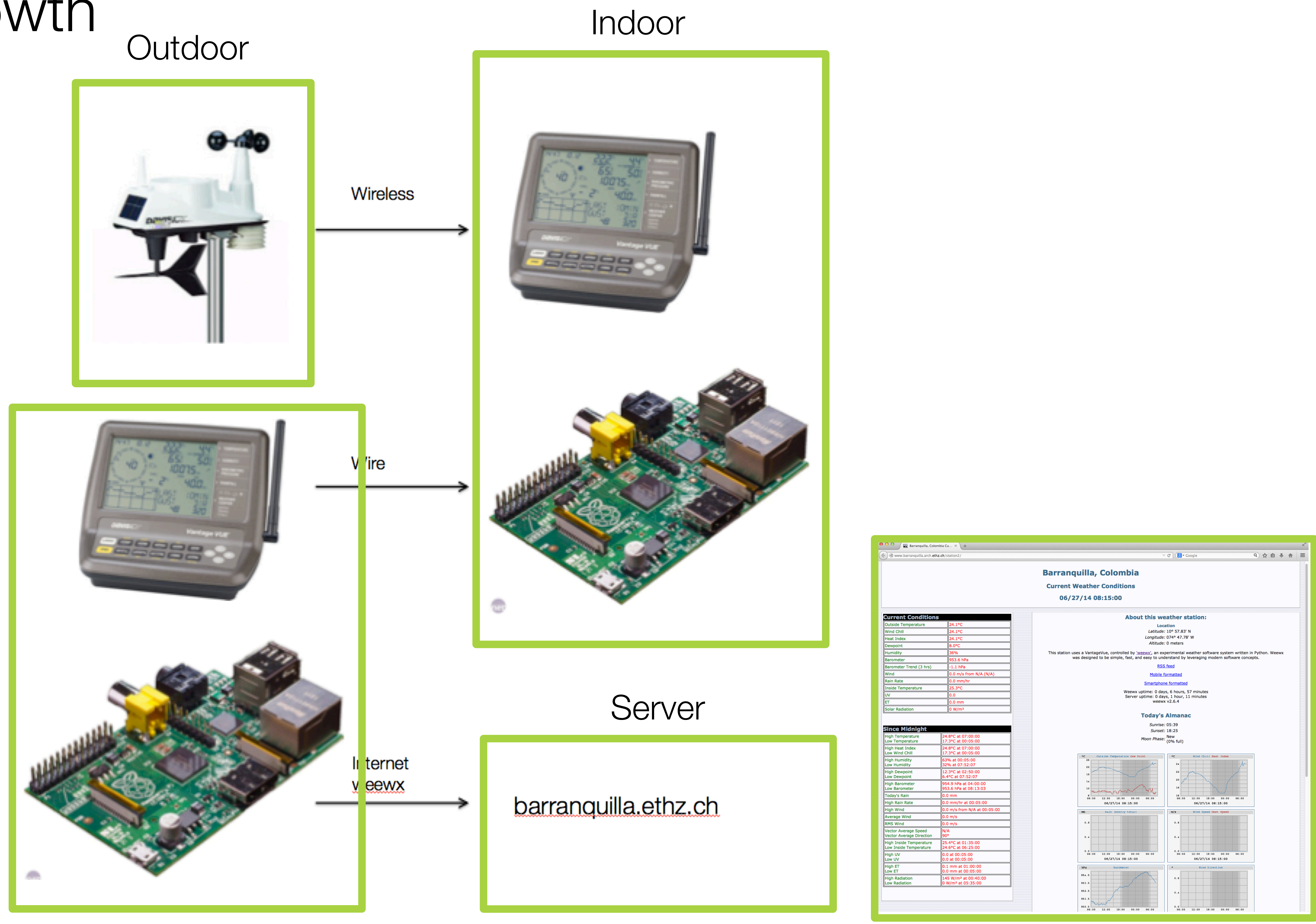

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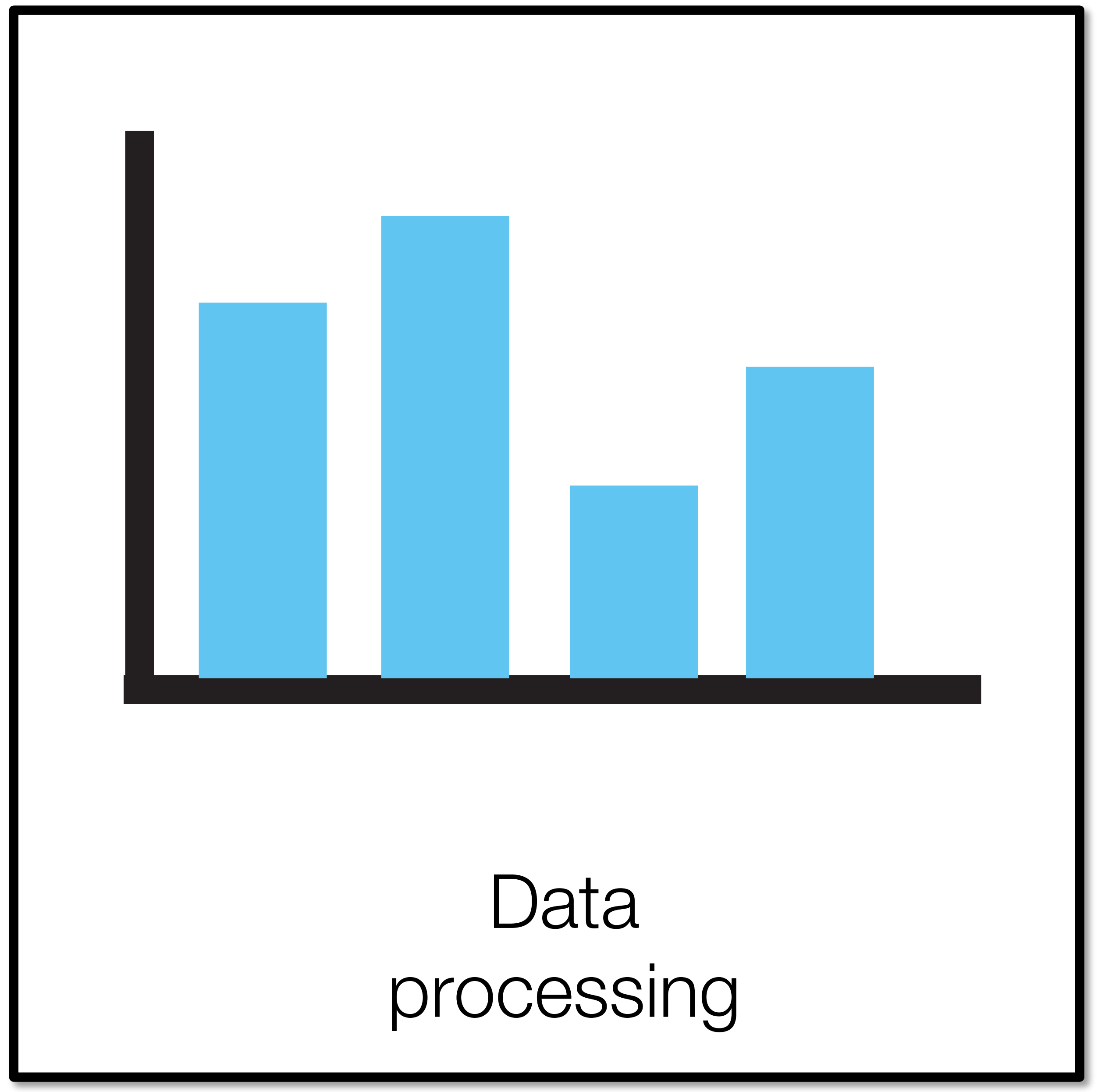

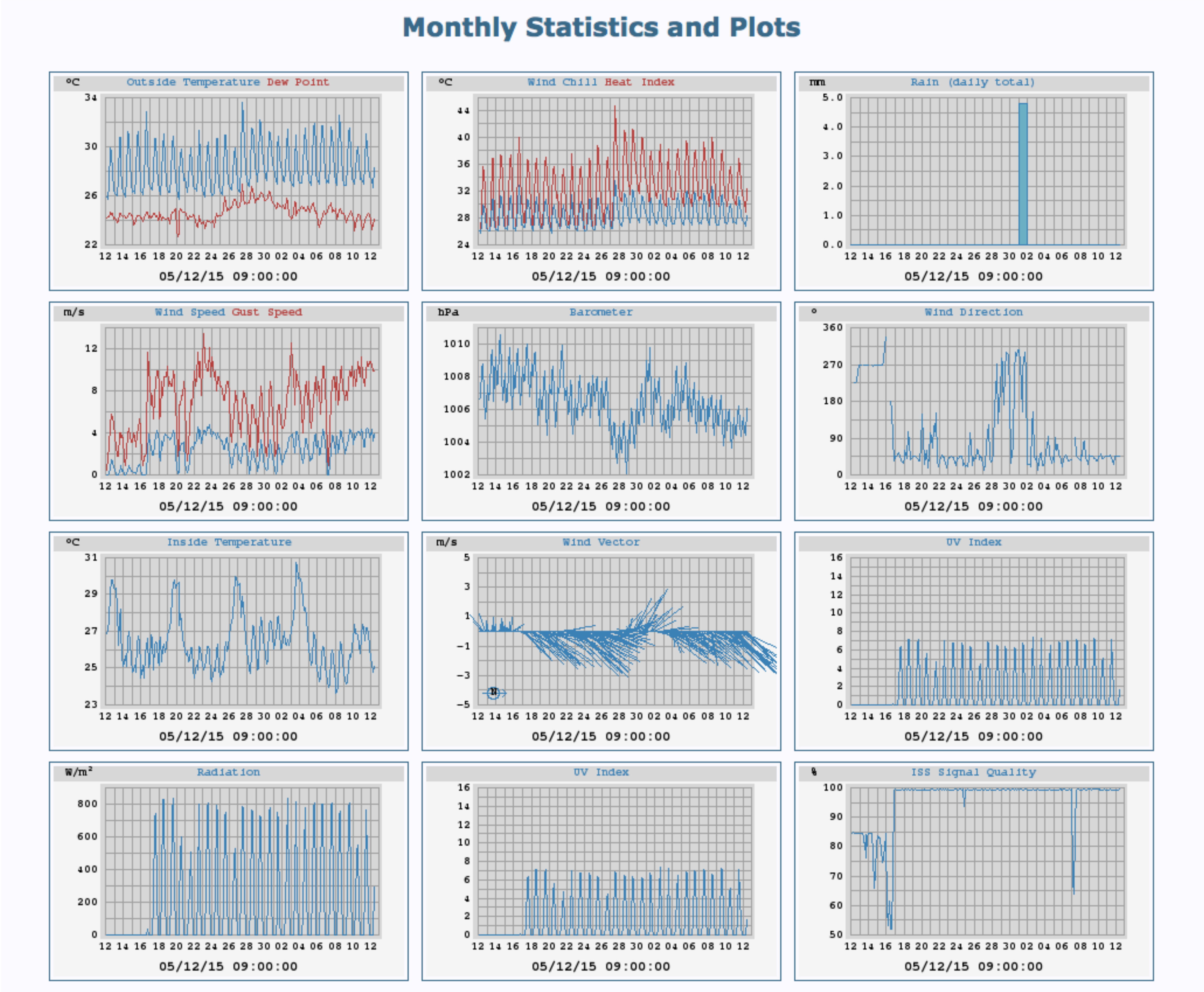

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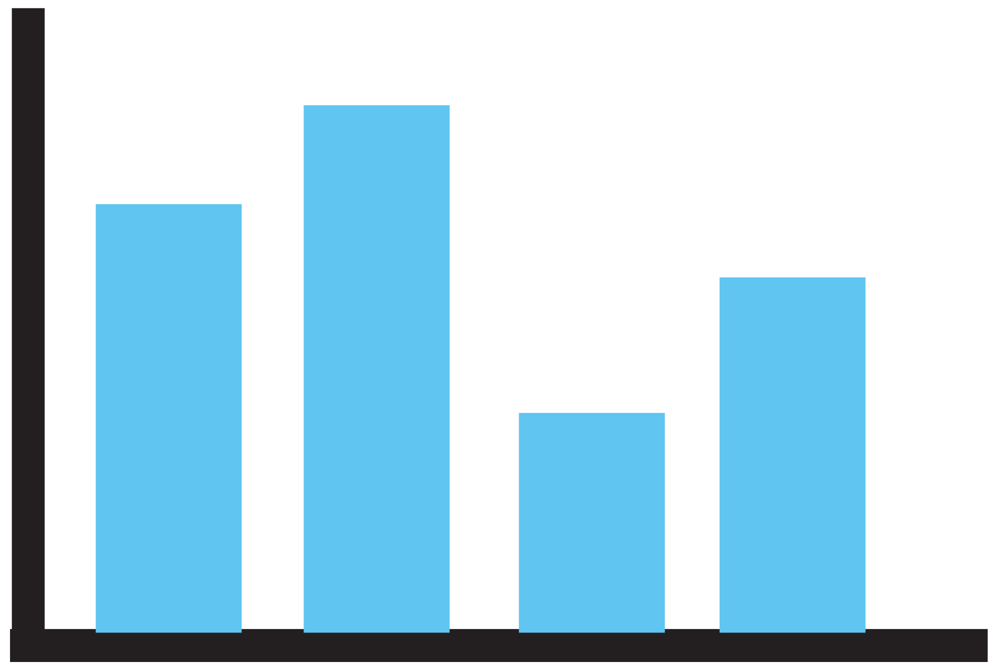


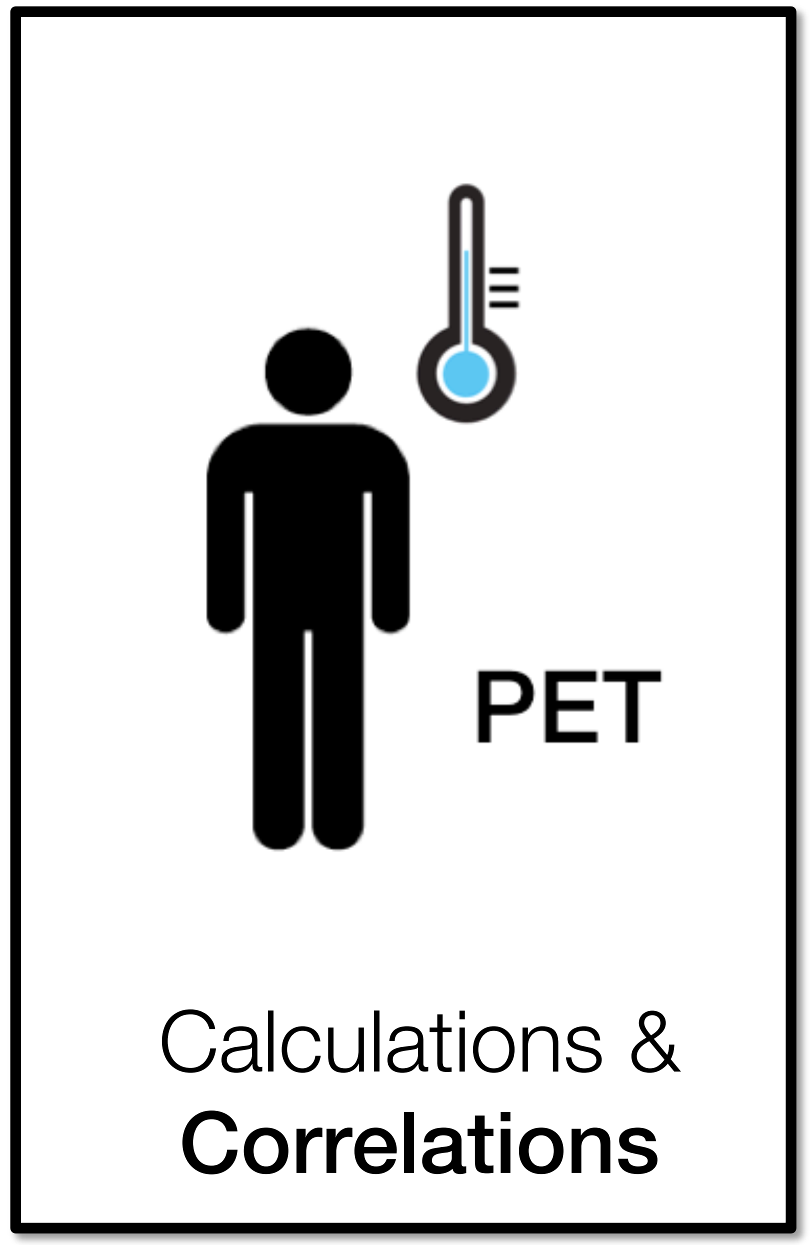
Data
processing

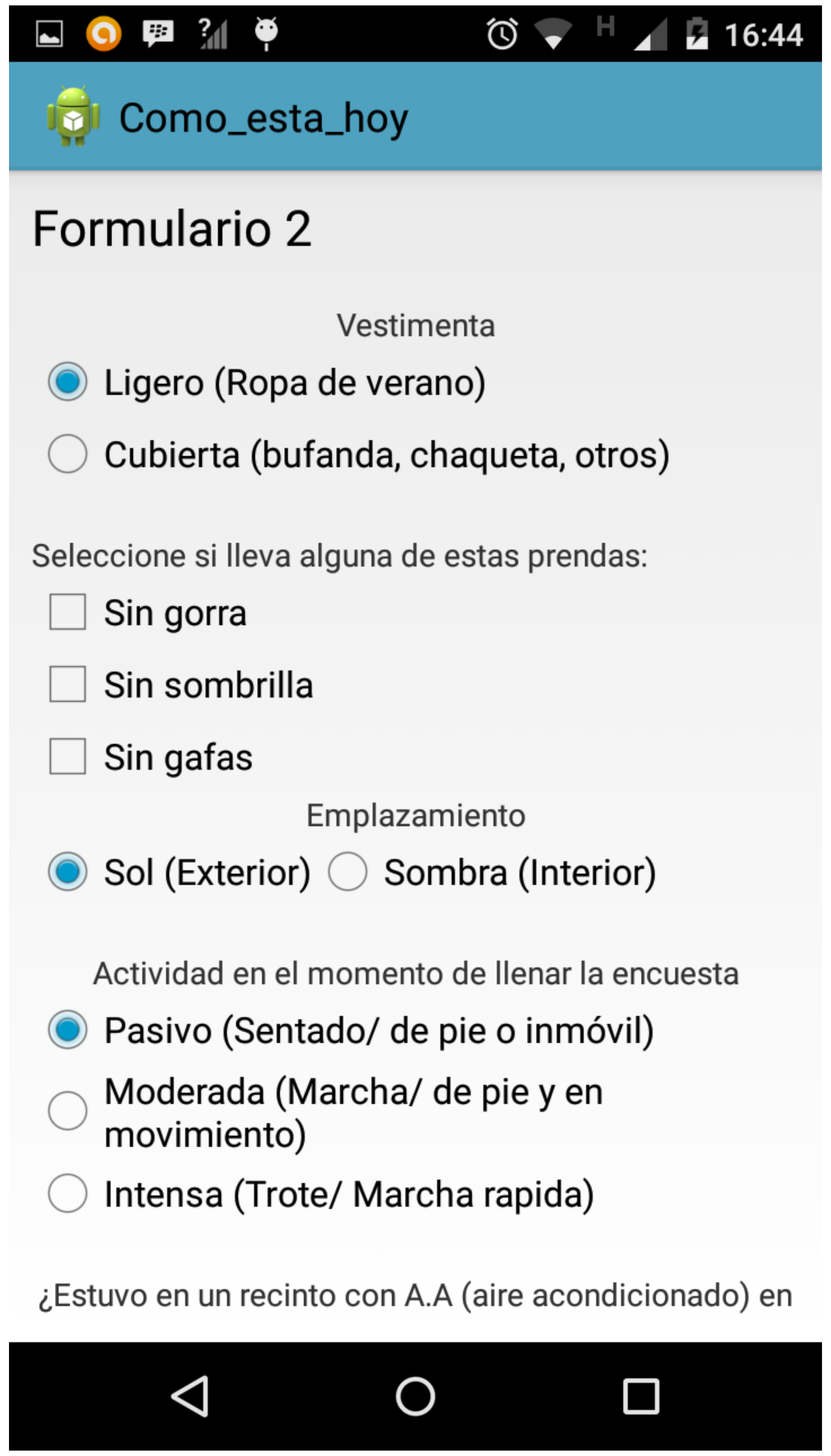
This Month	
High Temperature Low Temperature	33.7°C at 05/08/15 11:01:10 25.9°C at 05/01/15 08:05:41
High Heat Index	42.5°C at 05/08/15 11:09:20
Low Wind Chill	25.9°C at 05/01/15 08:05:41
High Humidity Low Humidity	93% 05/01/15 07:41:43 58% 05/08/15 10:53:58
High Dewpoint Low Dewpoint	26.6°C 05/03/15 08:59:35 22.8°C 05/10/15 03:10:07
High Barometer Low Barometer	1010.4 hPa at 05/01/15 09:08:01 1003.4 hPa at 05/10/15 15:08:00
Rain Total	4.8 mm
High Rain Rate	48.0 mm/hr at 05/01/15 07:12:49
High Wind Speed	12.5 m/s from 69° at 05/02/15 22:17:35
Average Wind	2.9 m/s
RMS Wind	3.1 m/s
Vector Average Speed Vector Average Direction	2.7 m/s 35°
High Inside Temperature Low Inside Temperature	30.8°C at 05/03/15 13:53:59 23.4°C at 05/08/15 06:18:57
High UV Low UV	9.5 at 05/02/15 11:48:21 0.0 at 05/01/15 00:00:04
High ET Low ET	0.7 mm at 05/06/15 12:00:00 0.0 mm at 05/01/15 00:05:00
High Radiation Low Radiation	1037 W/m² at 05/02/15 11:14:01 0 W/m² at 05/01/15 00:00:04

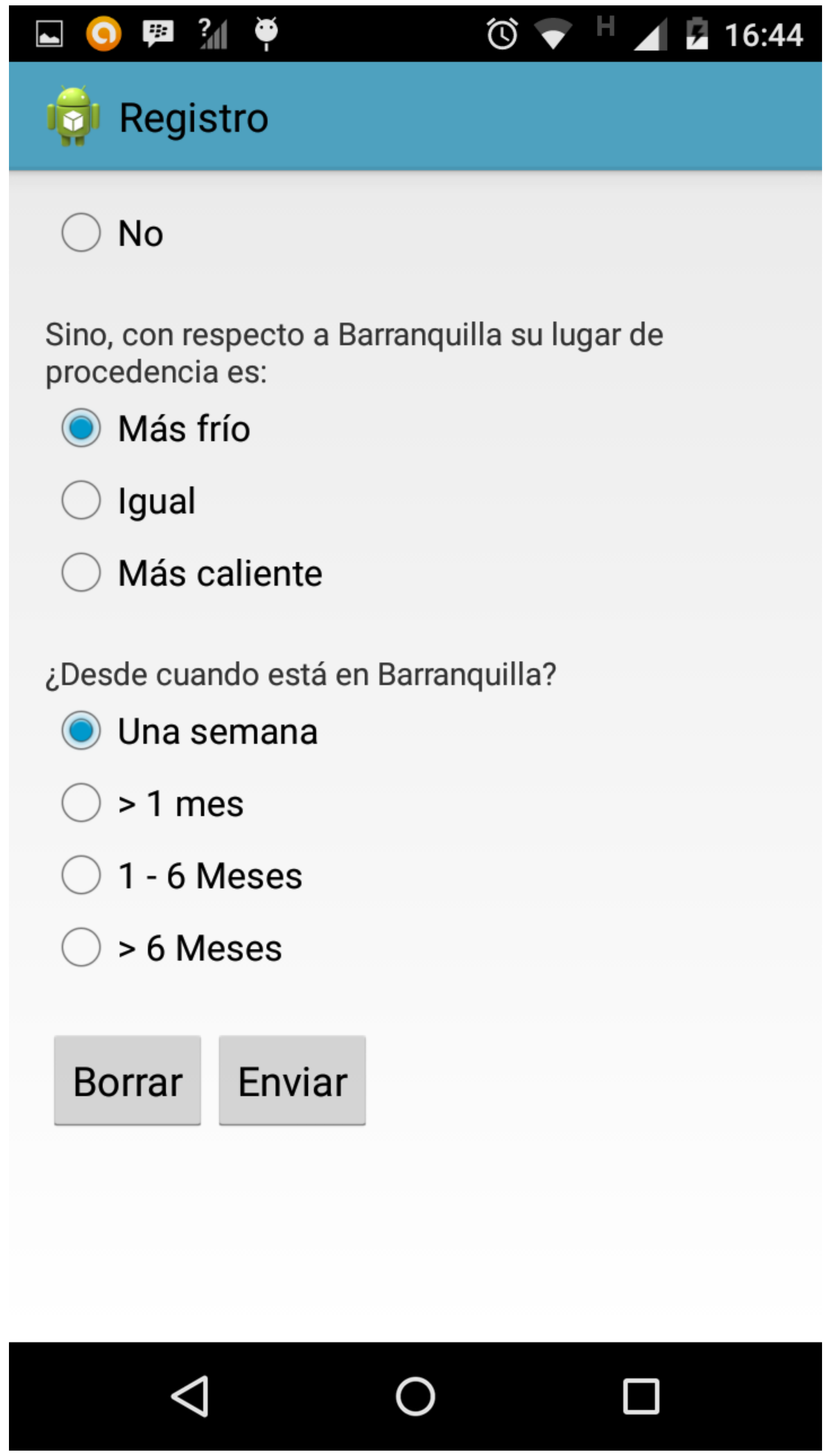
Climate-sensitive Urban Growth

Measurement Network – Barranquilla Colombia

PET vs. **Thermal sensation Smartphone app**







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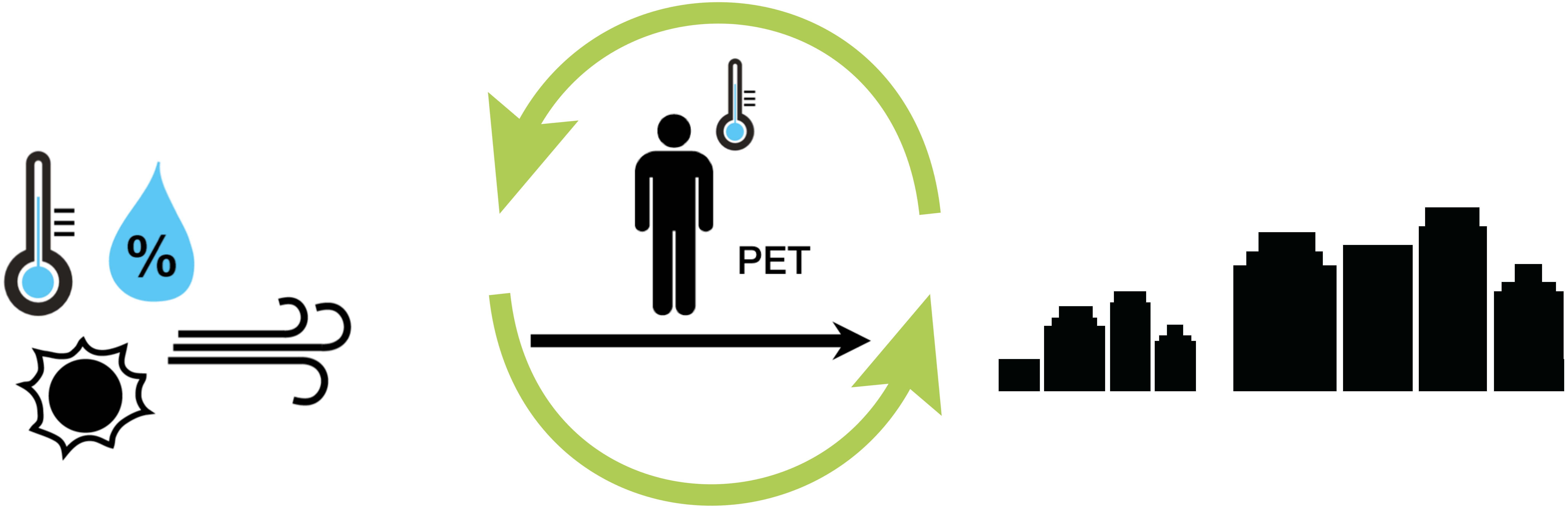

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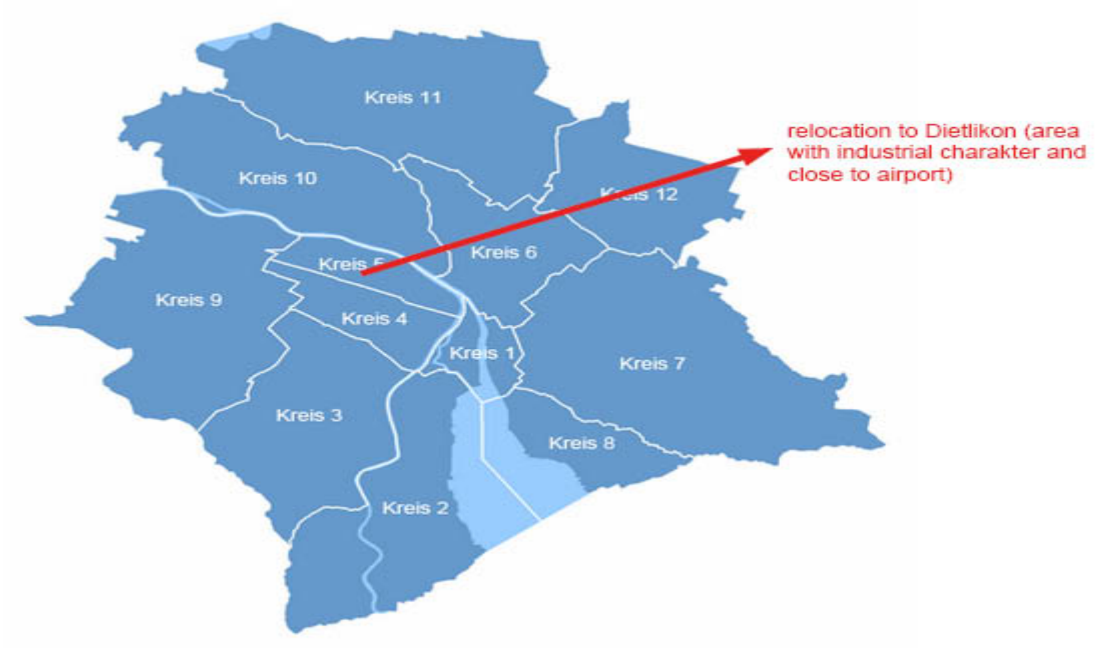
Livability

- Ranking metrics and standards
  - The Global Liveable Cities Index
  - The EIU's Global Liveability Report
  - Mercer's Quality of Living Survey
  - Monocle's Most Liveable Cities Index
  - Ranking the Liveability of the World’s Major Cities
  - ISO 37120:2014

- Healthy skepticism
  - http://ourworld.unu.edu/en/the-worlds-most-liveable-cities

stock & flow / example	people	water	material	energy	density	information	finances
incresing livability							
HB	+++ **enabling sustainable flow of people to multiple destinations**	-- reducing available stock of clean water	++ enabling flow of goods for commerce	-- consuming high amount of energy	++ increasing attractiveness of neighbourhood -> potential for densification		++ - income possibility for shopowners, SBB and city - investment possibility
Biogas Zürich AG Vergärunganlage			+++ **converting flow of green waste to stock/flow of energy**	+++ **increasing stock/flow of energy**			+ - no additional investments required for biogas use - investment possibility
Kino Abaton	++ attracting local and foreign people	- reducing stock of clean water	-- requiring big stock of carbon intensive building materials	-- energy consuming	++ increasing attractiveness of neighbourhood -> potential for densification	+++ **flow of entertaining and potentialy useful visual and auditory information (movies)**	++ - income possibility for cinema operators and city - investment possibility
decreasing livability							
Verbrennungsanlage Josephwiese	- decreasing attractiveness of neighbourhood -> potentially making people move away		+ converting of (foreign) flow of waste to energy	+ converting of (foreign) flow of waste to energy	-- decreasing attractiveness of neighbourhood -> decreasing stock of density		--- negative impact on landprices -> decreasing stock of capital
Parkhaus Messe Zürich			-- heavy stock on non-renewable building materials only for serving private transportation	--- **- enabling energyintensive, inefficient private transportation** **- negative effect on urban heat island**			- requiring high investments with low rate of returning
Hardbrücke & Rosengartenstrasse	--- **causing unsustainable flow of people (individual motorized traffic) and congestions**		--- requiring heavy stock of carbon intensive building materials	-- very energy intensive construcion	-- decreasing attractiveness of neighbourhood -> decreasing stock of density		--- requiring high stock of tax money for construction and maintenance

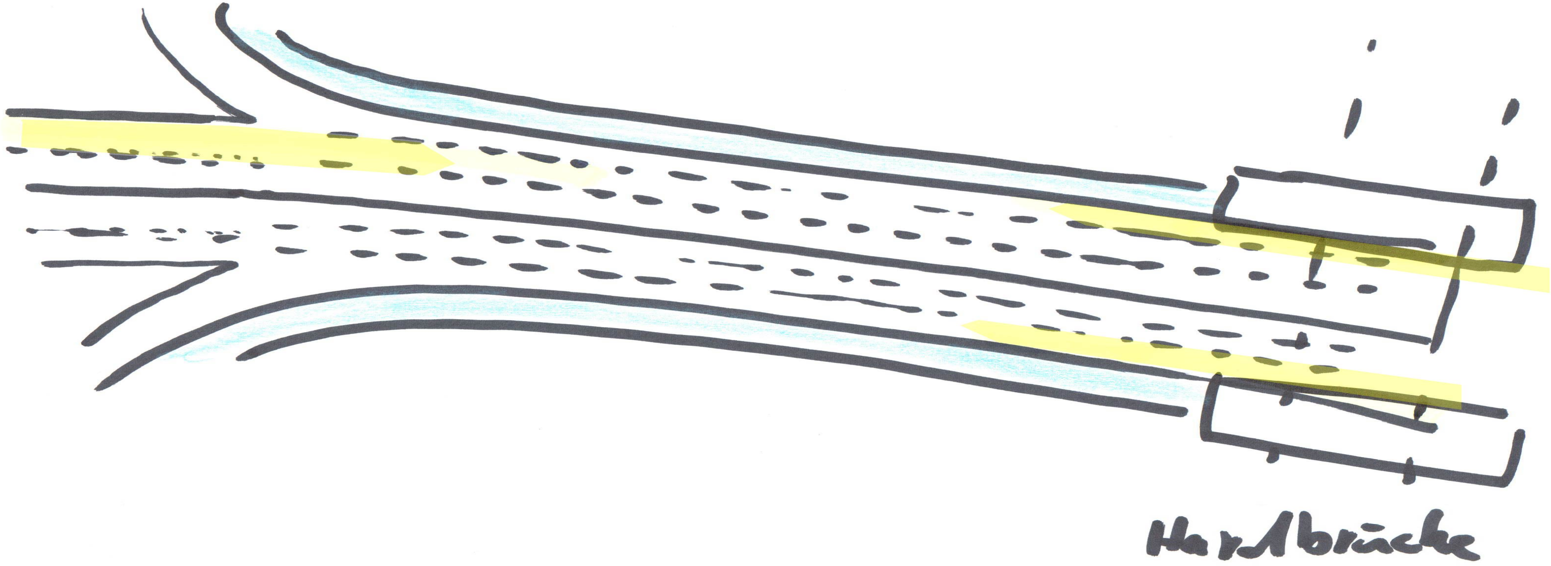
Improving Case 4 - Verbrennungsanlage Josefstrasse



Improving Case 5 – Parkhaus Messe Zürch

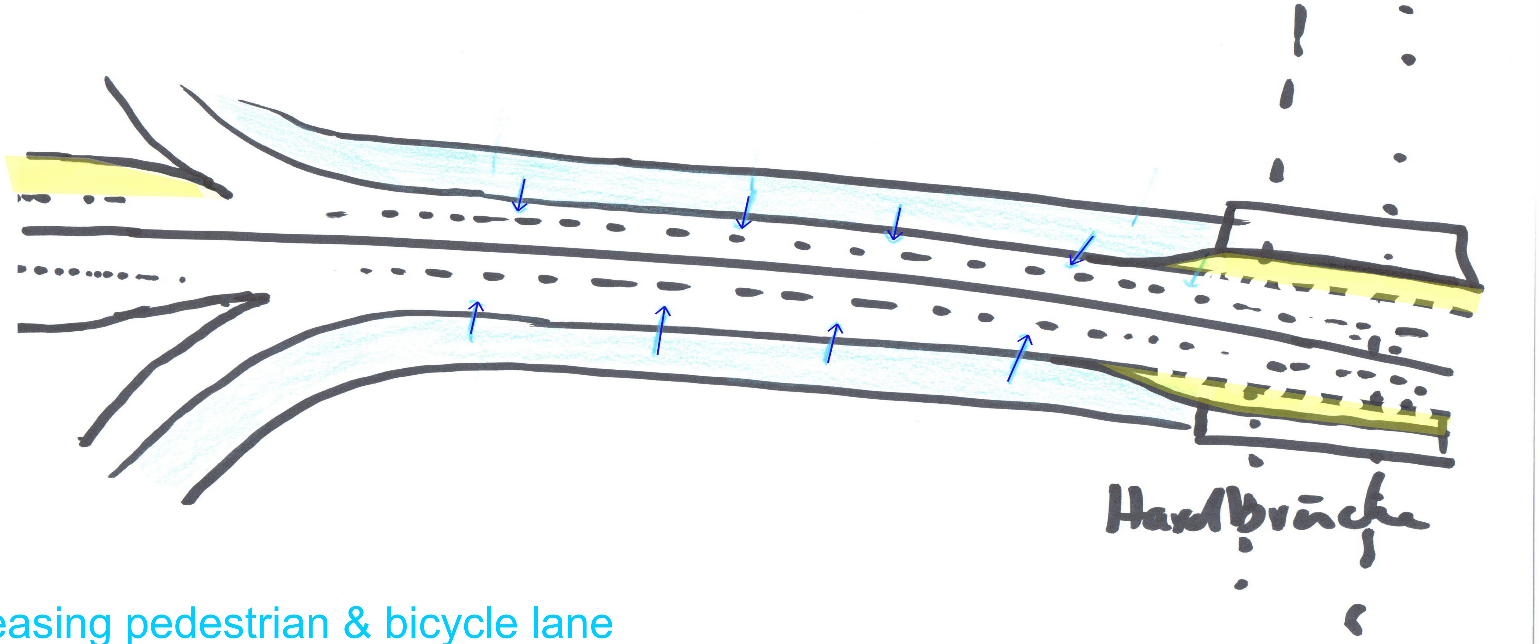
Moving underground or demolishing

Improving Case 6 – Hardbrücke & Rosengartenstrasse



- bus
- pedestrian & bicycle

Improving Case 6 – Hardbrücke & Rosengartenstrasse



-> Increasing pedestrian & bicycle lane

-> decreasing flow of traffic by reducing lane

-> eventually introduce new traffic reducing rules like for example that on some days only cars with odd numbers are allowed to pass while on other days only cars with even numbers are allowed to pass

Content

- Urban Research
- Metrics of Smart Cities
- A Conversation: Measurements in the City
- Questions regarding Exercise 2
- Conclusions

Summary

- Urban research requires measurements, resulting in data. If data are combined, they turn into information. If information is combined, it turns into knowledge
- Information and knowledge, combined with observation and compliance, are needed to improve a city
- To understand urban systems, measurements are important on all scales: buildings and neighbourhoods, districts and cities, regions and territories
- Measurements are a necessary (but not sufficient) activity for quantitative and qualitative urban improvements
- Ignoring information and knowledge, or not having access to it, can be deadly → transportation → Pompei