CARIBBEAN EXAMINATIONS COUNCIL

CAPE GREEN ENGINEERING WEBINAR

UNIT 2: APPLICATION OF GREEN ENGINEERING PRINCIPLES

Sustainable Utilization of Materials & Energy

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CARICOM Secretariat

Friday, 12 June 2020

SUSTAINABLE UTILIZATION OF MATERIALS & ENERGY

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- The Fundamentals
- Overview: Materials
- Overview: Energy
- Responsible Use of Materials & Energy: The Circular Economy
- Industrial Ecology: Principles & Practices
- Live Interactions

THE FUNDAMENTALS

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- **Atoms, Molecules & Compounds**

  ATOMS

  MOLECULES

  COMPOUNDS

THE FUNDAMENTALS

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- **Principles of Bonding**

  THE CHEMICAL BOND

  THE PHYSICAL BOND

THE FUNDAMENTALS

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- **Chemical Reactions**

Example: COMBUSTION

$CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (g) +$ **heat**

THE FUNDAMENTALS

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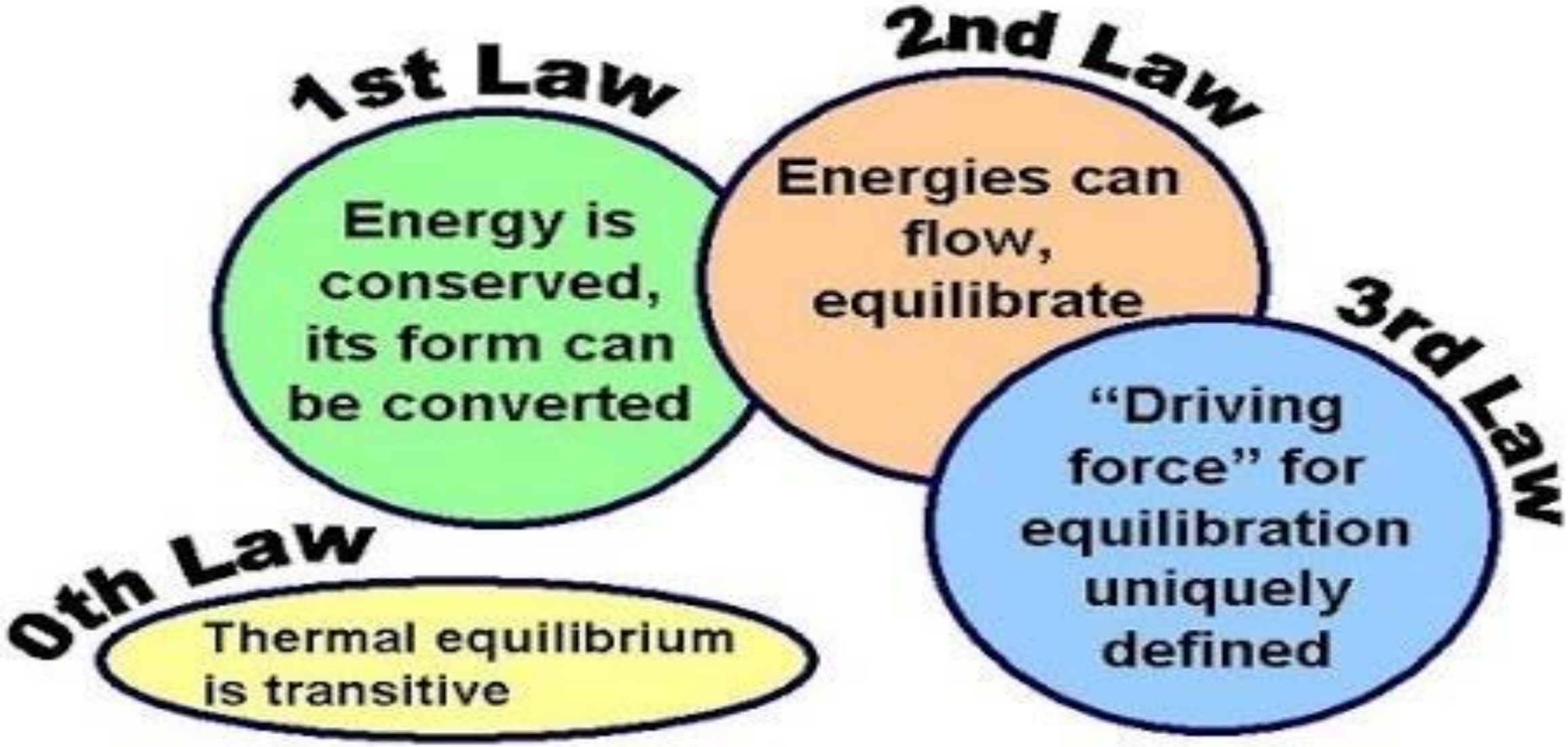
- **HOW FAR, HOW FAST?**

  THERMODYNAMICS

  KINETICS

The Thermodynamic Laws



MATERIALS

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- **Types of Materials**

  ORGANIC

  INORGANIC

MATERIALS

- **Some Organic Materials**

  Biopolymers

  Synthetic polymers

MATERIALS

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- **Some Inorganic Materials**

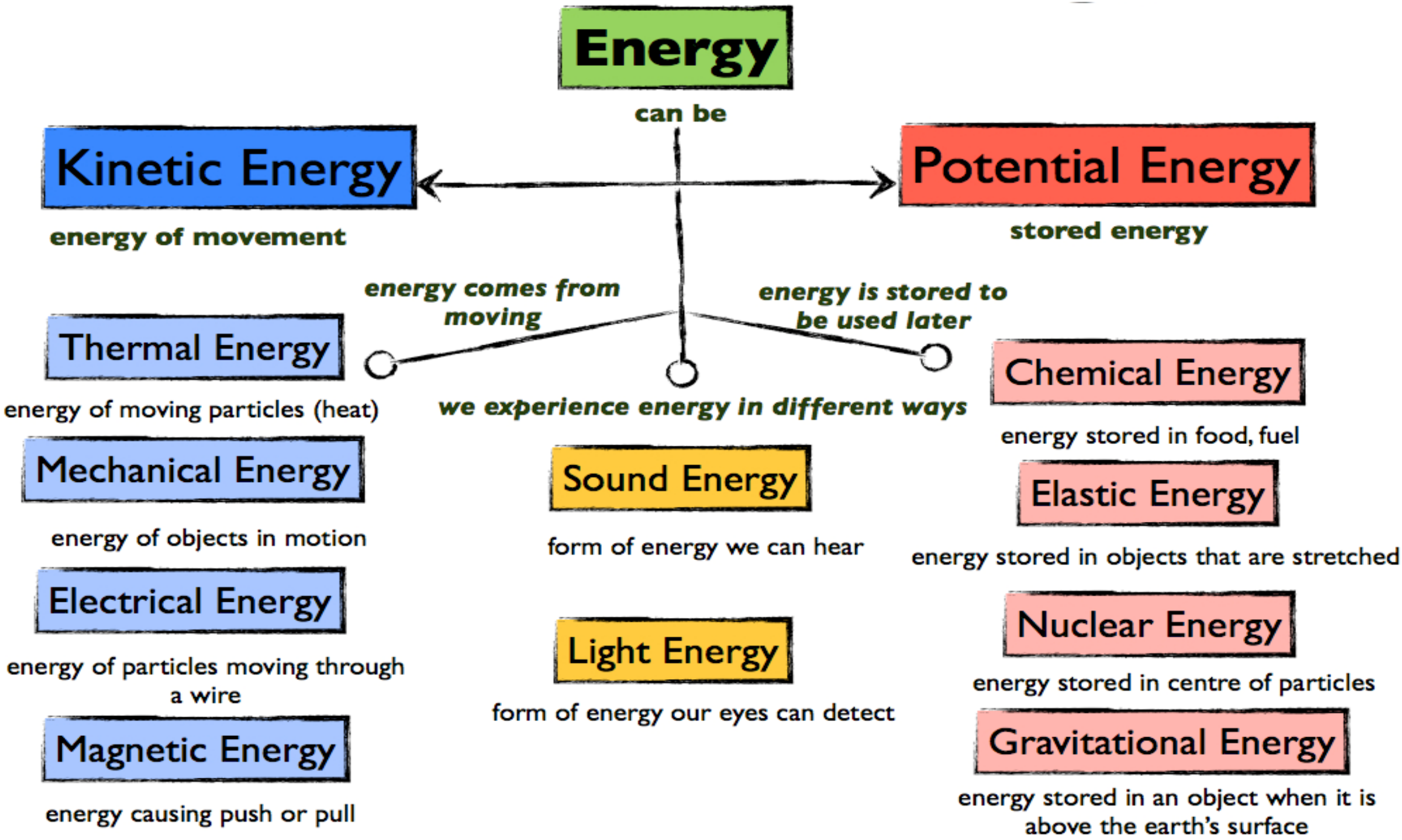
  Metallic compounds

  Composite compounds

  Ceramic compounds

MATERIALS

- **Nano-materials**


Energy
can be
Kinetic Energy
energy of movement
Potential Energy
stored energy
energy comes from moving
energy is stored to be used later
Thermal Energy
energy of moving particles (heat)
we experience energy in different ways
Chemical Energy
energy stored in food, fuel
Mechanical Energy
energy of objects in motion
Sound Energy
form of energy we can hear
Elastic Energy
energy stored in objects that are stretched
Electrical Energy
energy of particles moving through a wire
Light Energy
form of energy our eyes can detect
Nuclear Energy
energy stored in centre of particles
Magnetic Energy
energy causing push or pull
Gravitational Energy
energy stored in an object when it is above the earth's surface

ENERGY

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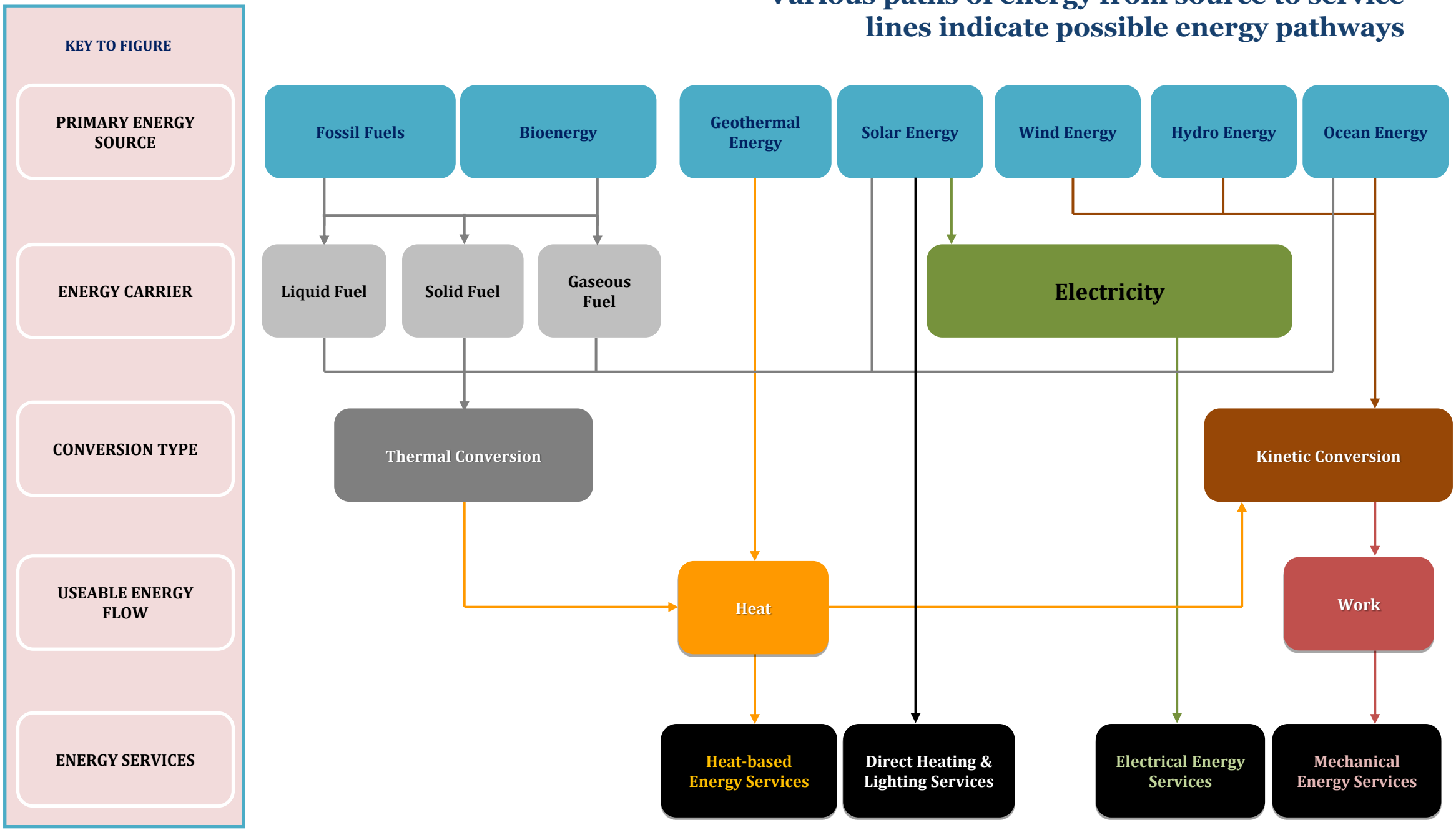
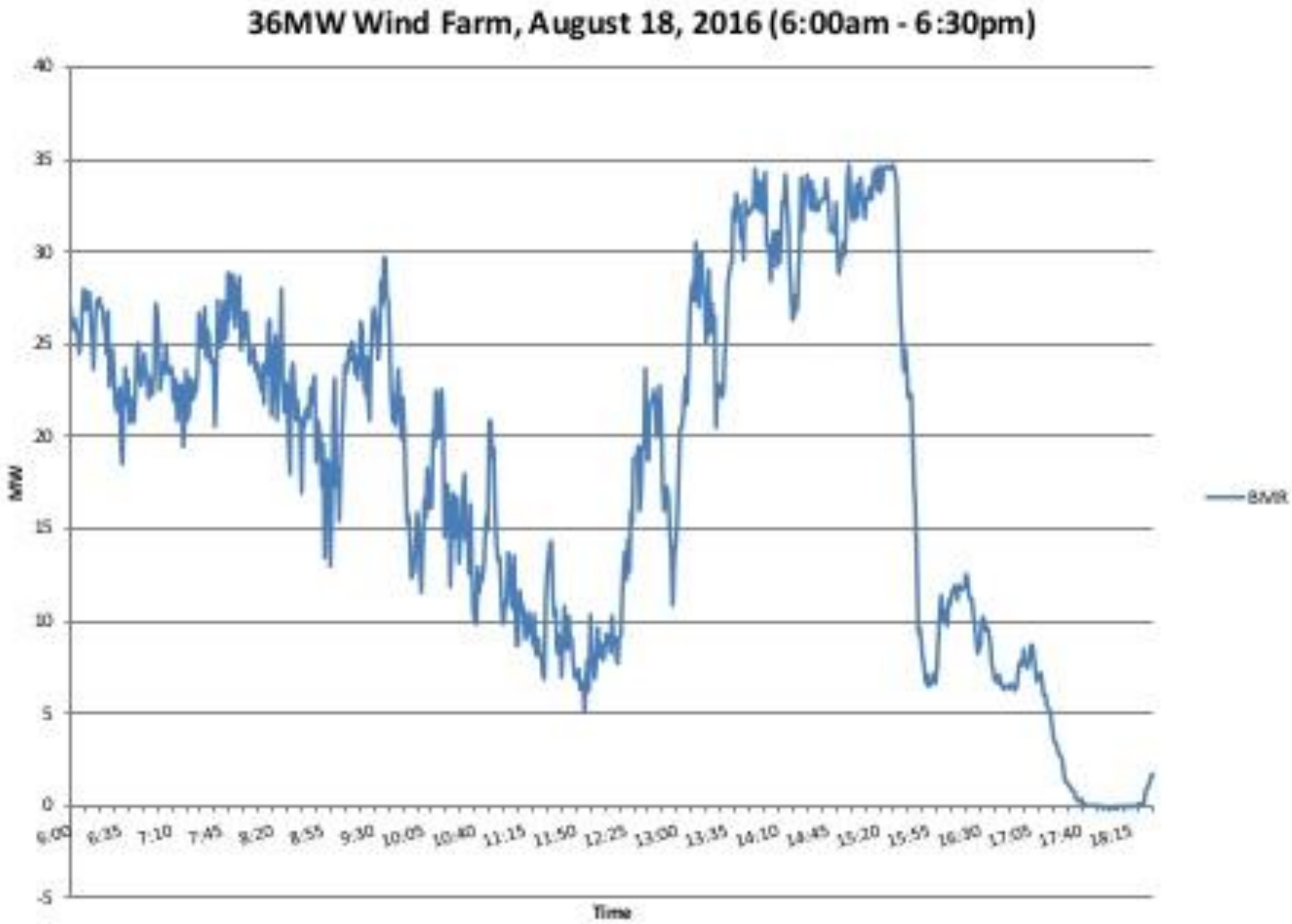
- **How is energy typically, produced, delivered & used?**

Various paths of energy from source to service lines indicate possible energy pathways




36MW Wind Farm, August 18, 2016 (6:00am - 6:30pm)
MW
40
35
30
25
20
15
10
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0
-5
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6:35
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7:45
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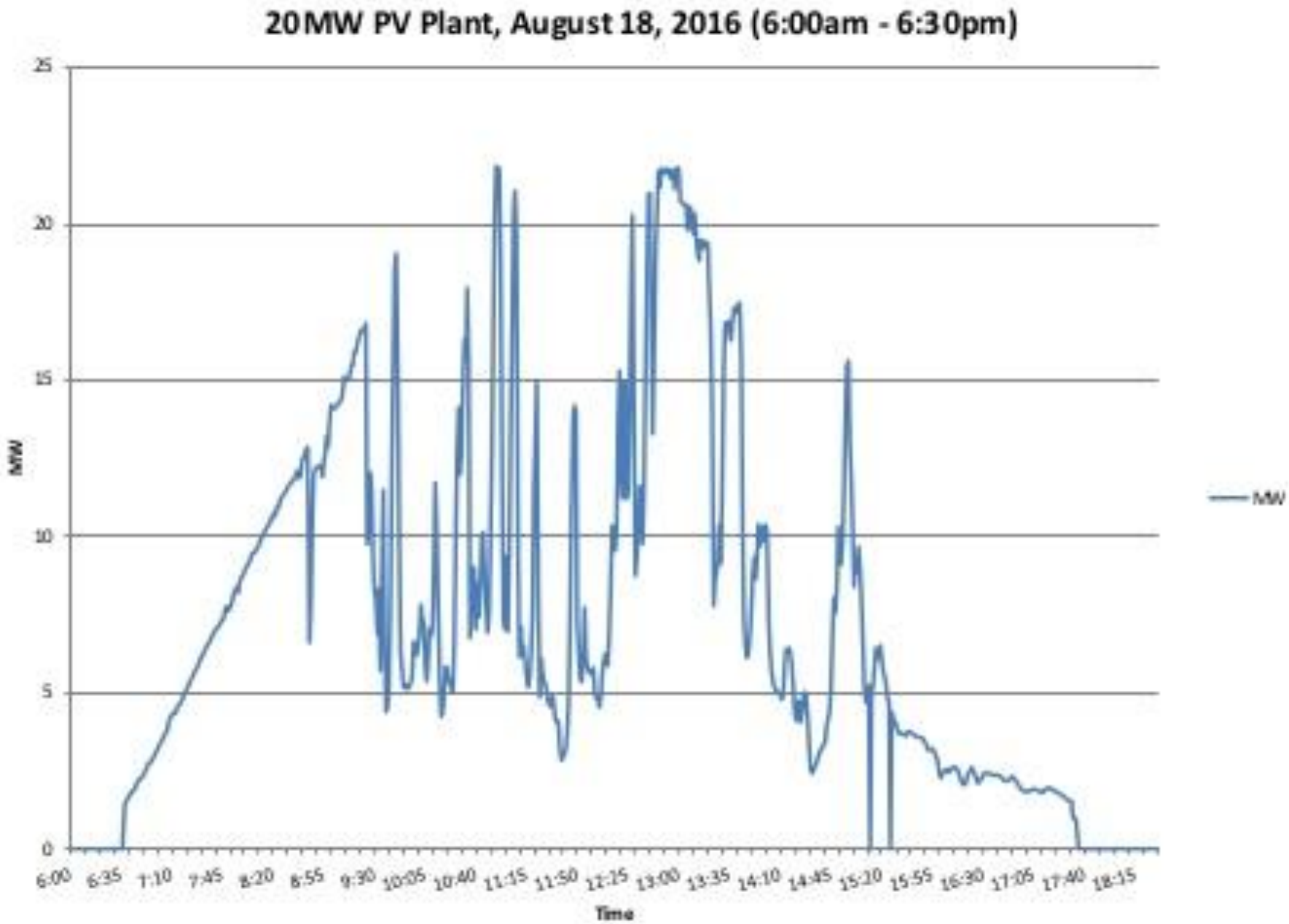
18:15
Time
BMR


20MW PV Plant, August 18, 2016 (6:00am - 6:30pm)
25
20
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MW
6:00
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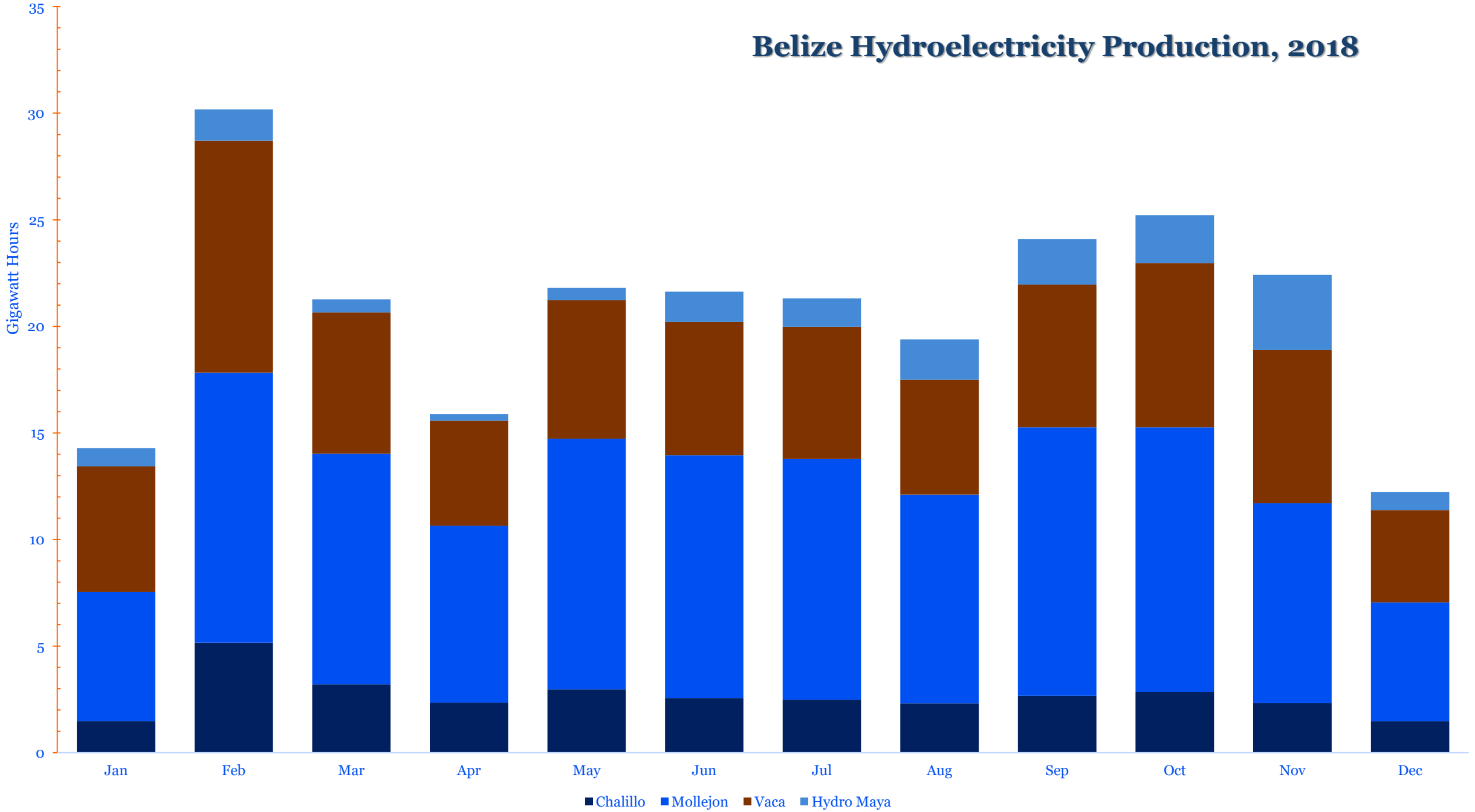
18:15
Time
MW

Belize Hydroelectricity Production, 2018



St. Thomas, U.S. Virgin Islands
September 2017

RESPONSIBLE USE OF MATERIALS & ENERGY

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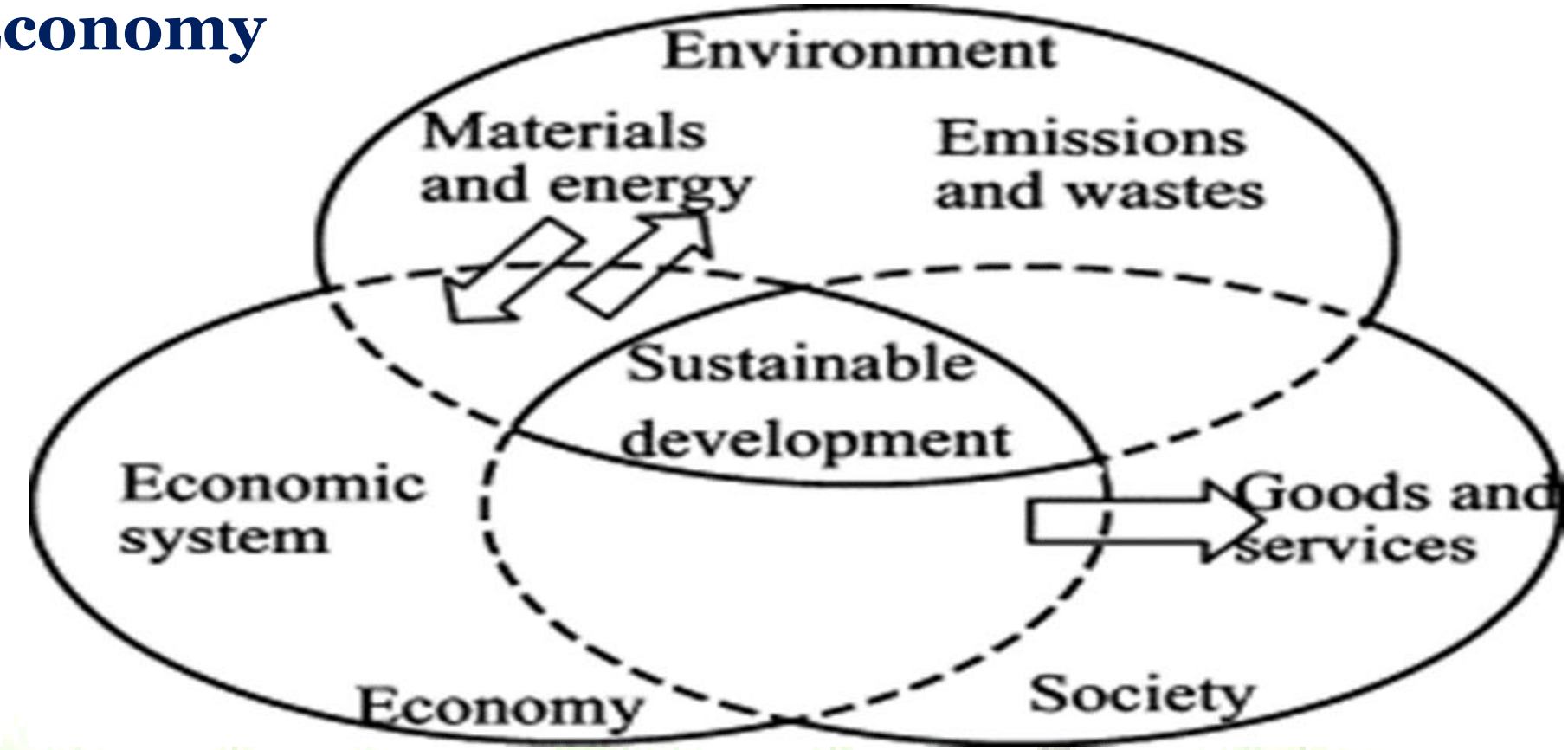
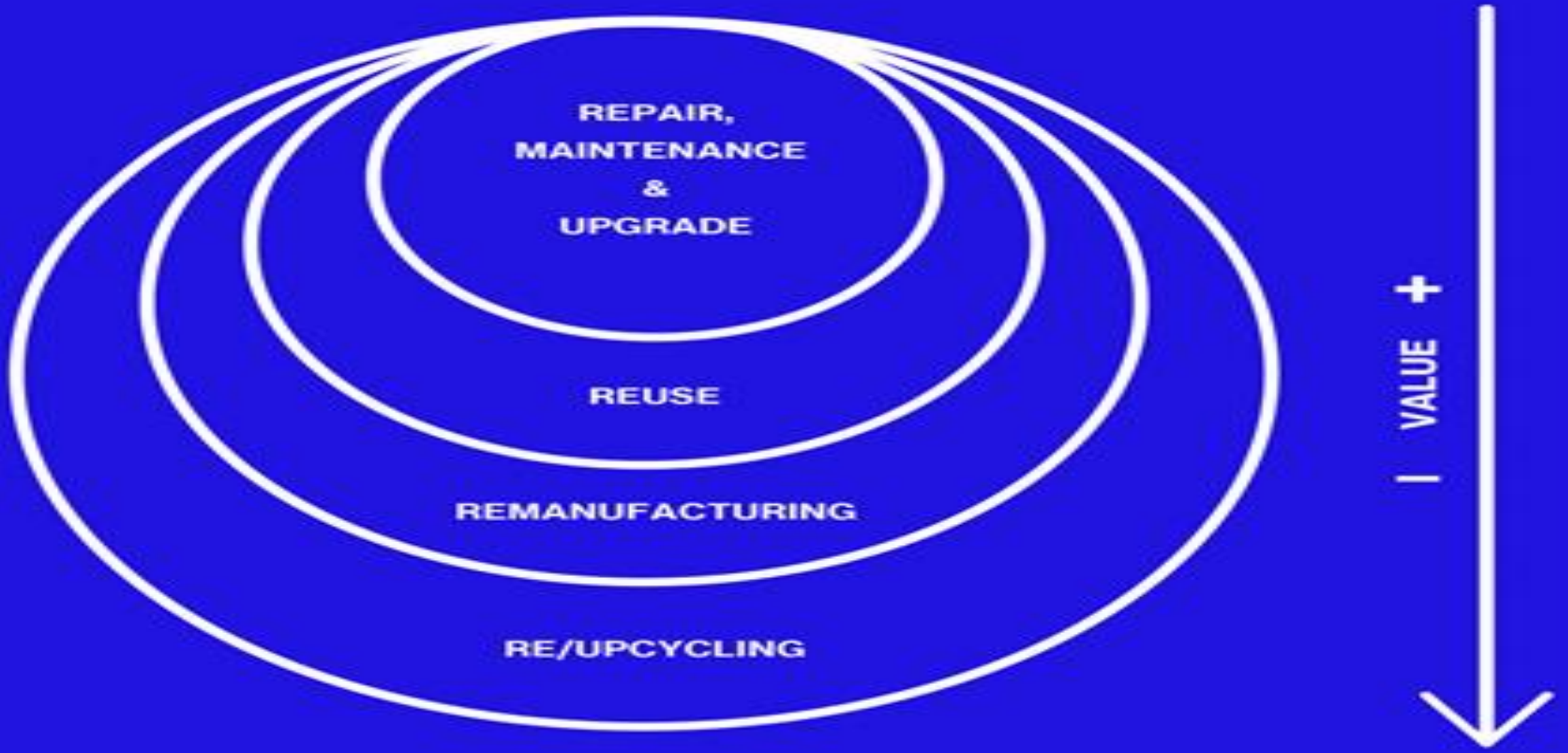
- **The Circular Economy**




REPAIR,
MAINTENANCE
&
UPGRADE
REUSE
REMANUFACTURING
RE/UPCYCLING
VALUE +

- **Energy Balance:** Identify all energy inputs including energy to operate equipment and energy content of raw material.

  What fraction of the input energy is "recovered" in process outputs?

- **Material Balances**: Account for the fate of all the raw material inputs - such as air, water, etc. - in the process.

  What portion of the materials entering the process is contained at the exit stage?

- **Technical Feasibility Esssentials:** Identify the thermodynamic and kinetic performance limits of the process and the degree to which the available technology hardware provides safe and reliable operation.
  - **Scale at which performance has been suitably proven**
  - **Technology readiness levels**
  - **Supporting Infrastructure**
  - **Project Location**
  - **Timescale**

- **Environmental Considerations:** Identify the current and future effect of the process on the local land, water and air resources and the economic cost of environmental protection, as well as the potential cost of clean-up and restoration, where necessary.
  - **Local Pollutants**
  - **GHG Balance**

Energy Hierarchy

Avoiding Unnecessary Energy Use
Re-organise systems so that energy use can be reduced to the minimum, for example by designing buildings to be warmed by the sun, using natural light and ventilation, or enabling people to get access to the amenities they want with fewer and shorter car journeys.

Use Energy more Efficiently
Finding ways of getting more benefit per unit of energy, for example by using higher efficiency appliances, generating heat and power together or insulating buildings better to retain heat.

Use Renewable Energy
Switch to less damaging low-carbon energy sources, especially renewables, for example solar and wind power, energy crops or hydro.

INDUSTRIAL ECOLOGY

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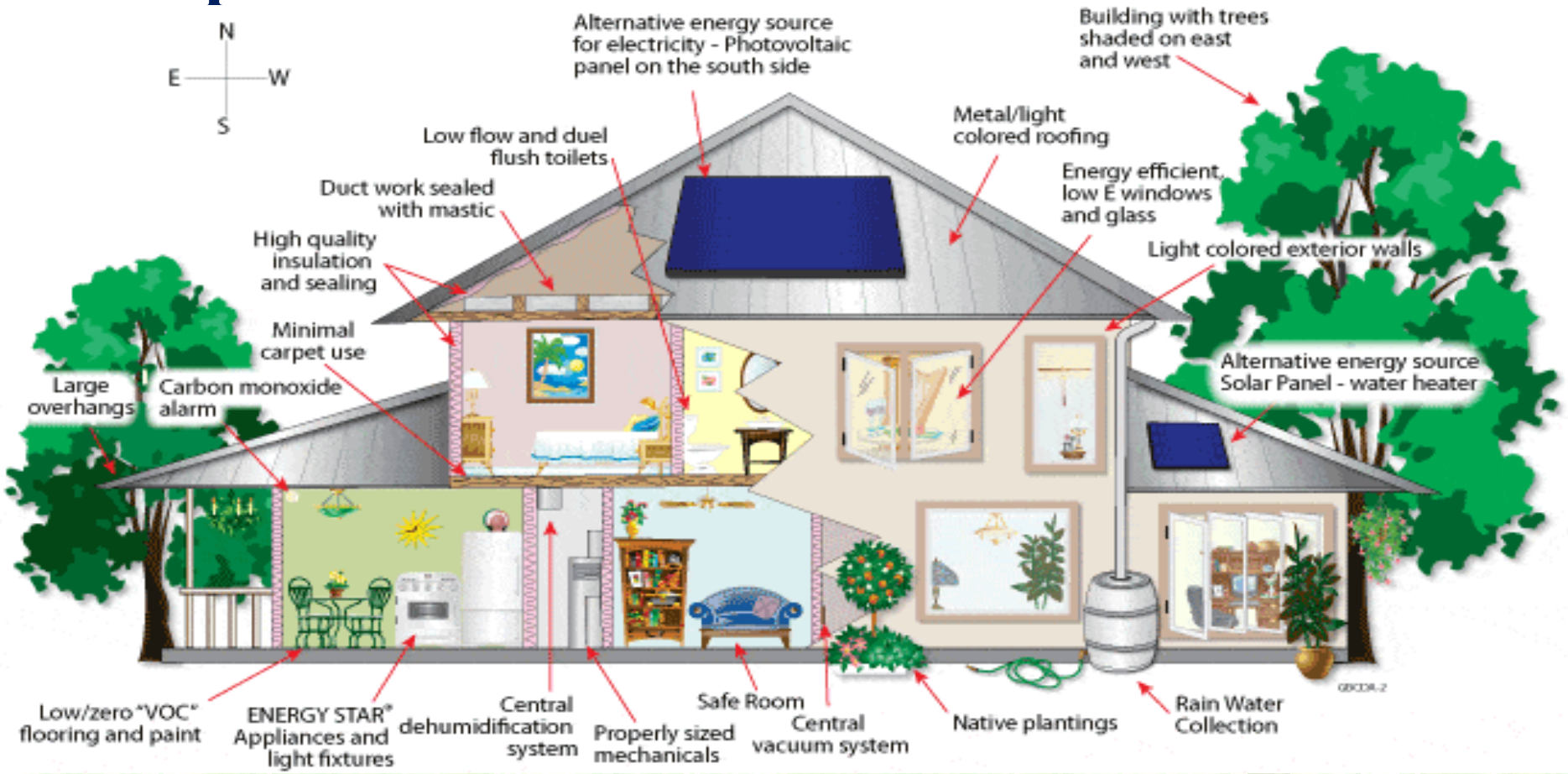
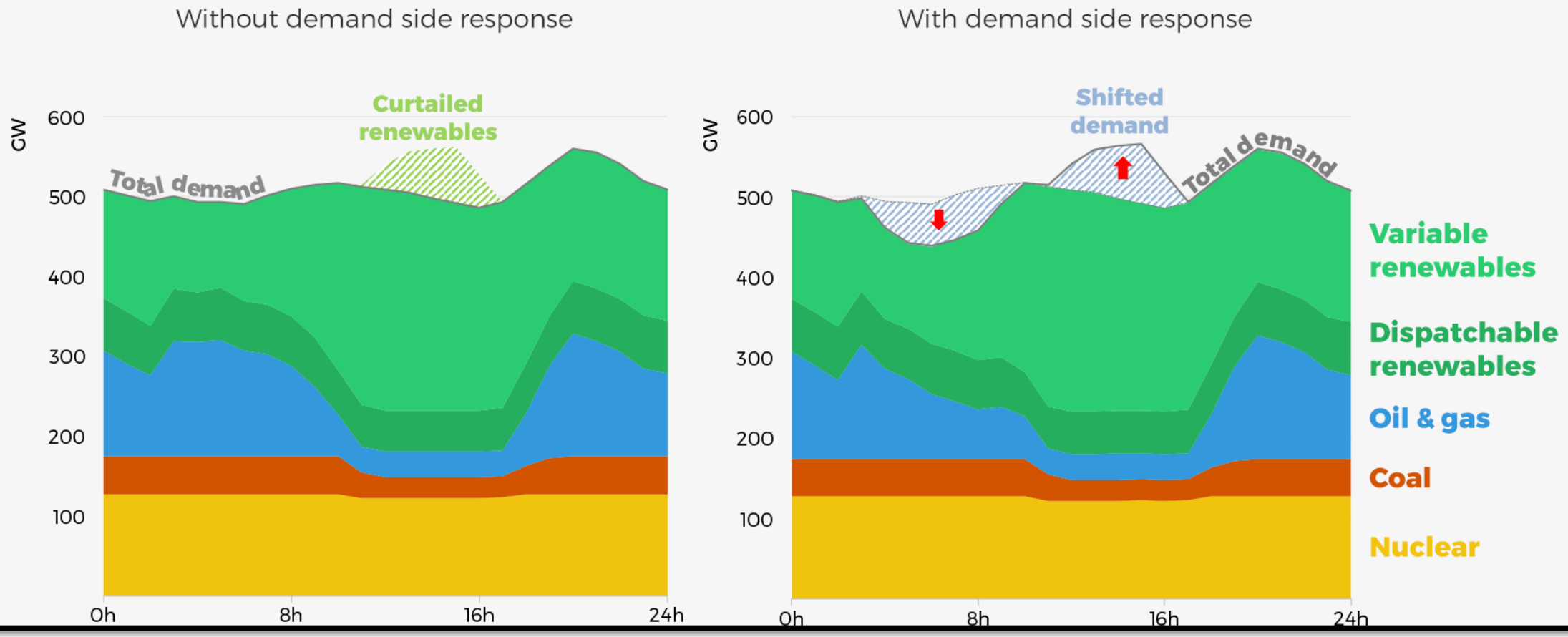
- **A Case Example**



Impact of demand response on a daily load curve

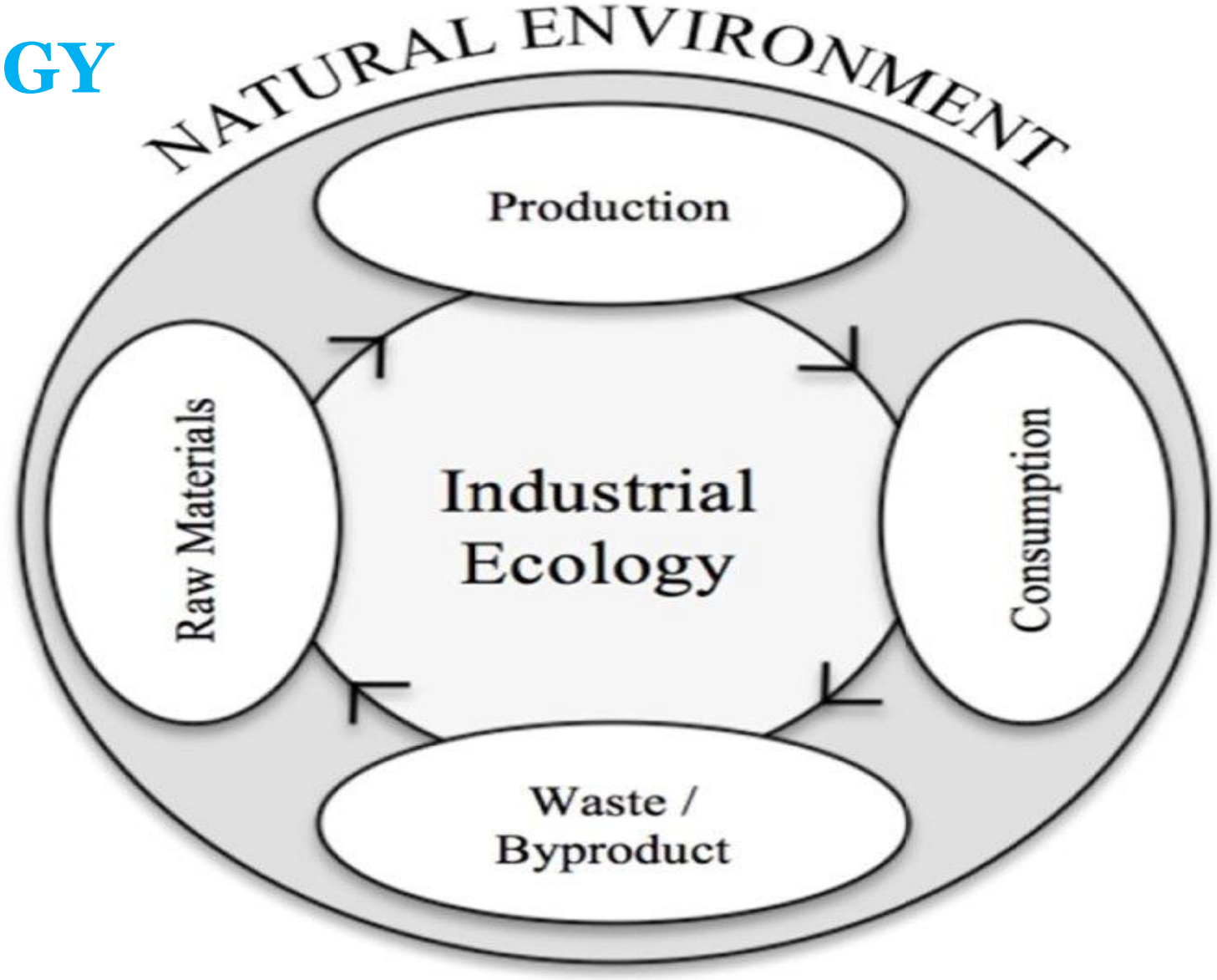
World Energy Outlook 2017

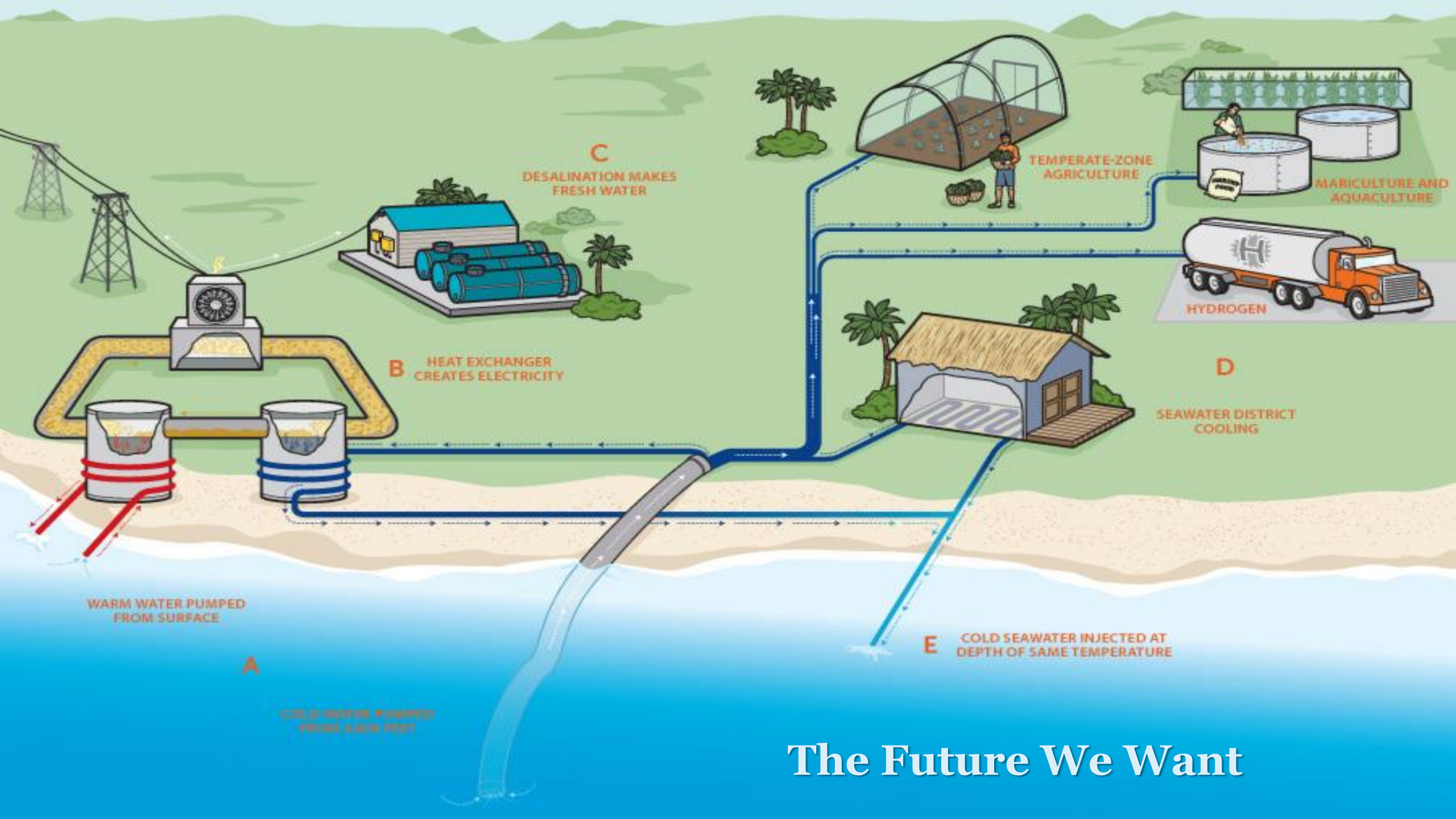


INDUSTRIAL ECOLOGY

Significant attention paid to resource efficiency, with focus on local resource use

- **RECYCLED & REUSED CONTENT**
- **NATURAL & RENEWABLE MATERIAL & ENERGY**
- **RESOURCE-EFFICIENT PROCESS**
- **LOCAL CONTENT**





The Future We Want

QUESTIONS

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QUESTIONS

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"For the things we have to learn before we can do them, we learn by doing them."

-Aristotle

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