



**Monitoring and Commissioning for  
Green Campuses**

**International Conference for Enhanced Building  
Operations (ICEBO 2014)**

**Tsinghua University,  
September 14-17, 2014, Beijing, China**

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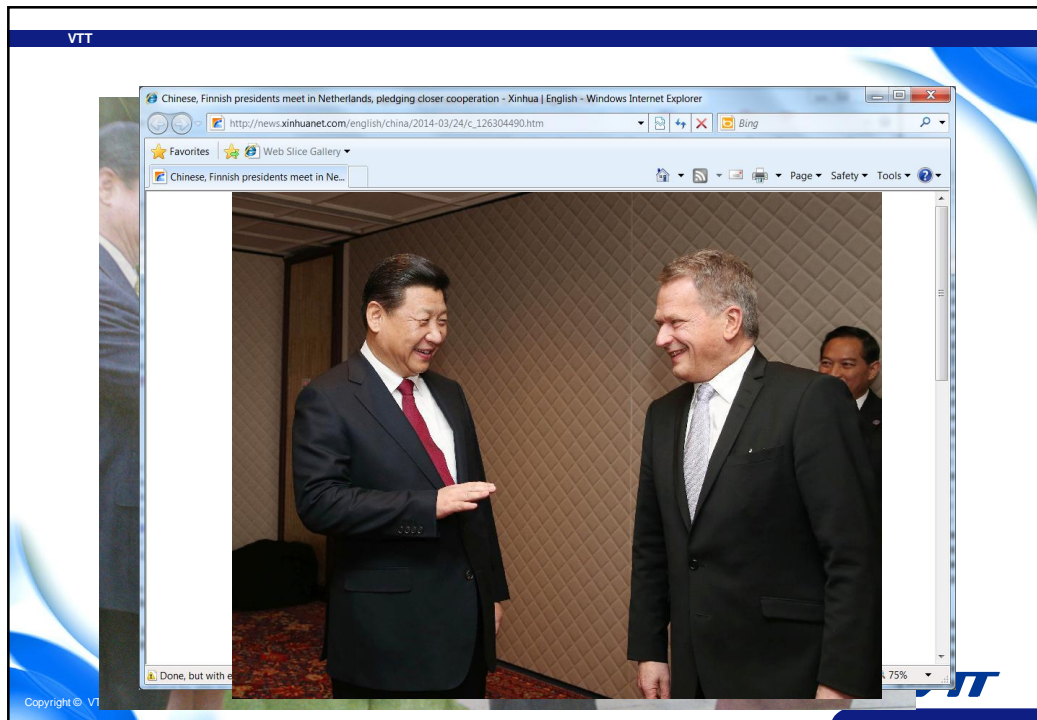
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## Outline

1. VTT very briefly
2. Why Green Campus?
3. GreenCampus LivingLab
4. Monitoring and commissioning
5. Some results
6. Conclusions

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## VTT creates business from technology

VTT Technical Research Centre of Finland is the biggest multitechnological applied research organisation in Northern Europe. VTT provides high-end technology solutions and innovation services.

**Main part of work contract research and joint projects**


- Improved competitiveness: new and improved products, equipment, production methods and processes

**Technology enhancement and transfer also by producing public research knowledge**

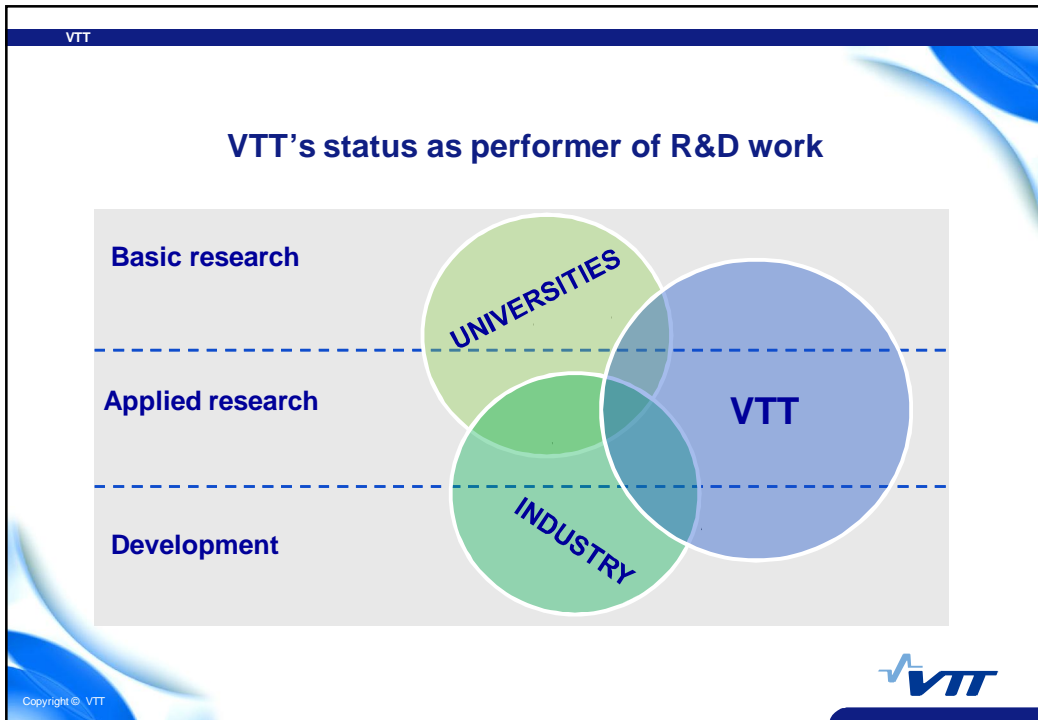
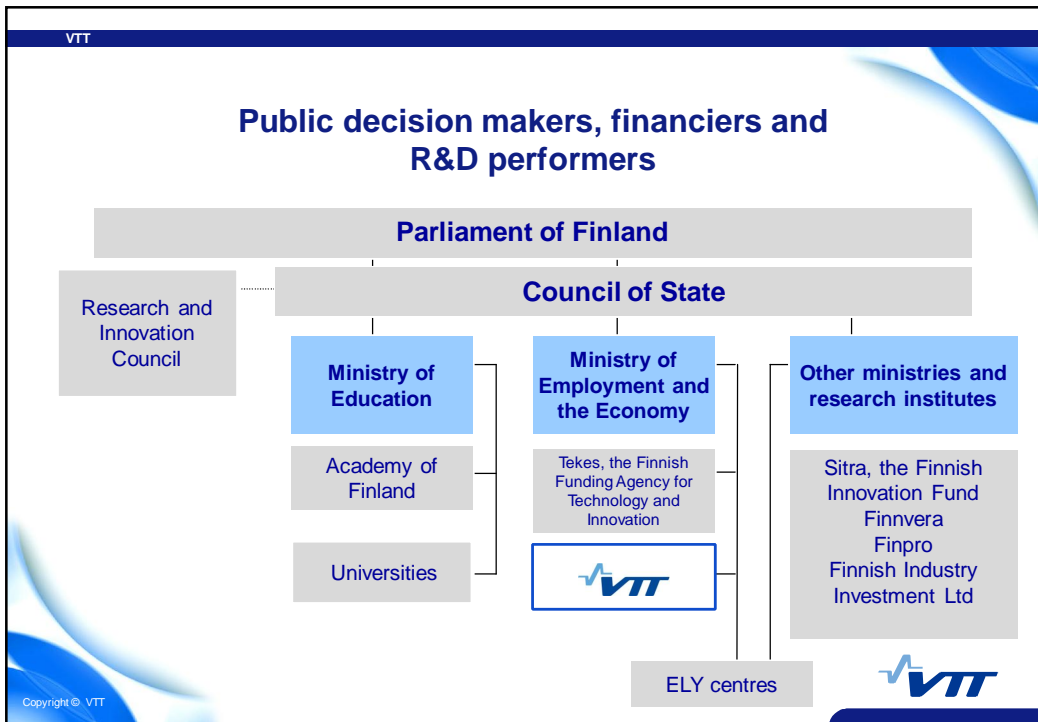
- Growth ground for science-based innovations

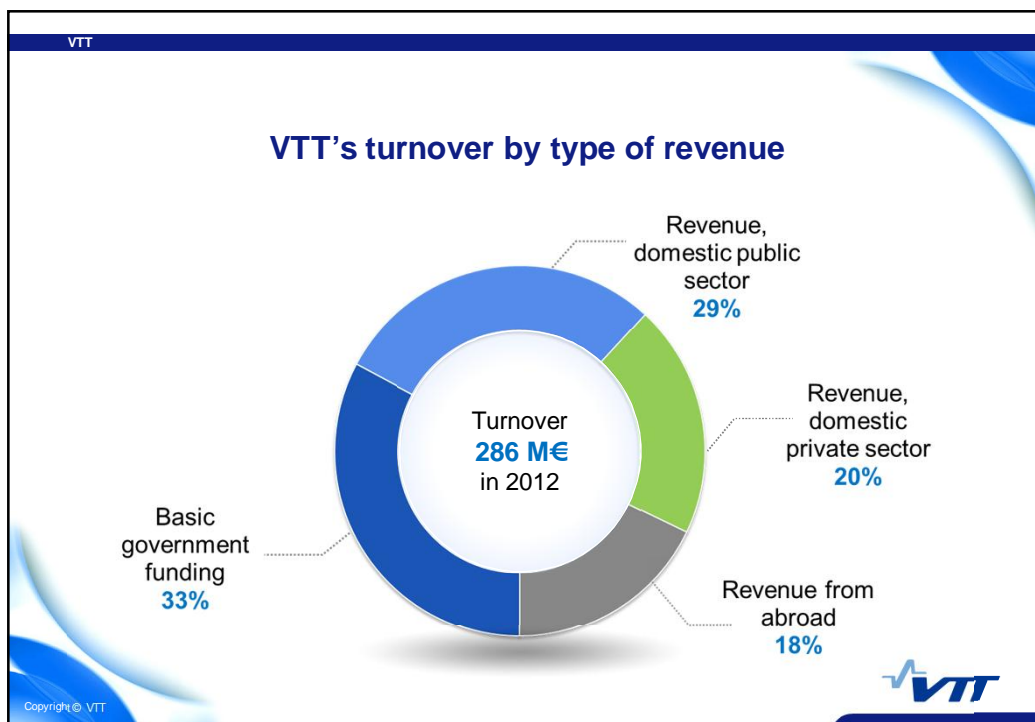
**Active participation in both domestic and international research programmes and collaboration networks**

- Effective technology transfer and access to co-operation partners



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### VTT Group in brief

Turnover 316 M€ (2012) • Personnel 3,206 (31.12.2012)



**Customer sectors**

- Biotechnology, pharmaceutical and food industries
- Chemical industry and environment
- Electronics
- Energy
- Forest industry
- ICT
- Machine, vehicle and metal industries
- Real estate and construction
- Services and logistics



**Focus areas of research**

- Applied materials
- Bio- and chemical processes
- Energy
- Information and communication technologies
- Industrial systems management
- Microtechnologies and electronics
- Services and the built environment
- Business research



**VTT's operations**

- Research and Development
- Strategic Research
- Business Solutions
- Business Development
- Group Services
- VTT's companies
  - VTT Expert Services Ltd (incl. Labtium Ltd and Enas Ltd)
  - VTT Ventures Ltd
  - VTT International Ltd (incl. VTT Brasil LTDA)
  - VTT Memsfab Ltd

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## VTT's strategic research portfolio

**Bioeconomy transformation**

- Sustainable use and refining of bio-based raw materials
- Industrial biotechnology and green chemistry
- Process and manufacturing technologies
- Bioeconomy business ecosystems




**Low-carbon economy**

- Energy efficient solutions for industry, built environment, and transport
- Renewable energy sources
- Nuclear energy: safety and waste management
- Energy systems modelling



**Clean environment**

- Clean water cycles on demand
- Industrial ecology and life cycle design
- Waste refineries, material recovery, and recycling
- Substitute material solutions



Horizontal research: Business and services – Innovation methods and policies – Safety and security – User and customer understanding

**Digital world**

- High-performance microsystems and sensing solutions
- Printed intelligence
- Scalable digital service economy
- Internet of Things (IoT)



**Resource efficient production systems**

- Eco-efficient machines
- Resource efficient processes
- Simulation based design
- Global production and services



**Health and wellbeing solutions**

- System biology and diagnostics
- Food products and health
- ICT for health
- User-driven spaces and environments



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## Research results



New business models for cloud-based business



New products from forest biorefineries



New customer value from services in the mechanical engineering industry



State-of-the-art centre for water technology



Additional value for metal products with sol-gel coatings



Grid electricity from natural gas using fuel cell technology



Research and development promote energy efficiency



Electronic services for the healthcare sector

Pavola, S. / Science Photo Group, Mexico City

For more examples see: [www.vtt.fi](http://www.vtt.fi)



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## VTT's mission

VTT produces research and innovation services that enhance the international competitiveness of companies, society and other customers.

VTT creates the prerequisites for society's sustainable development, employment and wellbeing.

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VTT Technical Research Centre of Finland - Business from technology - Mozilla Firefox

www.vtt.fi

Teknologiasta liiketoimintaa

Suomeksi | In English | På svenska

Palautte Kirjoita hakusana HAE

Etusivu VTT Palvelut Tutkimus ja teknologiat Referensseja ja tuloksia Uutiset ja tapahtumat Julkaisut Työpaikat Yhteystiedot

Let's imagine develop a better world.

**Palvelut toimialtoittain**

- Bio-, lääke- ja elintarviketeollisuus
- Eläintarviketeollisuus
- Energia
- ICT
- Kiinteistö- ja rakentaminen
- Koneet ja kulutusvälineet
- Palvelut ja logistiikka
- Metsäteollisuus
- Kemianteollisuus ja ympäristö

**Palvelukokonaisuuksia**

- Tutkimus ja kehitys
- Asiantuntijapalvelut, testaus, sertifiointi - VTT Expert Services Oy
- IPR, kaupallistaminen
- Spin-off-toiminta - VTT Ventures Oy
- MEMS sopimusvalmistus - VTT MEMSFAB LTD

**Uutisarkisto**

Teknologia ja uudet toimintatavat mahdollistavat laadukkaat ja kustannustehokkaat vanhuspalvelut

Valujen valmistus kotimaassa voi olla riskittömin vaihtoehto

VTT kehittää pientalojen energiaremonttipalvelumalleja

05.09.2012

VTT panostaa tulevaisuuden sähköajoneuvojen kehittämiseen

VTT on laajentanut tutkimusympäristönsä tulevaisuuden sähköajoneuvojen, sähköisten liikkuvien työkalujen, akustojen ja komponenttien kehittämiseksi. Laboratoriossa voidaan testata ja kehittää raskaatkin ajoneuvoja VTT:n ja Metropolia ammattikorkeakoulun Kabus Oyn bussirunkoon rakentama testisankobussi vauhdittaa kotimaisten komponenttien kehitystä. Testaussi esitellään ECX-tapahtumassa Otaniemessä 5.9.2012. Lue lisää...

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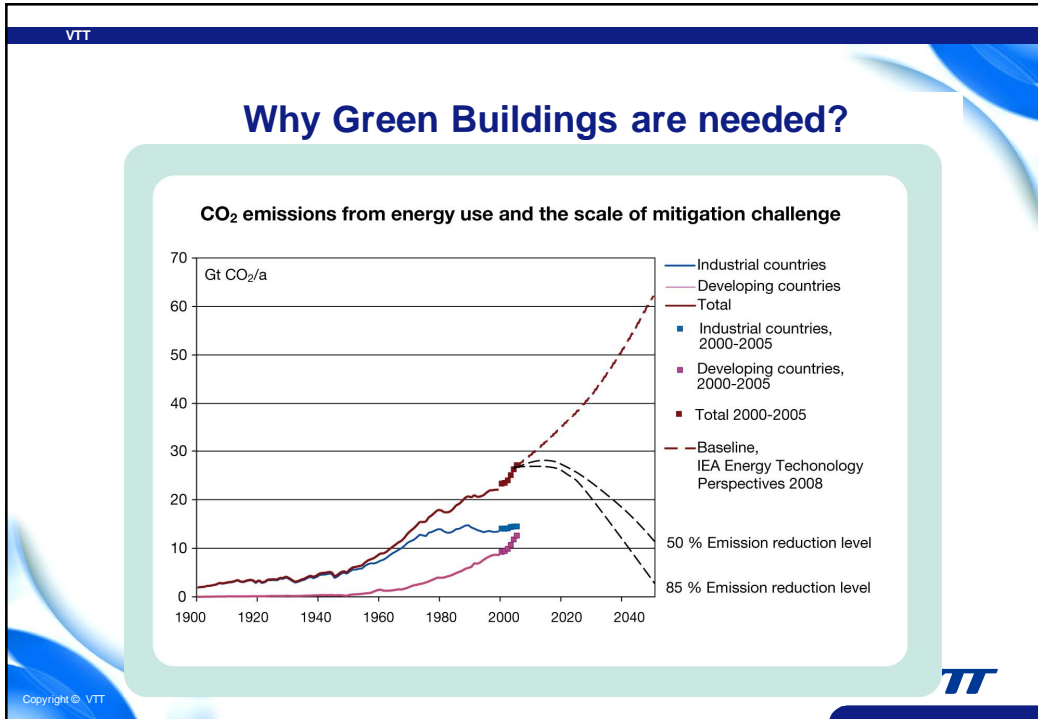
## Some Examples of R&D&I Activities at VTT

### 芬兰VTT技术研究中心

- ISoDH (District heating and cooling)
- EcoCities&EcoCommunities
- Green Buildings
- Building Commissioning
- GreenCampus



The image shows a slide with a blue header and footer. The main content is a list of R&D&I activities at VTT. The VTT logo is located in the bottom right corner of the slide.





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## Use of Energy Means Pollution as well!

**WHO: Ilmansaasteiden vaarallisuus rinnastettavissa tupakkaan**

17.10.2013 16:48 0 Suosittu 0

Erik Nyström  
HELSINGIN SANOMAT

REUTERS

Liikennettä savusumun keskellä Jiaxingissa Kiinassa 2010.

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Source: Helsingin Sanomat 17.10.2013

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## Disappearing City

PROVIDED TO CHINA TODAY

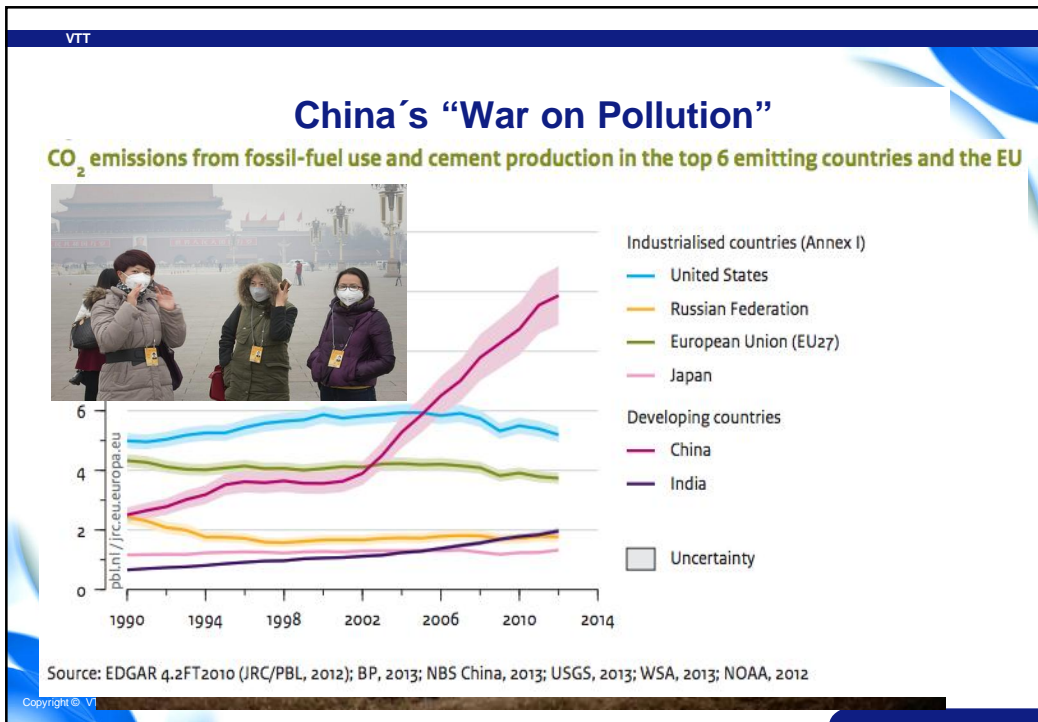
Students wear face masks to protect themselves from heavy smog in Harbin, the capital of Heilongjiang province. Visibility has dropped to less than 10 meters, and local authorities have suspended classes at schools and kindergartens to avoid health risks.

**Smog wraps northeast, schools forced to close**

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Source: China Today 21.10.2013

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EU-maat sopuun unionin ilmasto- ja energiapaketista - HS.fi - Talous - Microsoft Internet Explorer

## EU Countries committed strongly to cut the CO<sub>2</sub> emissions

ERIC FEFERBERG / AFP

**20 - 20 - 20**

The collage illustrates the EU's 20-20-20 climate targets. The central text reads "EU Countries committed strongly to cut the CO<sub>2</sub> emissions". Below this is a photograph of EU leaders. A large green box prominently displays "20 - 20 - 20". To the right, three browser window screenshots show "EU targets" with icons and text: "less greenhouse gases", "20% more renewable energy", and "more energy efficient".

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## Buildings have key role in climate change combat!



**Major challenge in existing buildingstock!**

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## But also biggest potential!

All sectors and regions have the potential to contribute

IPCC  
Intergovernmental Panel on Climate Change



Sector	Region	World Total (GtCO <sub>2</sub> , eq/yr)
Energy supply	<20	~1.5
	<50	~3.5
	<100	~4.5
Transport	<20	~1.5
	<50	~1.5
	<100	~2.0
Buildings	<20	~5.5
	<50	~6.0
	<100	~6.5
Industry	<20	~1.0
	<50	~3.5
	<100	~4.0
Agriculture	<20	~1.5
	<50	~2.5
	<100	~4.5
Forestry	<20	~1.0
	<50	~2.0
	<100	~3.0
Waste	<20	~0.5
	<50	~0.5
	<100	~0.5

Emission reductions based on the end-use of energy

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## Building Commissioning

ASHRAE Guideline 0-2005

**ASHRAE GUIDELINE**

**The Commissioning Process**

Approved by the ASHRAE Standards Committee on February 8, 2005, and by the ASHRAE Board of Directors on March 11, 2005.

ASHRAE Guidelines are updated on a five-year cyclic basis following the guideline number in the year of approval. The latest edition of an ASHRAE Guideline may be purchased from ASHRAE Customer Service, 1791 Taylor Drive, Atlanta, GA 30329-2205. E-mail: [orders@ashrae.org](mailto:orders@ashrae.org); Fax: 404/891-6178; Telephone: 404/894-8400 (person-to-person) or toll free 1-800-827-4273 (for orders in U.S. and Canada).

©Copyright 2005 ASHRAE, Inc. ISBN 1549-894X

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.  
1791 Taylor Drive NE, Atlanta, GA 30329  
[www.ashrae.org](http://www.ashrae.org)

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Jorma Pietiläinen, Timo Kauppinen, Keijo Kovanen, Veijo Nykänen, Mikko Nyman, Satu Paho, Janne Peltonen, Hannu Pihala, Timo Kalema & Hannu Keränen

**ToVa-käsikirja**

Rakennuksen toimivuuden varmistaminen energiatehokkuuden ja sisäilmaston kannalta

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## Fragmented Construction Process

Archi tecture Structural systems HVAC Electric systems

Responsibilities in Design and Construction  
Functional responsibility gaps

+

Needs  
Programming  
Design  
Procurement  
Construction  
Handing over & Mobilization  
M&O and Use

Phases in Construction Process

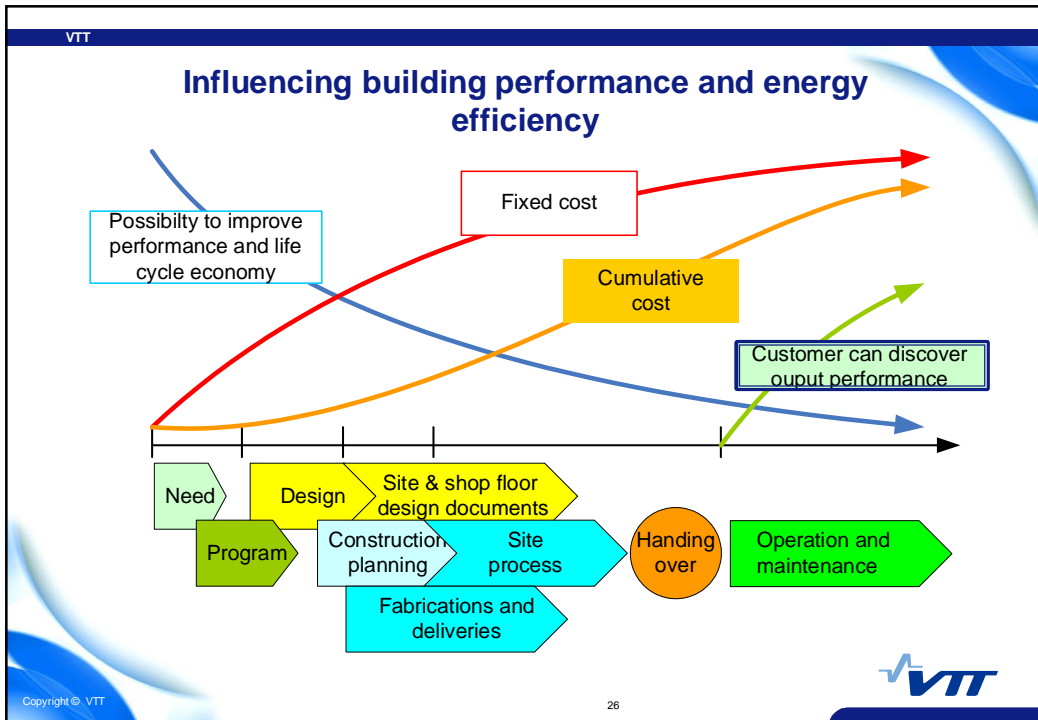
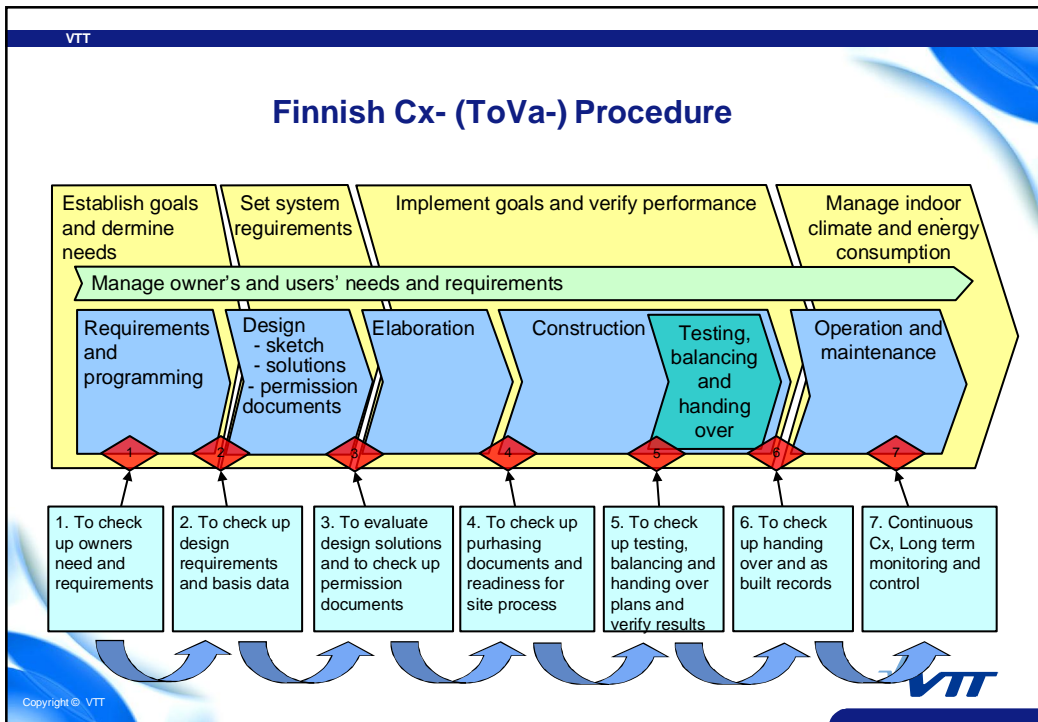
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**Cx ?**

Operative barriers  
Weak coordination and information exchange

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## Commissioning Procedures and Tools for Energy Performance Verification

ESPOO 2007 VTT TIEDOTEITA 2413

Jorma Pietiläinen, Timo Kauppinen, Keijo Kovanen, Veijo Nykänen, Mikko Nyman, Satu Pailho, Janne Peltinen, Hannu Pihala, Timo Kalema & Hannu Keränen

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# "What you cannot measure, you cannot manage or improve"

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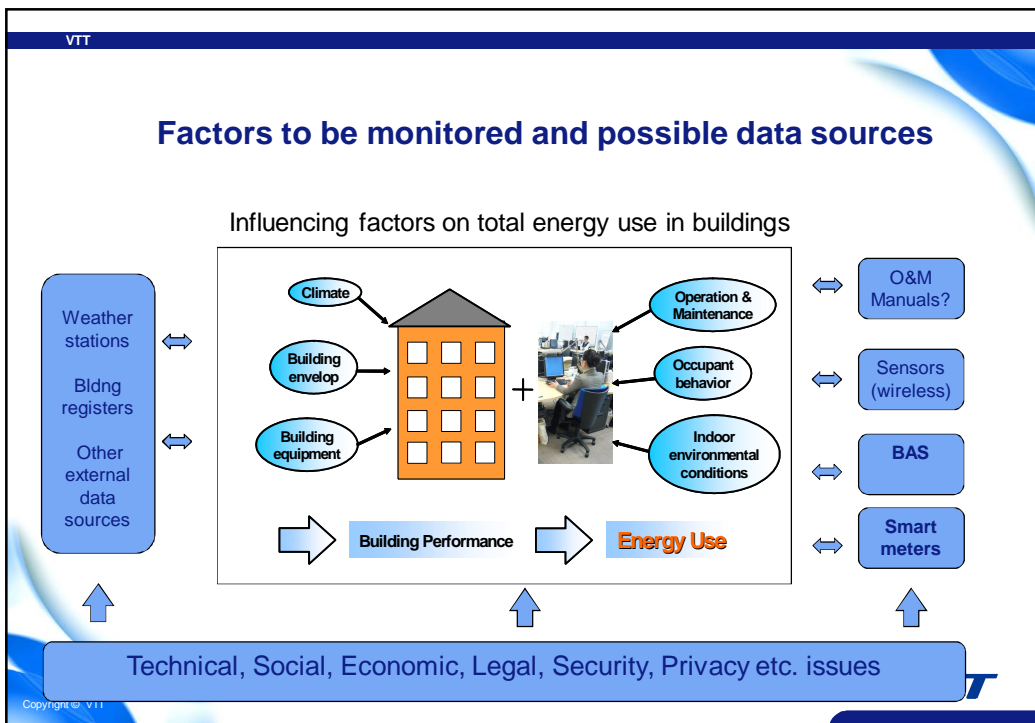
Copyright © VTT

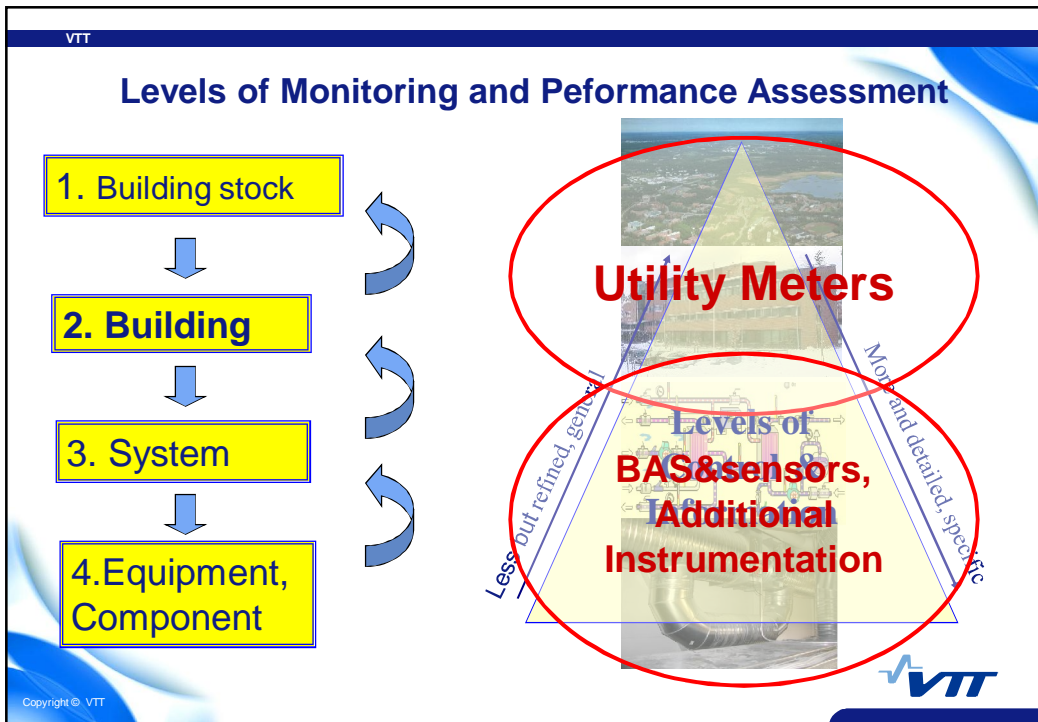
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## Monitoring = Basis for Everything!

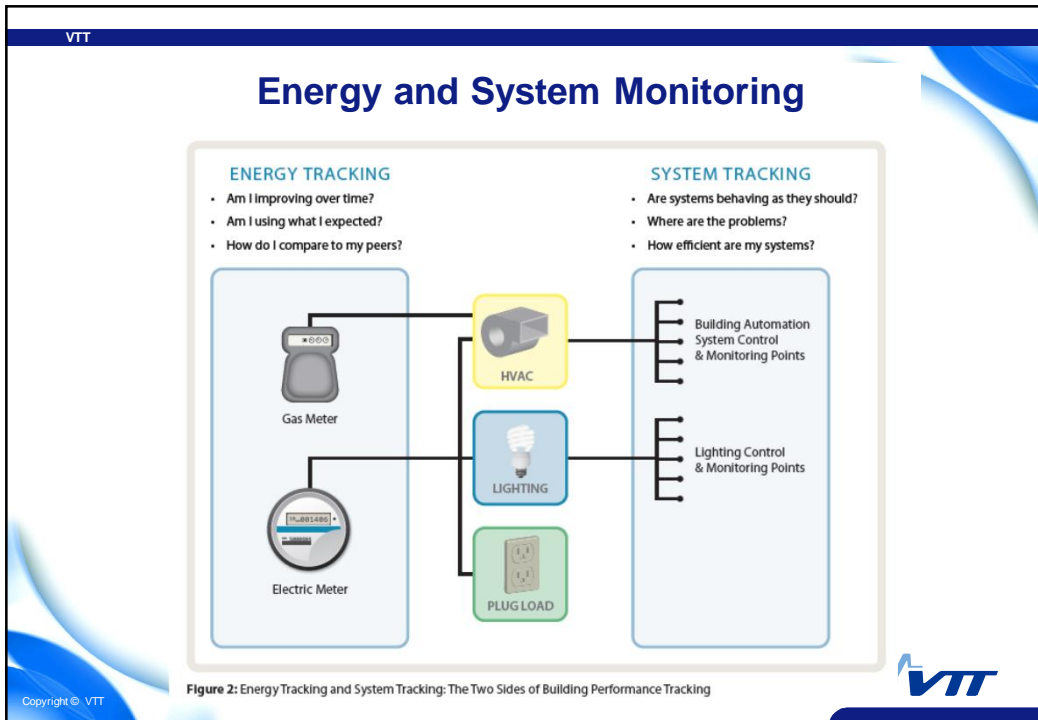
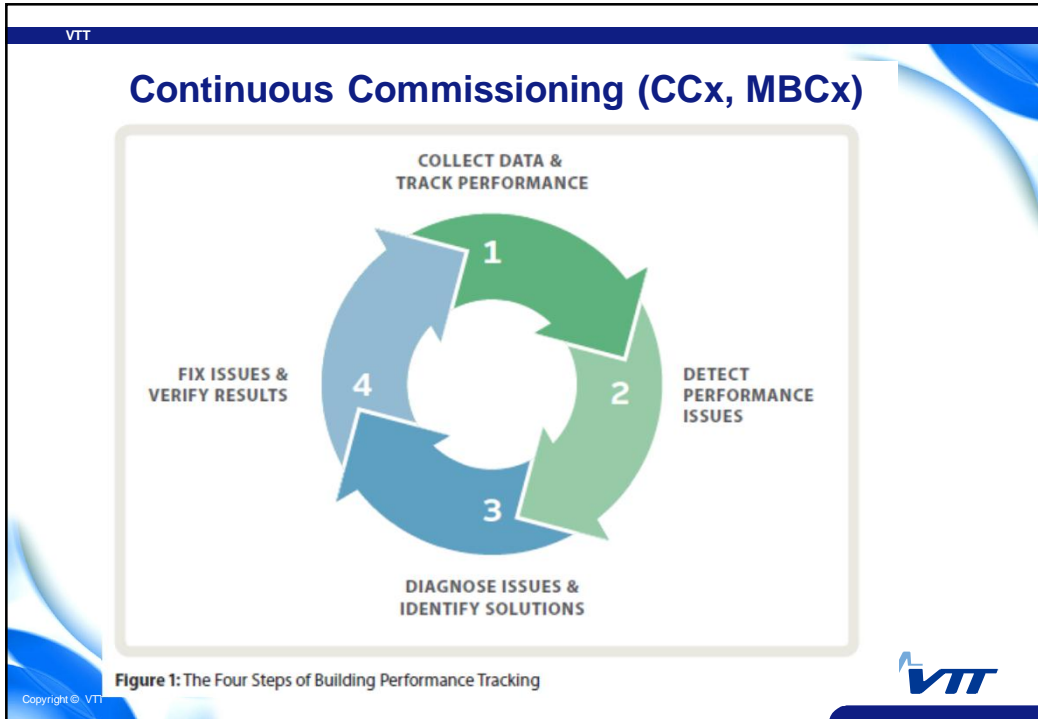
- Reliable consumption data forms the **basis for the assessment of energy performance and for the planning of retrofitting and saving measures**
- **Verification** of implemented saving measures is impossible without reliable consumption figures:  
**=> Energy Saving = Baseline Energy Use – Post Retrofit Energy Use**
- **Feedback to M&O personnel** is the key for the operational efficiency (basis for motivation, training etc.)
- **Occupants and users, owners, decision makers, designers, authorities etc. must** be informed as well (influence to the attitudes and habits)
- Monitoring can be used for many other purposes as well - like for the **Building Energy Certification**

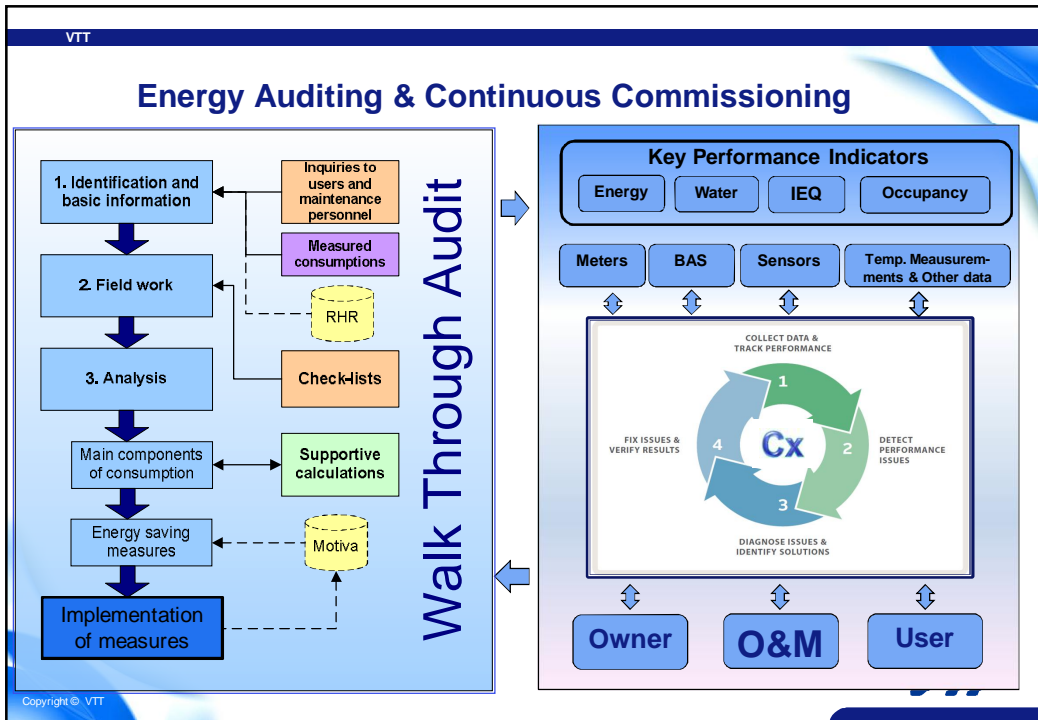
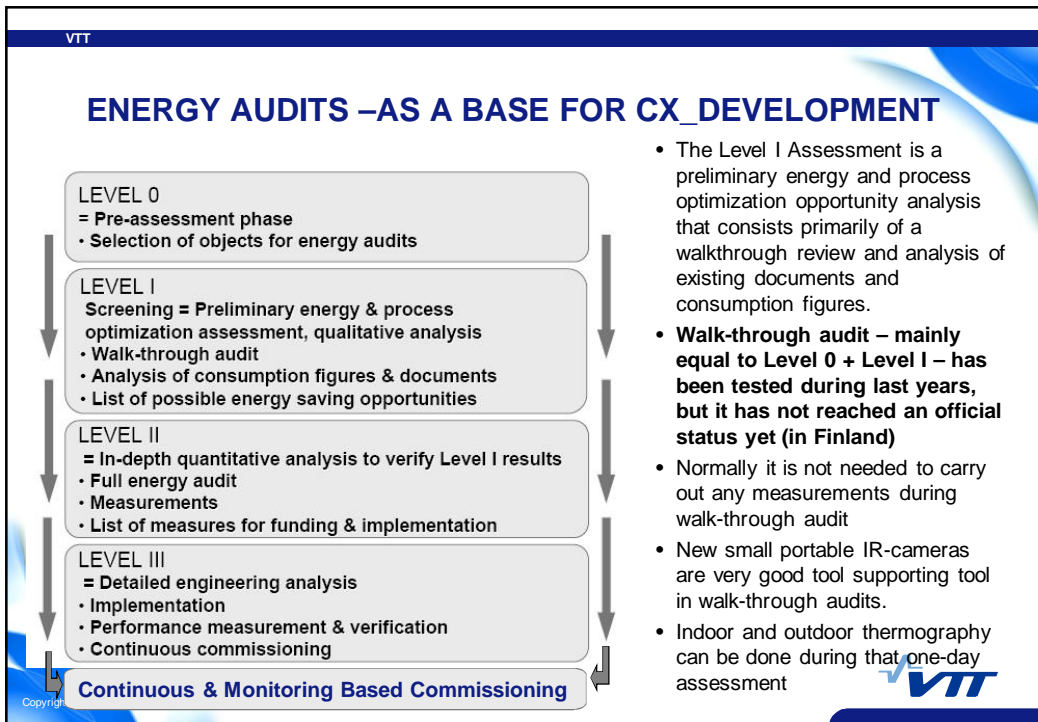
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## VTT's Strategy

### Can shoemaker's children afford shoes?

VTT as the technology leader brings success to its customers

VISION 2020

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MISSION

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VALUES

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ETHICAL NORMS

- Internationally recognised, synergic and flexible partner
- An engine of technology development in Finland
- Best investment option in the innovation environment
- The preferred employer for experts who want to improve their knowledge and succeed

Through creating and applying technology, we actively enhance the competitiveness of industry and other business sectors, and thus increase the welfare of society.

- Science-based innovations
- Customer and demand orientation
- Genuine collaboration
- Encouraging peak performance

Impartiality, reliability, integrity and responsibility

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St. Petersburg 14.5.2008 Jorma Pietiläinen

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## Environmental monitoring for Otaniemi Campus

**Continuous assessment and improvement of own activities**

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## Realtime Feedback to various stakeholders

**Users**  
**Feedback**  
 Owners Operators  
**Awareness**  
**Motivation**  
**Actions**

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## Internet – Natural Platform also for Energy Monitoring and Control

Internet

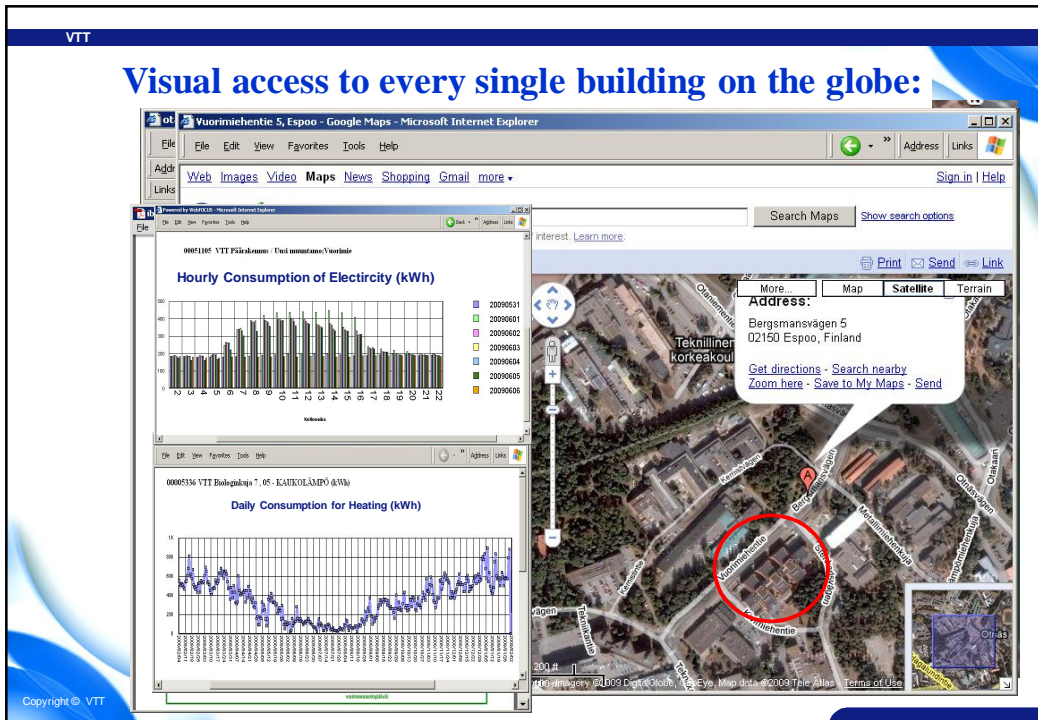
Otaniemi, Finland

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## Buildings and equipments will be connected as well

Internet

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## Next Generation Internet

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RFID

IDENTIFICATION WORLD

Identification of all things using codes that represent group or individual product. Knowing what is the exact item in question and what information is linked to it. For example, origin, history, price, location of a certain car, lamp, sofa, chair, apple, sensor or actuator.

SENSOR

SENSOR WORLD

Using sensors for measuring and sensing of things, environment, persons, operation, temperature, weather, pollution and traffic. Information is pre-processed locally, transmitted, combined from many sensor sources and used for best business outcome.

ACTUATOR

ACTUATOR WORLD

Reacting and influencing the things in real world. Remote control of motors, valves, heating and cooling systems, electric locks, lighting and access control. Actuation is controlled by other machines and IT-systems automatically, but also by humans.

**FIGURE 1.4.** Internet of things consists of three "worlds" that are interconnected. Identification of objects is a fundamental extension from IP-addresses. Sensors are needed to provide real time information on the objects and actuators are needed to act upon the information.

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## Sensors - knowing the world in real time

2013

2020

2020

2020

2013

2020

VISION

FROM CLOSED SYSTEMS

...TO OPEN REAL-TIME SENSOR DATA

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更多 MORE

更乱 Messy

数据化 DATIFICATION

价值 VALUE

角色定位 ROLE

管理变革

风险 RISKS

更好 CORRELATION

生活、工作与大思维的大变革

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St. Petersburg 14.5.2008 Jorma Pietiläinen

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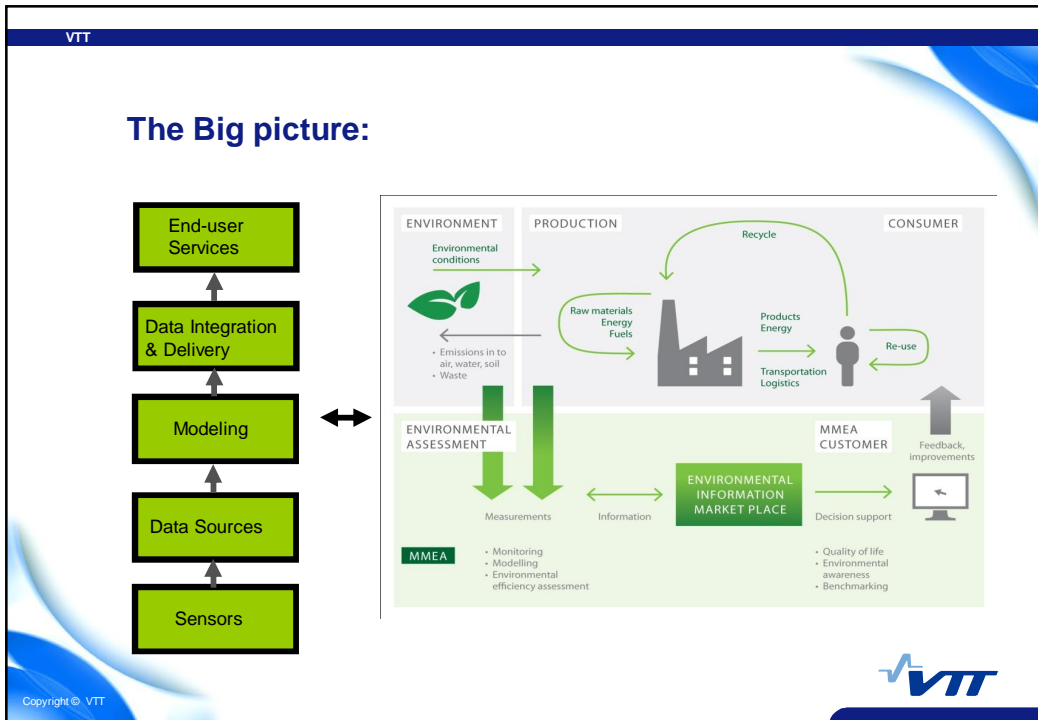


Business from technology

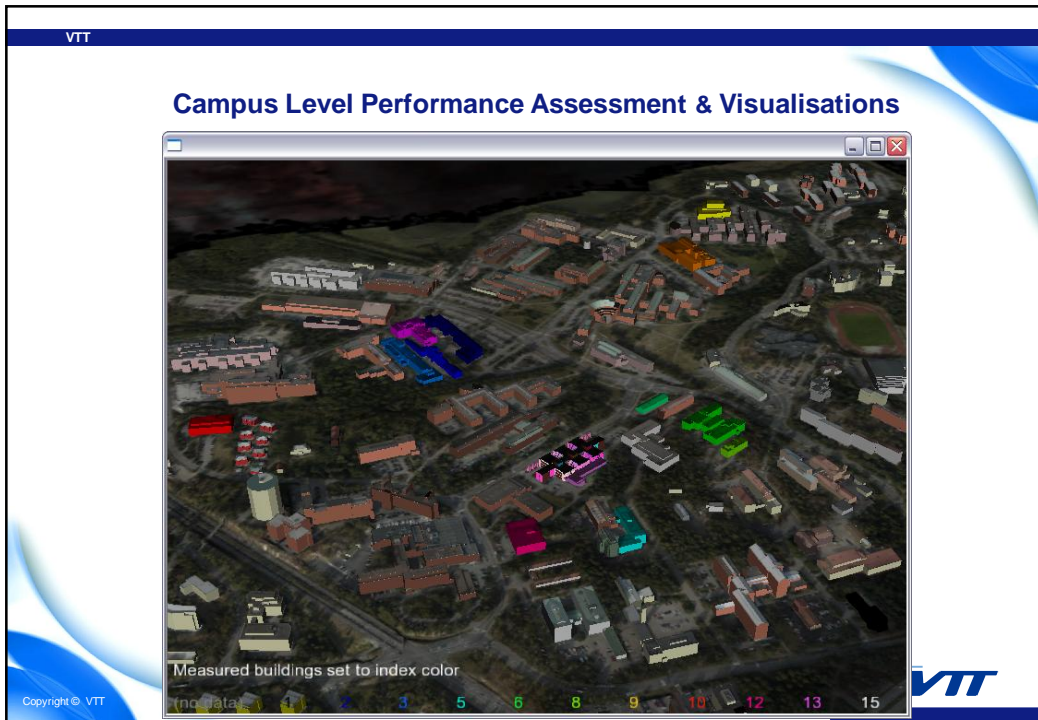
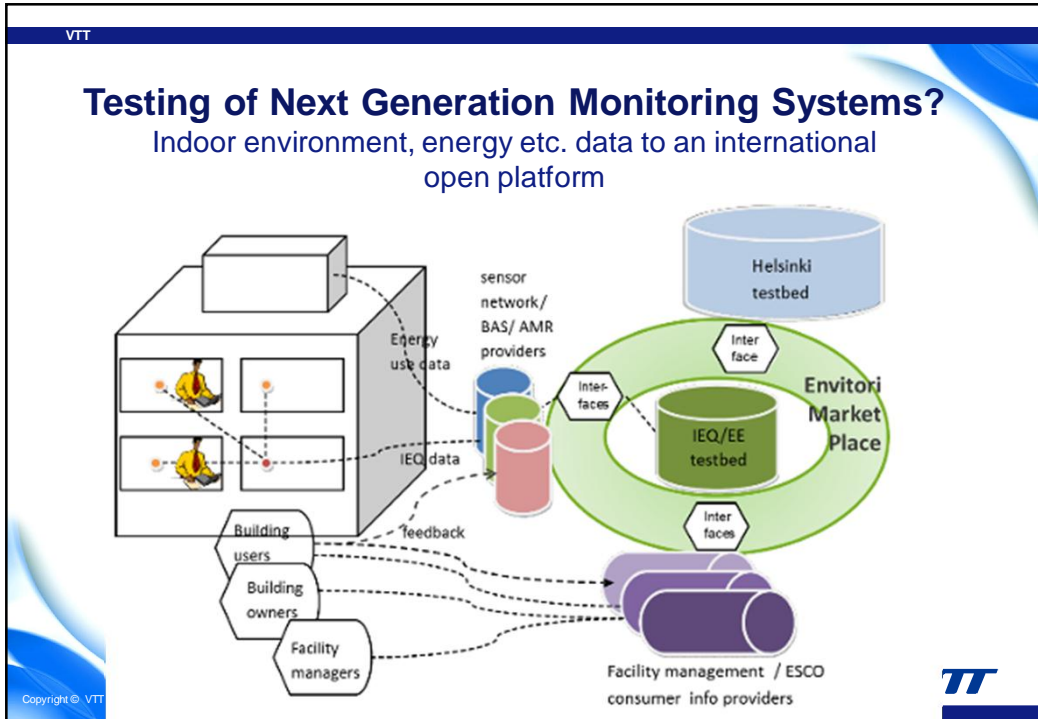


**mmea**  
Measurement, Monitoring and Environmental Assessment

Development of measurement and monitoring technologies at CLEEN Oy







VTT TECHNICAL RESEARCH CENTRE OF FINLAND 09/05/2011 10 VTT

### Building Level Performance Assessment & Visualisations

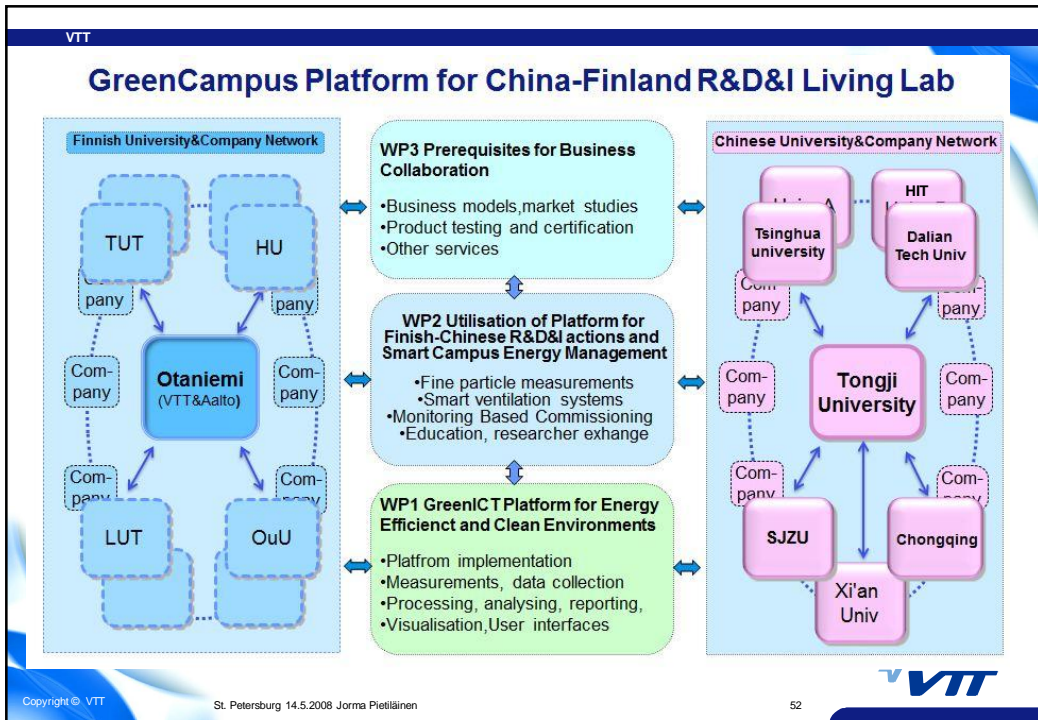
#### Visualisation: Digitalo rooms, IEQ Index

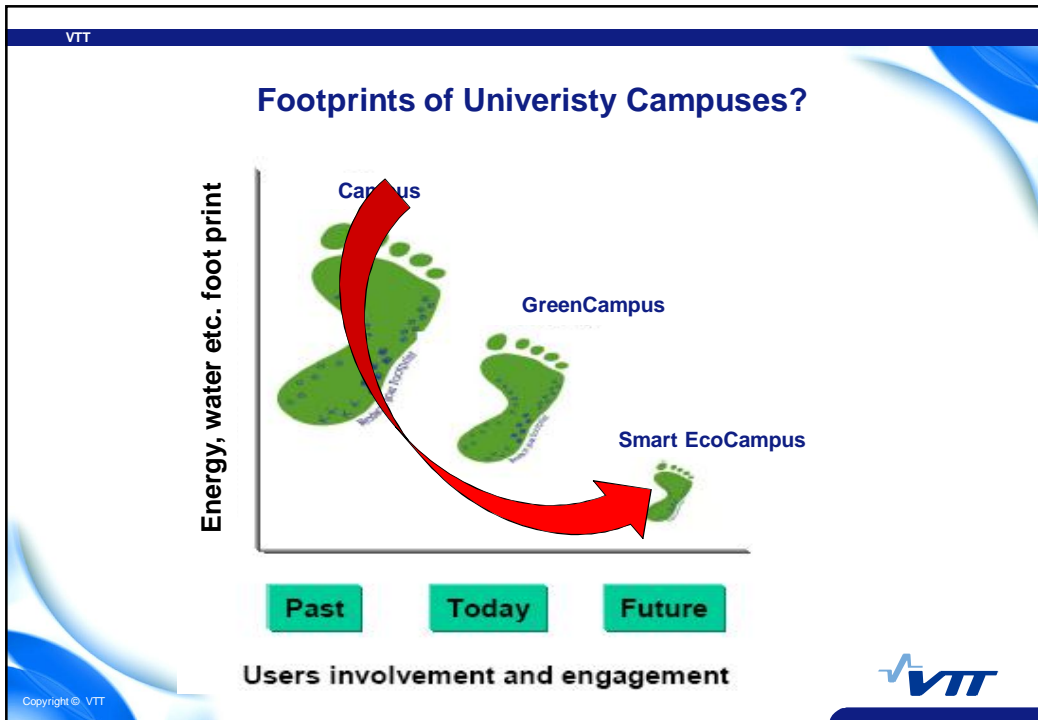
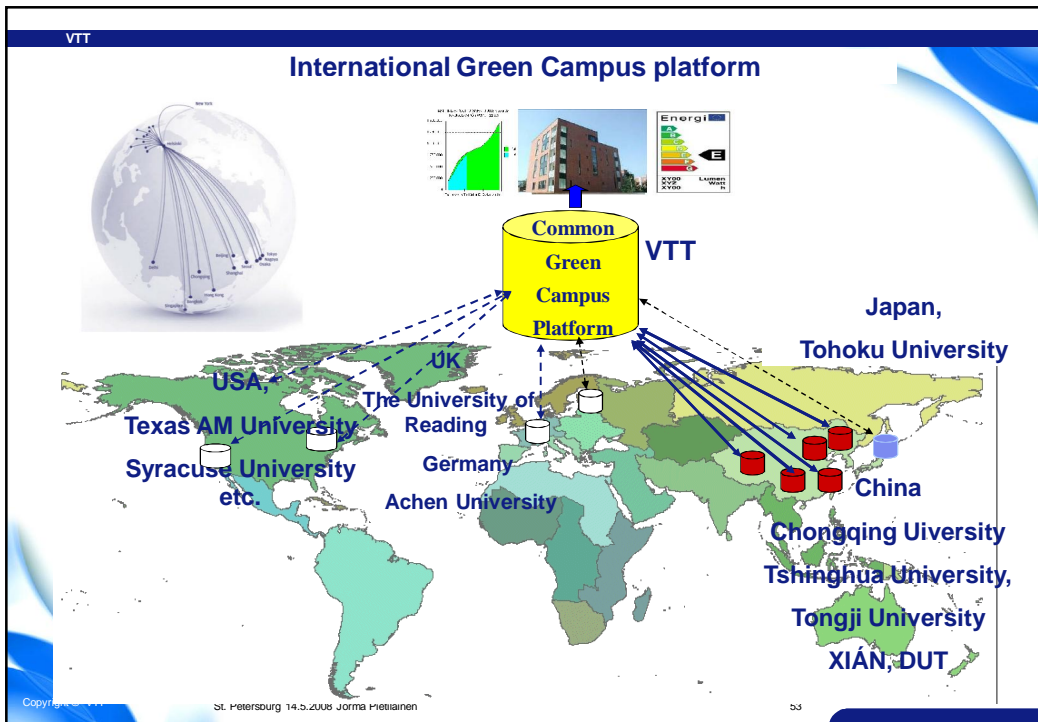
- As the 9th parameter that can be visualised the program shows the thermal comfort index (IEQ index)
- Comfortable room temperature = green; red = too hot, blue = too cold

IEQ index (temperature/CO<sub>2</sub>/etc.)

Target values of temperature (FISIAQ Cat S2)

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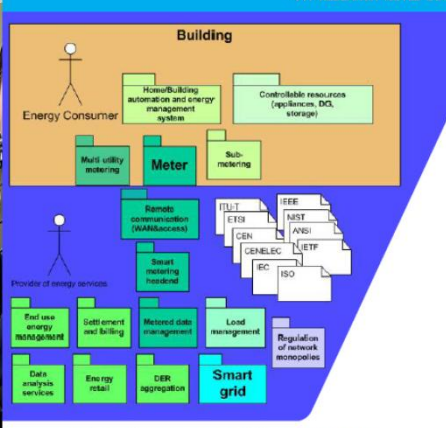


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## Smart Meters - new data source for performance assessment!

Helsingin Sanomat - Microsoft Internet Explorer

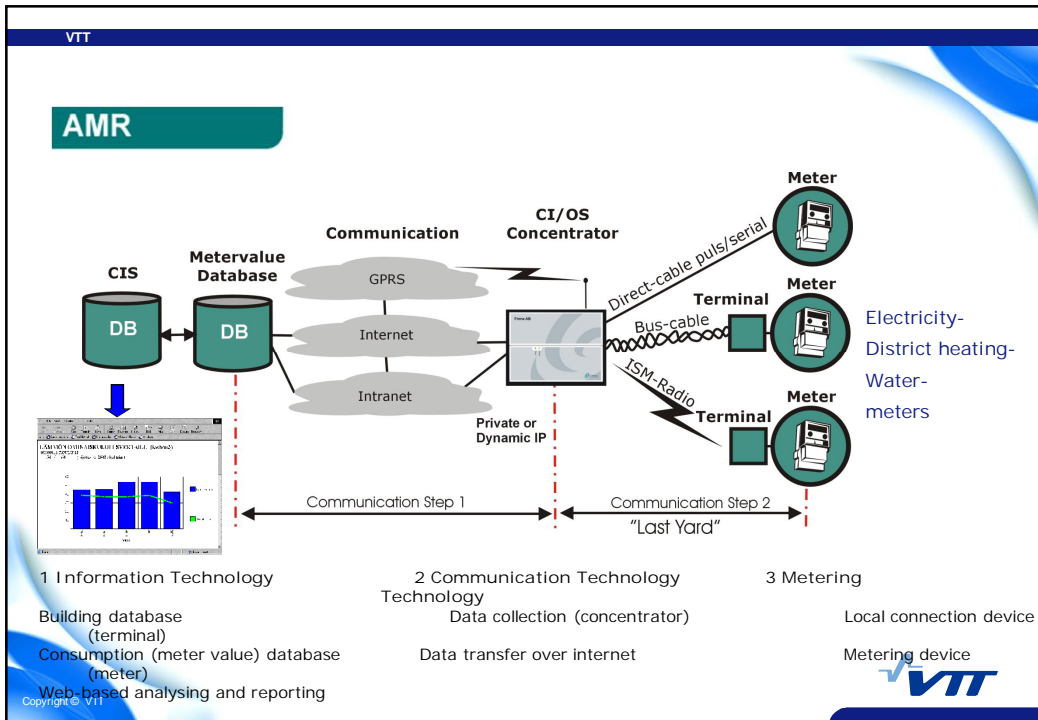
VTT RESEARCH NOTES 2542

Pekka Koponen, Marja-Leena Pykälä, Janne Peltonen & Pasi Ahonen

### Interfaces of consumption metering infrastructures with the energy consumers

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## GreenCampus – Demonstrating New Technologies

The image shows an aerial view of a campus with several technology-related labels overlaid:
 

- AMI** (Advanced Metering Infrastructure) labels are placed in several locations across the campus.
- DR** (Demand Response) labels are also present.
- EV Charger** labels are shown in red circles.
- LOC-EMS** (Local Energy Management System) is shown in a blue circle with a downward arrow.
- PV System** (Photovoltaic System) is shown in a red circle.
- A central image shows a computer workstation with multiple monitors displaying data.
- Another image shows a row of electrical meters.
- A third image shows a modern building with a glass facade.

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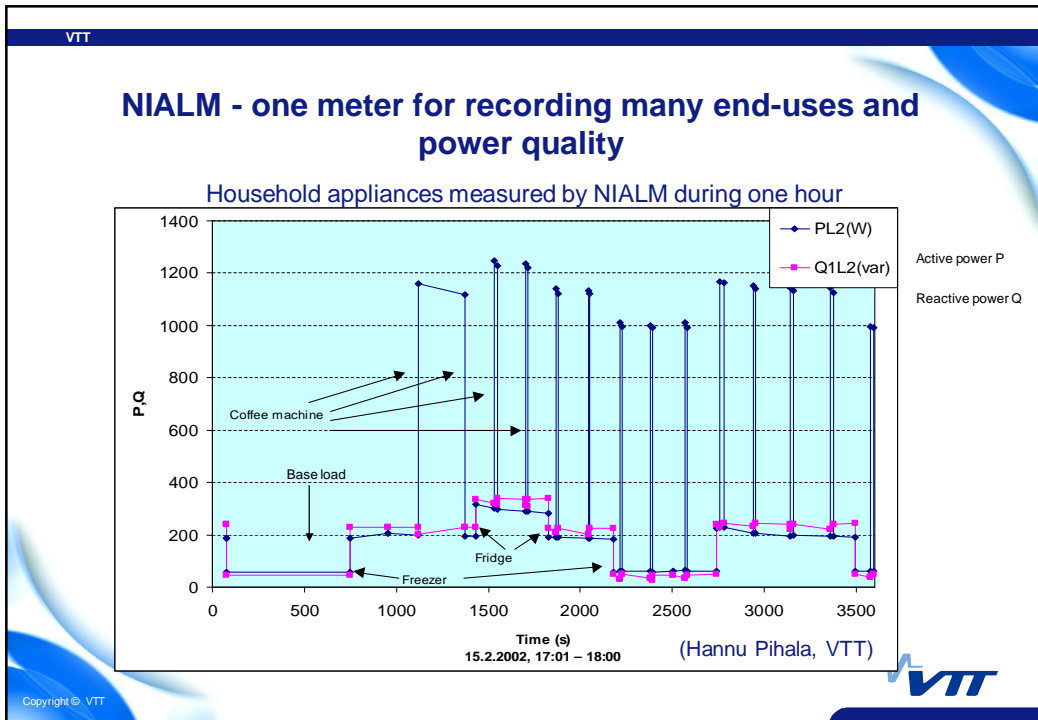
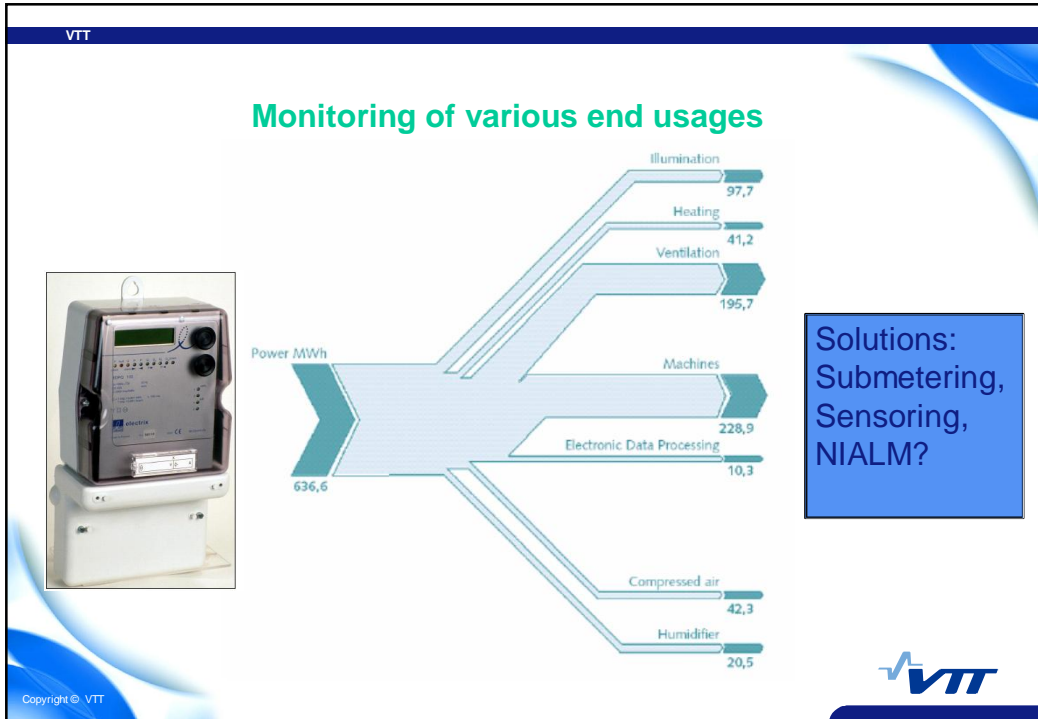
## MxElectrix – NIALM Meter

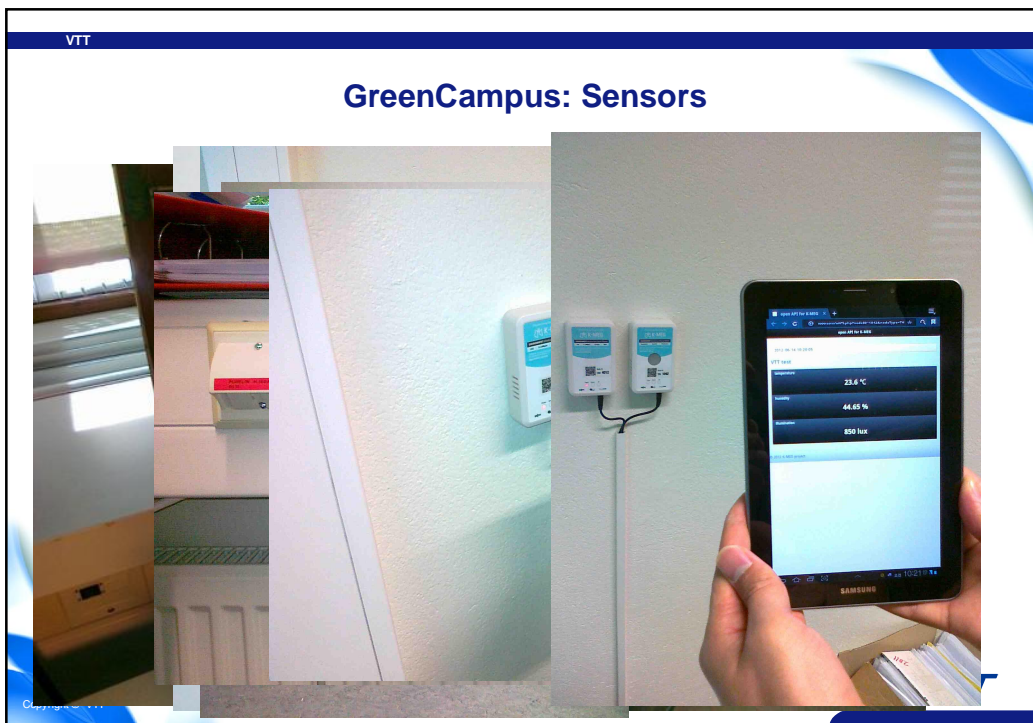
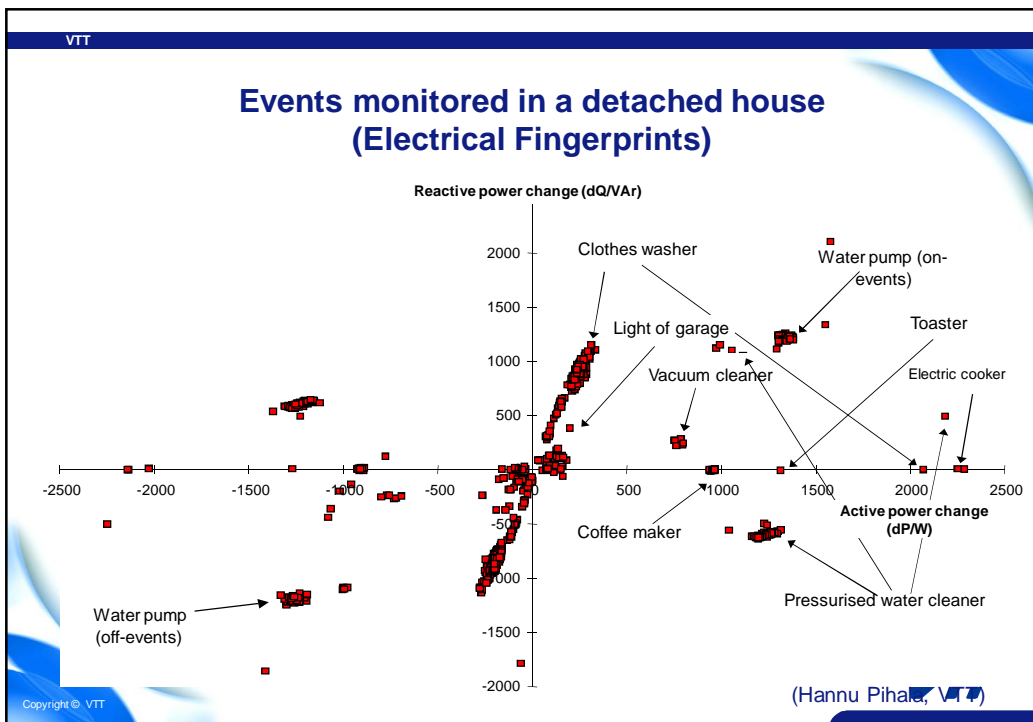
### eQL Meter 2.0

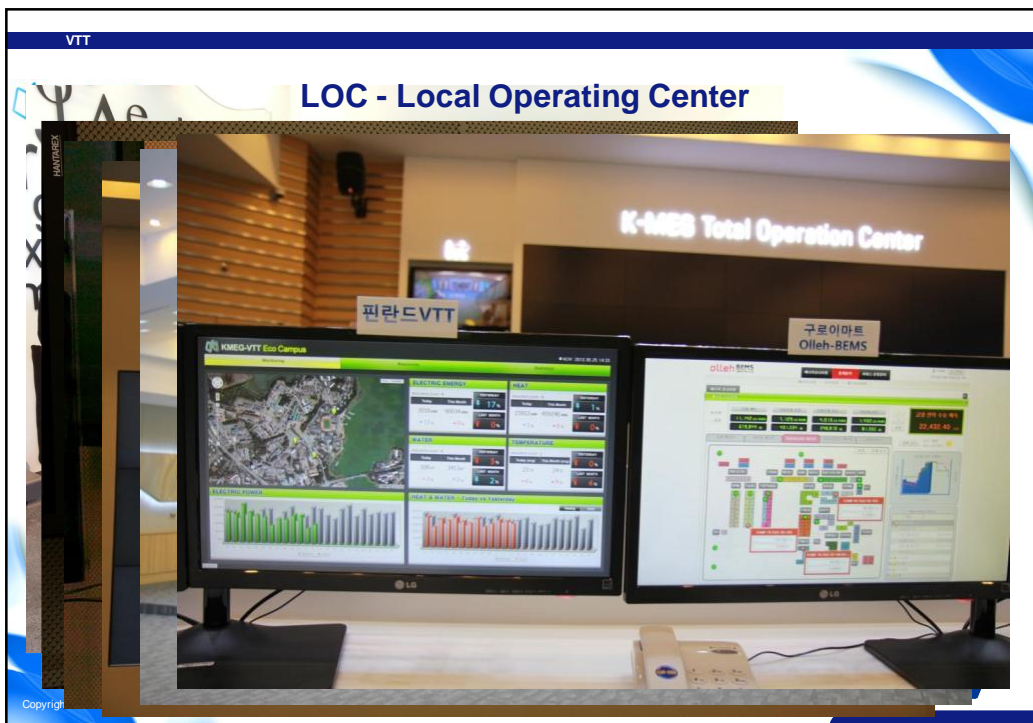
- \* Energy/Voltage quality meter
  - \* Remote reading
    - \* 3G
    - \* Ethernet (TCP/IP)
  - \* Energy measurement: active power and reactive power
    - \* P+, P-, Q+ ja Q-
  - \* Voltage quality measurement
- \* Meter version:
  - \* Direct connection: 3\*400/230 V, 5(60) A, 50Hz
  - \* LV-measurement: 3 \* 400/230 V, 5 A, 50 Hz
  - \* MV-measurement: 3 \* 100/57,7 V, 5 A, 50 Hz

The image shows a photograph of the MxElectrix eQL Meter 2.0, a three-phase energy and voltage quality meter. It is a grey and white device with a digital display and various ports on the front panel.

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## The establishment of campus energy management system (CEMS)

Energy Monitoring  
 Energy Efficiency Management  
 Energy Audit  
 Energy Efficiency Retrofit  
 Energy Conservation Education

Expand the CEMS to Over 200 Univ.s

Source: Shuqin Chen, Tongji University

## China Green Campus Network!

中国绿色建筑与节能专业委员会绿色校园学组

**学组新闻**

- 2013-10 2013.10.31 2013“国际绿色校园行动”系列研讨会顺利召开
- 2013-05 2013.05.23 2013 全国大学生绿色校园概念设计大赛 获奖作品公示
- 2013.05.20 绿色校园学组与同济大学材料学院活动简报
- 2013.05.20 《绿色校园评价标准》(发布稿) 20130309
- 2013-04 2013.04.03 吴志强教授获得中国绿建委表彰
- 2013.04.03 绿色校园学组再次获得中国绿建委表彰
- 2012-11 2012.11.25 第九届中外绿色人居论坛
- 2012.11.21 2013 全国大学生绿色校园概念设计大赛通知
- 2012.11.07 中国绿色建筑与节能专业委员会《绿色校园评价标准》(送审稿) 通过审查
- 2012-09 2012.09.17 2012世界屋顶绿化大会会议通知

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## International Green Campus Network!

The screenshot shows the ISCN website with the following member lists:

- AMERICAS**
  - Ball State University
  - Boston Architectural College
  - Brown University
  - Carnegie Mellon University
  - Chatham University
  - Columbia University
  - Georgetown University
  - Harvard University
  - Johns Hopkins University
  - Massachusetts Institute of Technology
  - Monterey Institute for Technology and Higher Education
  - Pontifical Catholic University of Peru
  - Stanford University
  - The University of British Columbia
  - Universidad Internacional del Ecuador
  - University of Pennsylvania
  - Yale University
- EUROPE**
  - Aalto University
  - Cyprus University of Technology
  - Ecole Polytechnique Fédérale de Lausanne (EPFL)
  - Eindhoven University of Technology
  - Institut Européen d'Administration des Affaires (INSEAD)
  - KTH Royal Institute of Technology
  - Lappeenranta University of Technology (LUT)
  - London School of Economics
  - Politecnico di Milano
  - Swiss Federal Institute of Technology (ETH Zurich)
  - Università Ca'Foscari Venezia
  - Università degli studi di Milano (UNIM)
  - University of Cambridge
  - University of Gothenburg
  - University of Luxembourg
  - University of Oxford
- AFRICA**
  - University of Cape Town
- ASIA**
  - Indian Institute of Technology Madras
  - Keio University
  - Nanyang Technological University
  - National University of Singapore
  - Peking University
  - Shandong Jiaotong University
  - The University of Hong Kong
  - Tsinghua University
- AUSTRALIA**
  - The University of Melbourne
  - The University of Western Australia

ISCN members come from over the world and share sustainability goals and performance indicators in ISCN-GULF Charter Reports

CHARTER REPORTS

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## Feedback information to all users of campus!


The photograph shows a large digital display on a university campus. The display shows a bar chart titled "Energy Consumption of the University of Jyväskylä". The chart displays energy consumption data for various buildings over time. Below the chart, the date and time are shown: "2011年11月06日 星期日 15:24:34". People are seen walking past the display, and a bicycle is parked nearby.

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## Do as I say! - and as I do myself!

### Leading by Example!



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The next killer app: mobility?

CS Week offers up a wealth of consumer-facing thought practice

Kate Rowland | May 10, 2012

At the risk of dating myself, behind-the-scenes at utility conferences reminds me a lot of a popular musical from the early 1950s. "What's the Buzz? Tell me what's a-happening!"

This was certainly the case at CS Week last week.

The customer is front-and-center in the next-generation utility. This is not a new revelation. But the ways in which this is playing out in terms of customer-facing technology and services is moving rapidly forward, and this was evident in the numerous sessions, the exhibit hall floor, and in the "buzz" of discussions throughout



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