International Conference

Solar Energy and Architecture
Innovation and Development

medidaverde

Solar Energy Integration in an Urban Environment: A Systems Perspective

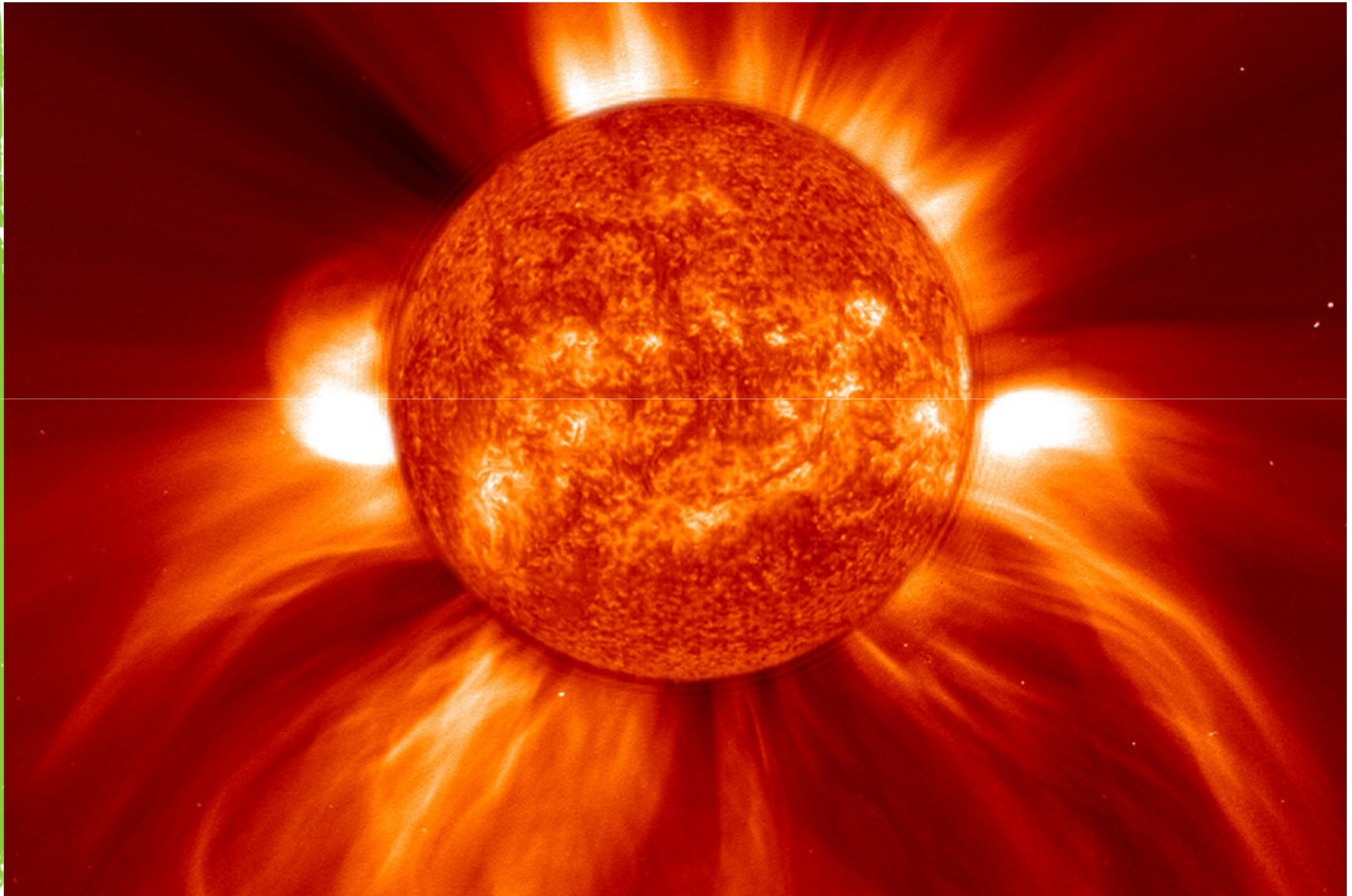# *OR...*

The Sun and the City

We will be talking about 3 things:

- **The Sun**
- **Buildings**
- **Cities**

The Sun

What about the Sun?

- Is behind all life on Earth

- Is dependable and predictable as an energy source, statistically speaking

- *In 90 minutes, enough energy from sunlight strikes the earth to provide the entire planet's energy needs for one year*

Source: IEA

- All of this energy is in the form of electro-magnetic radiation

- We can approximate solar irradiation to approximately 1.000 W/m2

So where's the "Energy Crisis"?

• Solar Energy changes from moment to moment, and there is no sun at night. The sun doesn't care when we "need" energy

• We can't cover the earth's surface with solar collectors…then again, we don't need to

• Electromagnetic radiation is, except for parts of the spectrum, not very useful *directly*

We need technology in the form of solar systems to convert sunlight to other forms of energy, store it, and put it to work!

What we get and what we need

What We Get

1 Thing only – Radiation

What We Need

Light

Heat

Cold
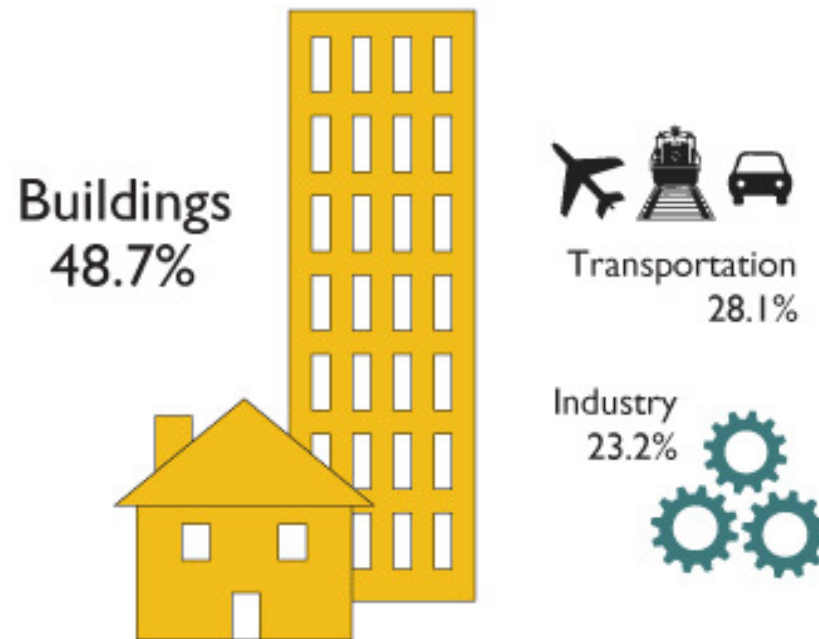
Electric Power

Humanity's first "solar system"

Humanity's first "solar system"

Why are Buildings important?

- **We spend most of our lives in Buildings**

  - **At Home**
  - **At Work**
  - **At Play**

- **Buildings are the world's prime energy consumer!**

Why are Buildings important

Buildings
48.7%

Transportation
28.1%

Industry
23.2%

U.S. Energy Consumption by Sector

Source: ©2011 2030, Inc. / Architecture 2030. All Rights Reserved.
Data Source: U.S. Energy Information Administration (2011).

If you look at electricity, buildings consume over 75% of electrical energy in the U.S

Solar Resource and Building Energy Needs

- ## Light
  - ### Windows and Similar devices/construction elements
  - ### Light collection devices
  - ### Interior and Exterior artificial Lighting

- ## Heating and Cooling
  - ### Building Envelope (roof, walls and windows)
  - ### Solar collectors
  - ### Absorption Chillers

- ## Electric Power
  - ### Photovoltaics
  - ### Low-Enthalpy Solar Thermal Systems (ORC)

Solar Energy in Buildings: Key Questions

- Is there enough of it?

- Can we transform it to *what* we need

- Can we store it for when we need it?

Is there enough of it?

• **Generically, YES!**

Remember, 1000 W/m2 – In Lisbon, on *average, 5600 Wh/m2 per DAY through the year*

Is there enough of it?

My household consumes ~500 kWh of electrical energy and ~450 kWh of natural gas per month, on average

At 60% conversion efficiency for thermal energy (solar thermal collectors) and 13% for electrical energy (photovoltaics), that equates to 4,5 m2 of solar thermal collectors and 23 m2 of photovoltaic panels

Can we transform it to what we need?

medidaverde
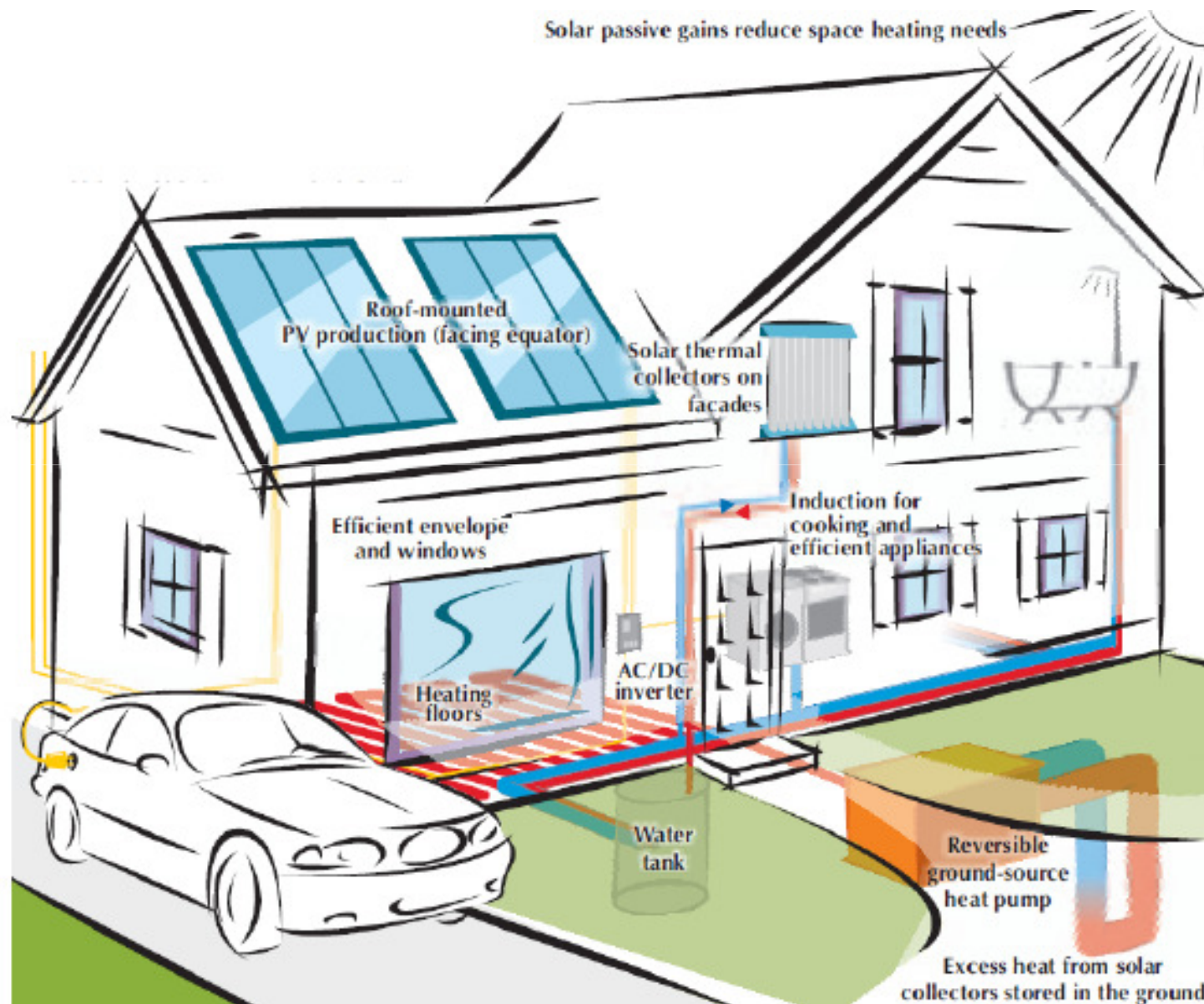
YES!
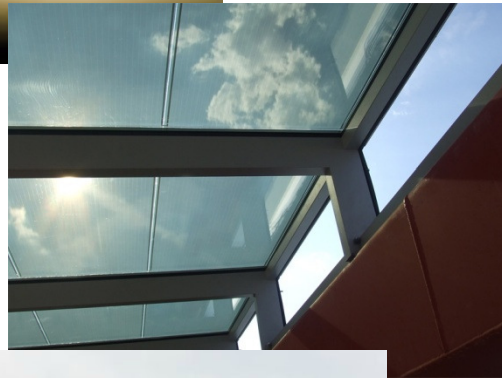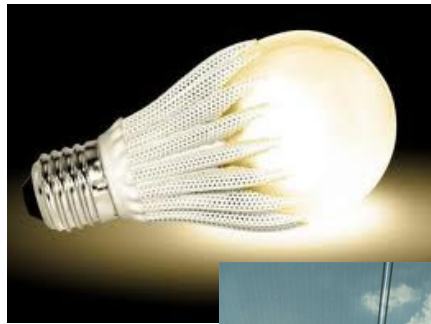
Can we Store it for when we need it?

To an extent….

•Yes for short-term use, albeit not too efficiently
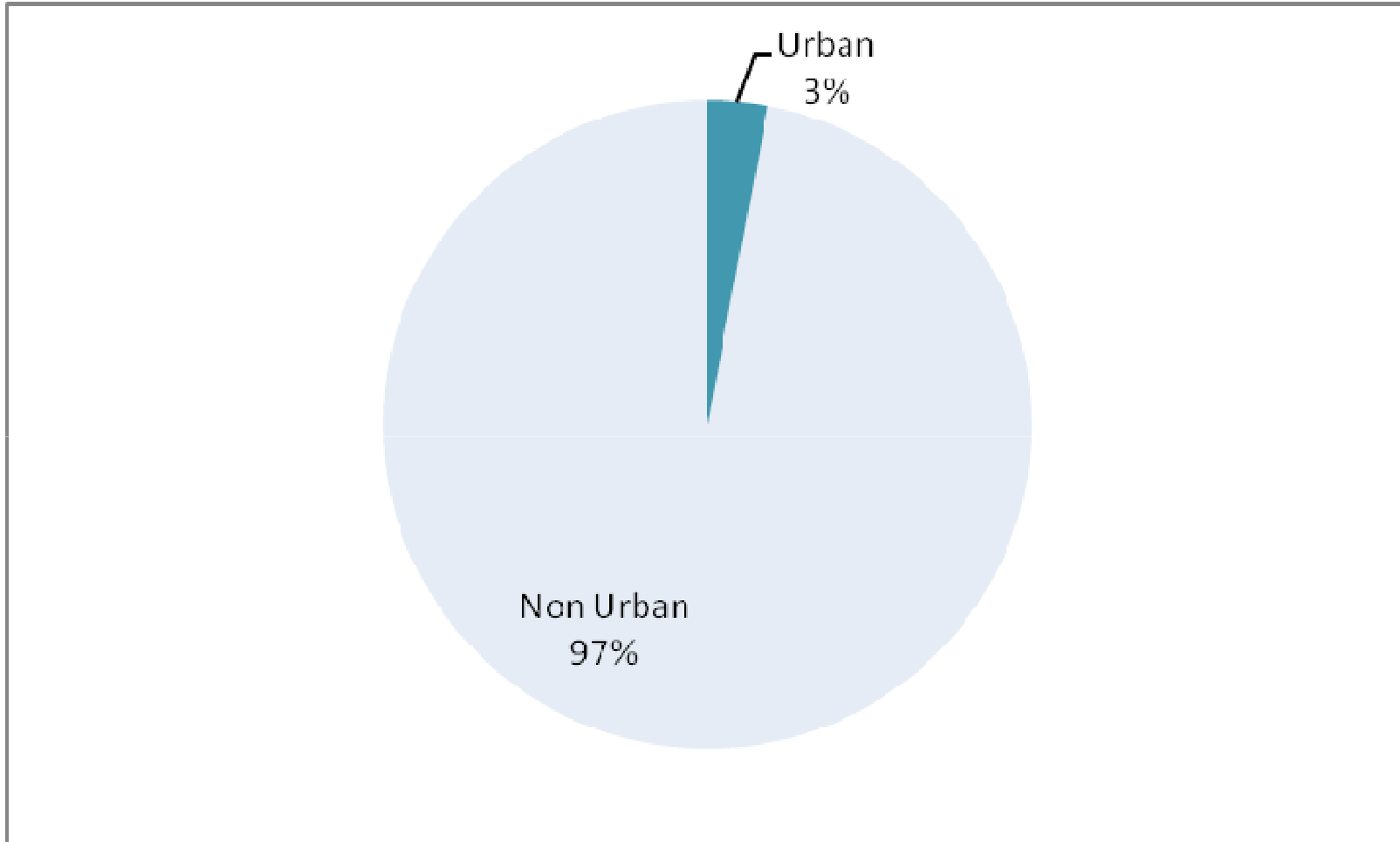
•Not really (yet!) over the long term

Easier to store heat than electricity, light can't be stored directly

This is a key area for development
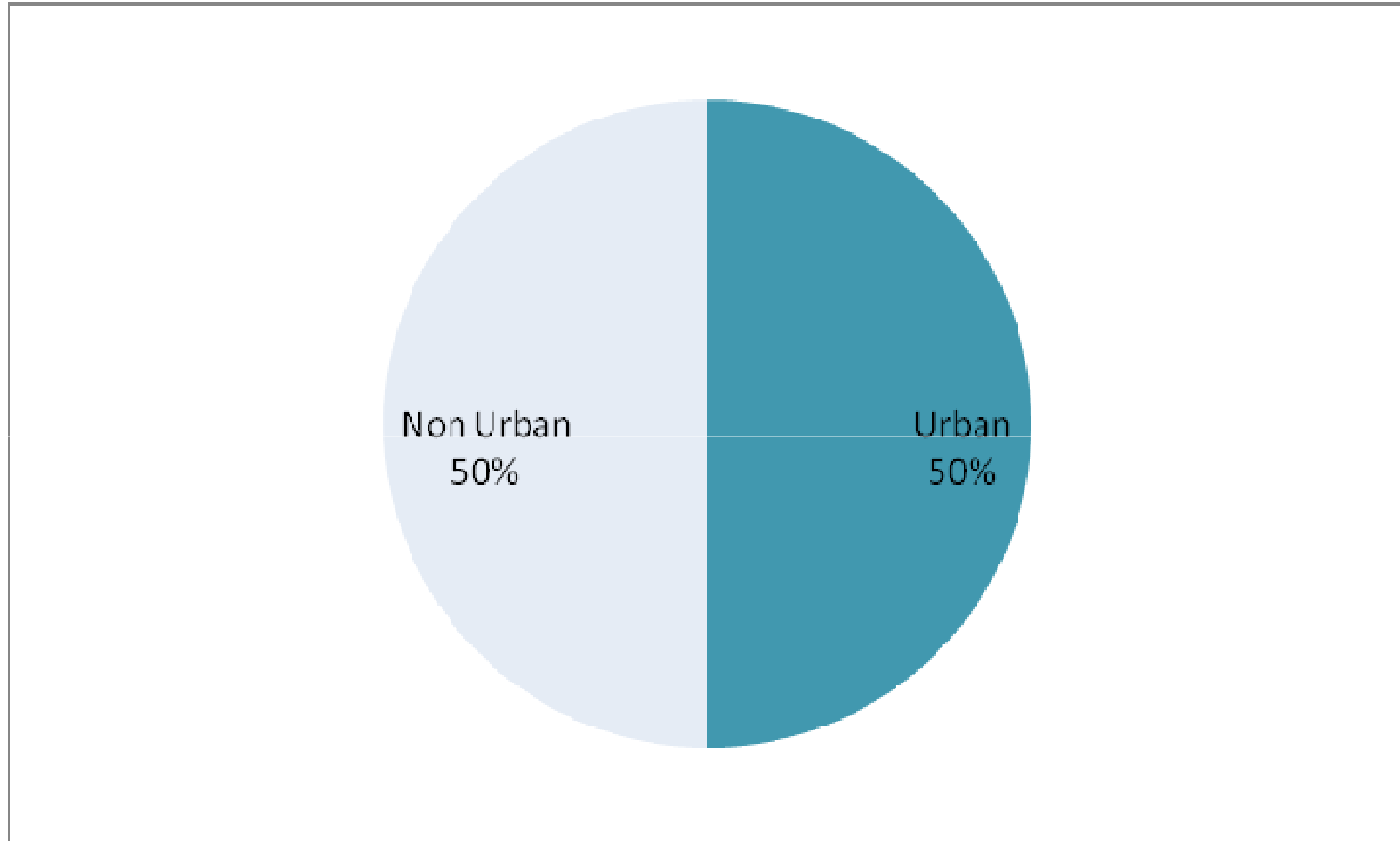
Can we transform it to what we need?

Solar passive gains reduce space heating needs

Roof-mounted PV production (facing equator)

Solar thermal collectors on facades

Induction for cooking and efficient appliances

Efficient envelope and windows

Heating floors

AC/DC inverter

Water tank

Reversible ground-source heat pump

Excess heat from solar collectors stored in the ground

Why are cities Important?

World Population, *circa* 1800

Why are cities Important?

World Population, Today

Why are cities Important?

Non Urban
40%

Urban
60%
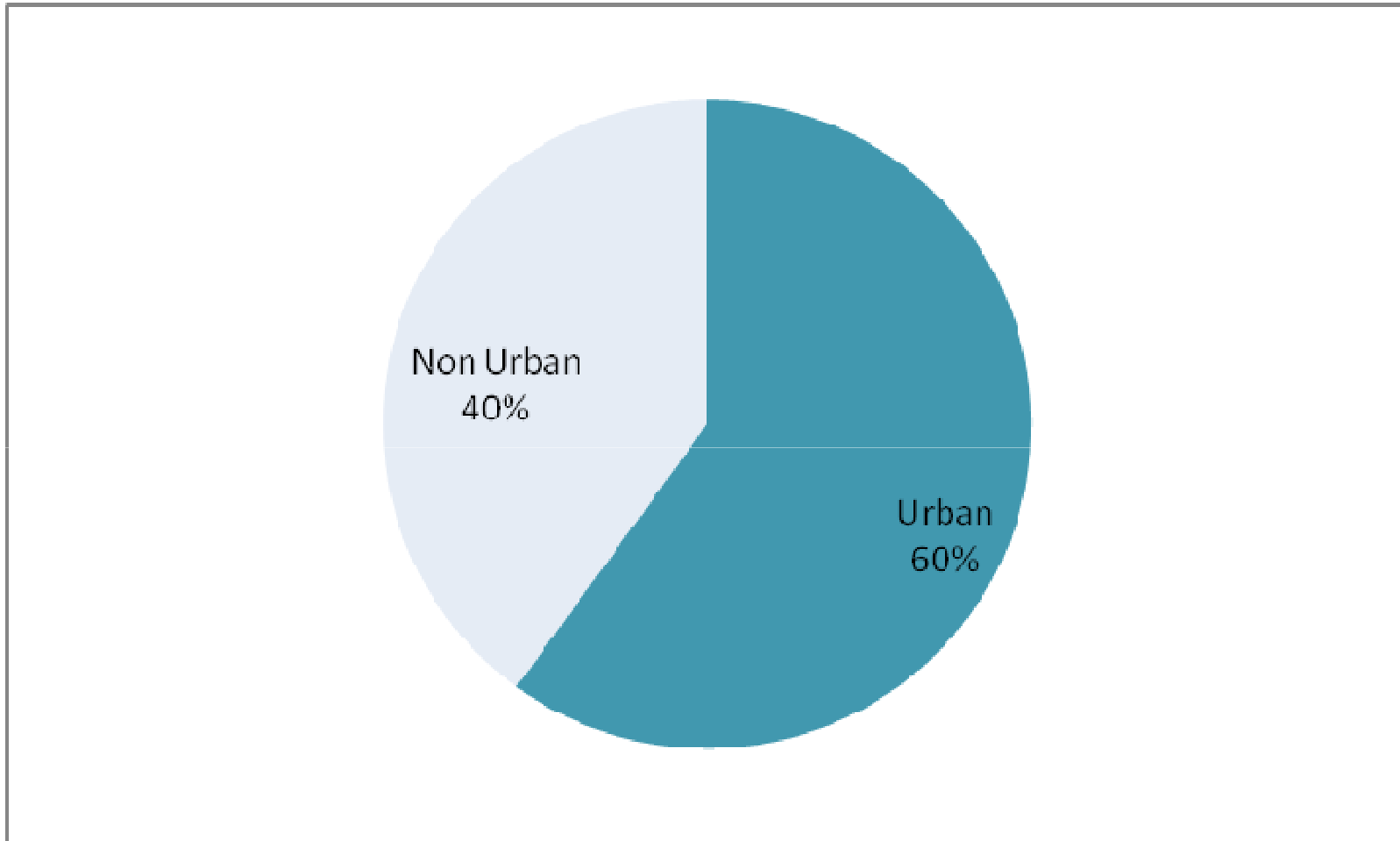
World Population, 2030 Forecast

Cities are *Different*

Cities are compact collections of people, buildings and things

Space and spatial constraints (e.g. other buildings) become a potentially conditioning factor....

Is there enough of it?

My building has 12 tenants and 400 m2 roof area, half of it facing south

Which comes out to 54 m2 of solar thermal 276 m2 of photovoltaics

Is there enough room? Just barely, in this case (and not at optimal positioning!)

Cities are *Different*

Cities are inherently *Service Networks*

- Streets/Roads
- Transportation
- Water
- Telecommunications
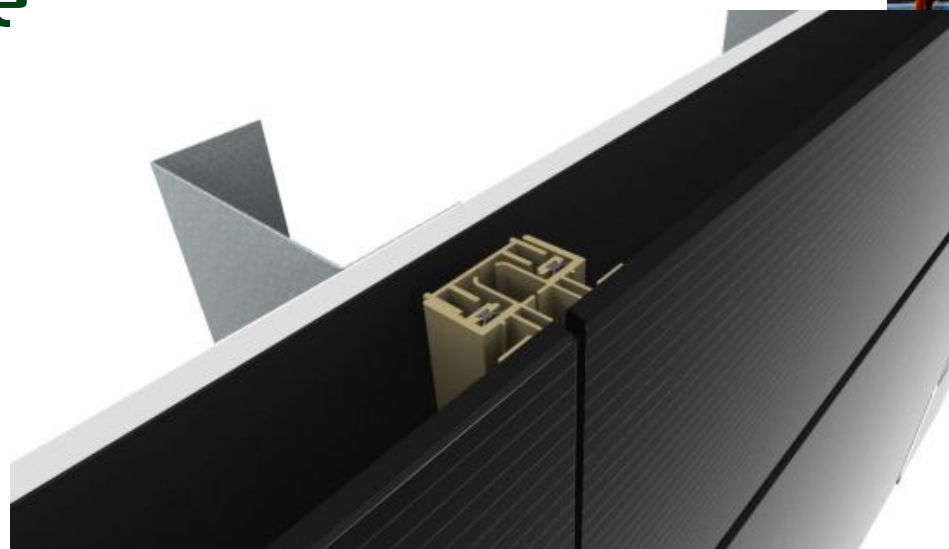- Electrical Energy
- Thermal Energy

Networks allow us to *share things*

- Storage is currently a limiting factor
- Why store when we can share?

So….

To overcome spatial limitations, we have to be more efficient and creative in using the solar resource

We can and should use the *networked nature* of cities to *provide* and *share* the resource

Cities are *Different*

We need to think in terms of Energy Systems

So......

As the system grows, we need more intelligence:

About what our energy *needs* are
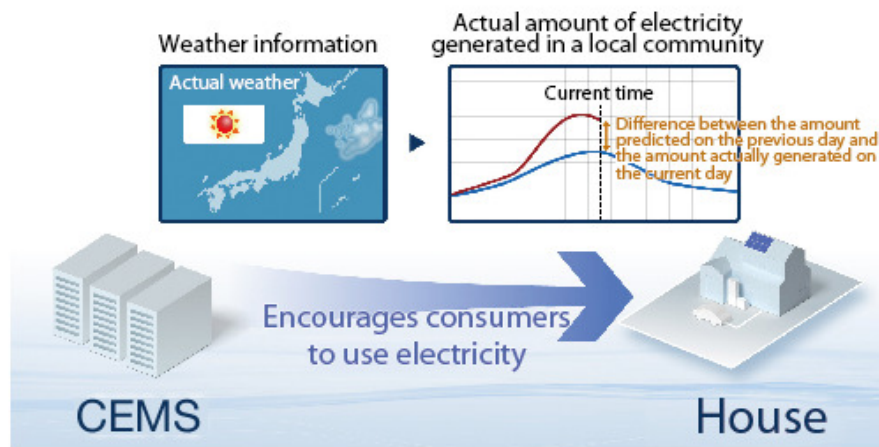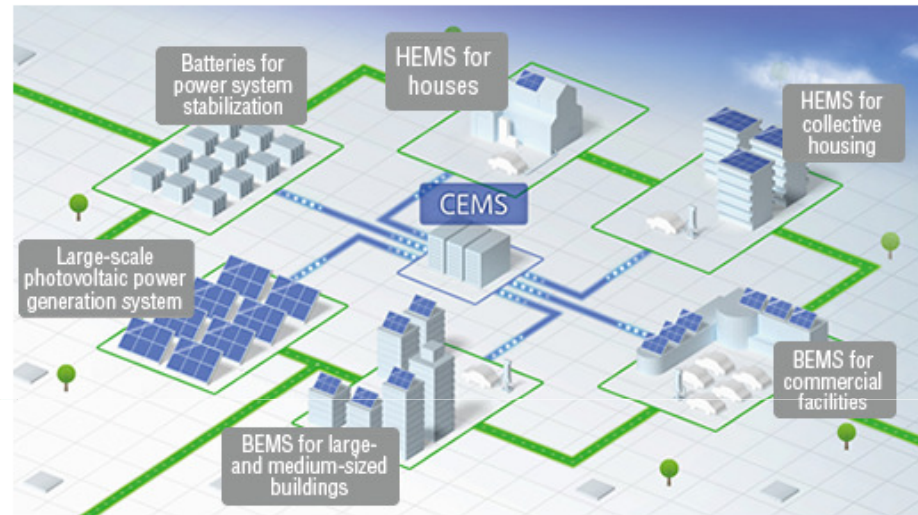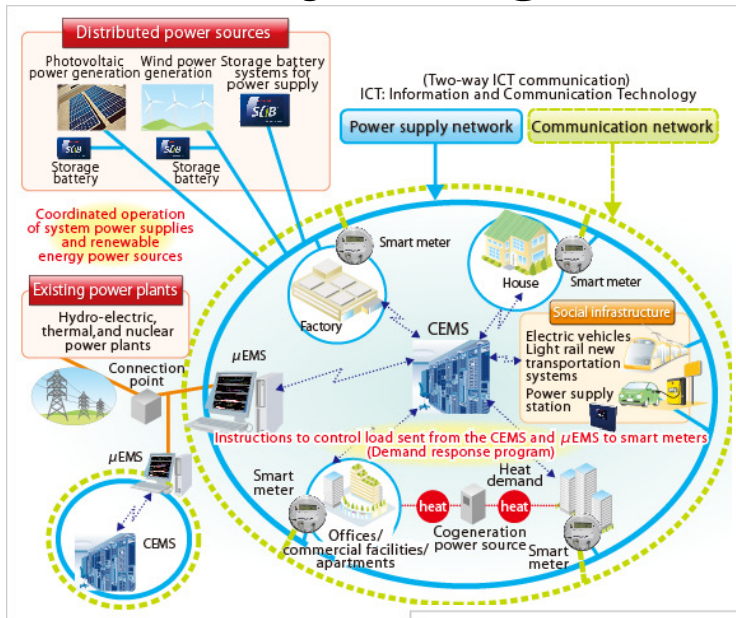About what our energy *supply* is
About *where* we can place surpluses or source shortfalls

This is *not* as easy! It requires a lot of "smartness" in devices, buildings and cities.
Both technology and regulatory change is required

So…..

As the system grows, we need more intelligence

Key Issues and Pointers

We need to start thinking of "solar" not as a technology but as a construction element

We need to to think in terms of Systems

We need to start seeing buildings and cities as functional spaces and service systems

We need to design and use buildings and cities as providers of these services and not just consumers

We need to work together!

We need to be intelligent about it!

Thank You!

Contacts
Augusto Carvalho
augustocarvalho@medidaverde.com