CENTRO INTERUNIVERSITARIO
DI RICERCA PER LO SVILUPPO
SOSTENIBILE CIRPS

SAPIENZA
UNIVERSITÀ DI ROMA

Sustainability Transition: International Research Initiatives towards Resources-circulating Society

Energy Sustainability in the framework of Sustainability Science

Closed cycles of resources and their application to energy systems

Prof. Fabio Orecchini
Head of Energy and Environment Research Group
CIRPS – Interuniversity research centre for sustainable development
Sapienza University of Rome, Italy

ENERGY SUSTAINABILITY

A definition of Energy Sustainability within the platform of Sustainability Science based on the following priorities:

- **Renewability of energy resources;**
- **Efficiency in energy conversion, distribution, use;**
- **Lowering of environmental impact;**
- **Increasing of energy access;**
- **Tailor making of energy systems on local social-economic-environmental conditions**

ENERGY SUSTAINABILITY

Necessary cooperation between several key energy-related disciplines:

- **Environmental sciences**
- **Economics**
- **Social Sciences**
- **Political Sciences**

ENERGY SUSTAINABILITY

Transdisciplinarity of Sustainability Science permit to:

- **Understand the links among environmental sciences, economics, social sciences and political sciences**
- **Have a global vision with different point of views**

ENERGY SUSTAINABILITY

Viable solutions, new technologies, new concepts

towards

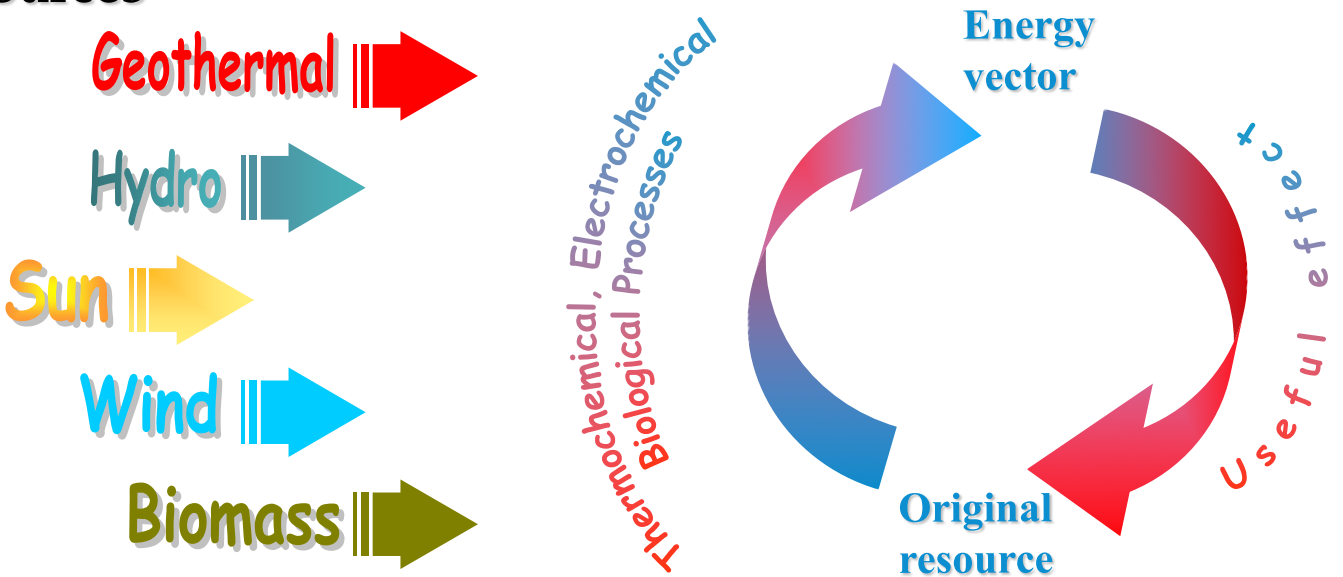
a new

Sustainable Energy Era

CLOSED CYCLES OF ENERGY RESOURCES

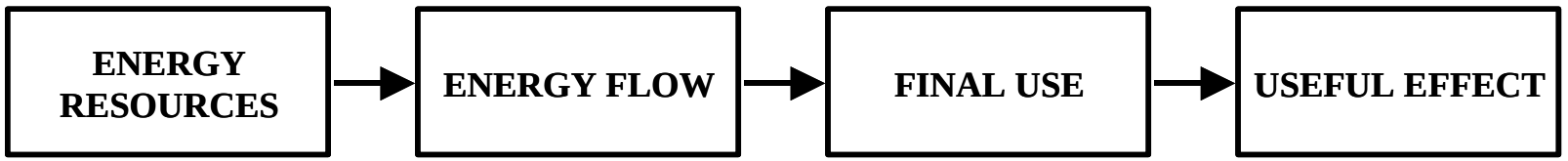
- What yesterday seemed impossible, today is our stated objective: to realise energy systems that do not consume resources and do not produce waste

- Energy systems based on what we call closed cycles of energy resources



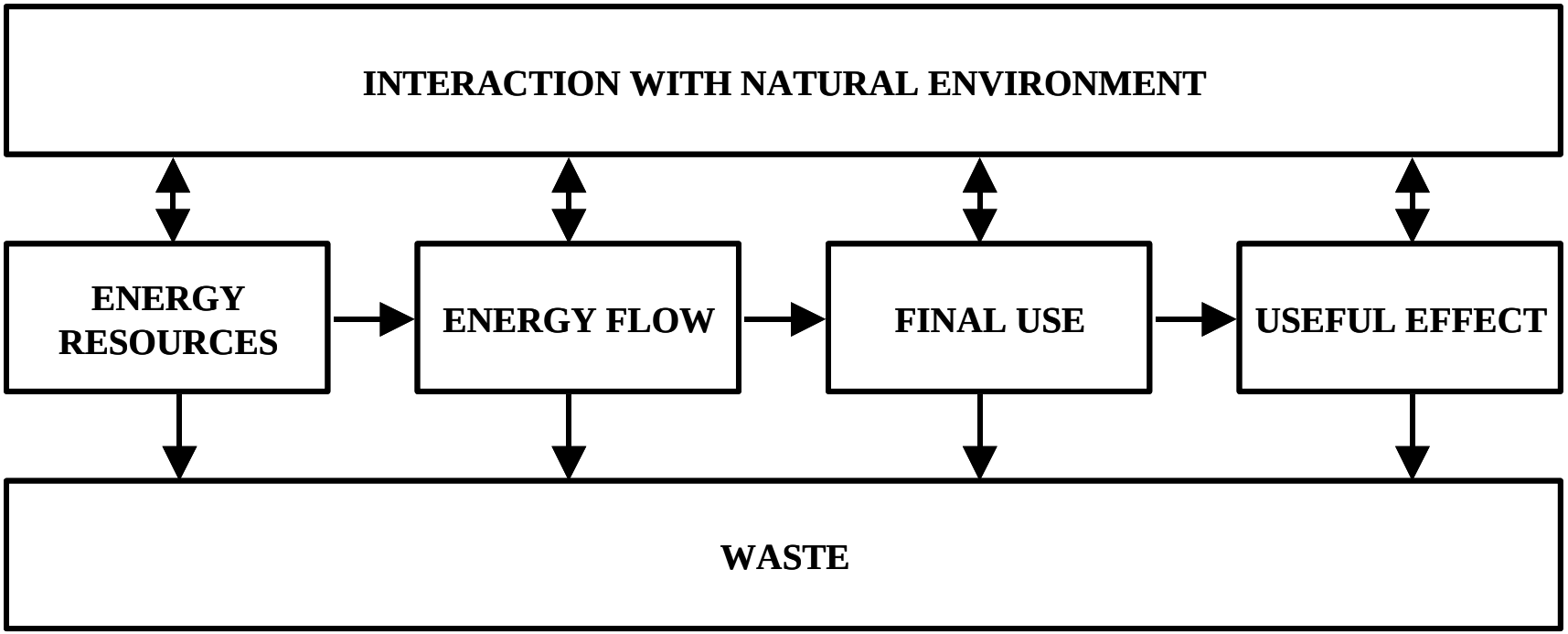
ENERGY SYSTEMS
Simple energy system / theoretical

- An energy system uses energy resources to produce an useful effect
- The useful effect is obtained at the end of the energy chain through a final use of mechanical energy, thermal energy, lighting energy, electric energy
- The energy system must be able to extract energy from the initial resource, make it flow in the appropriate form and deliver it with the needed characteristics for the final use that allow the supply of the desired useful effect



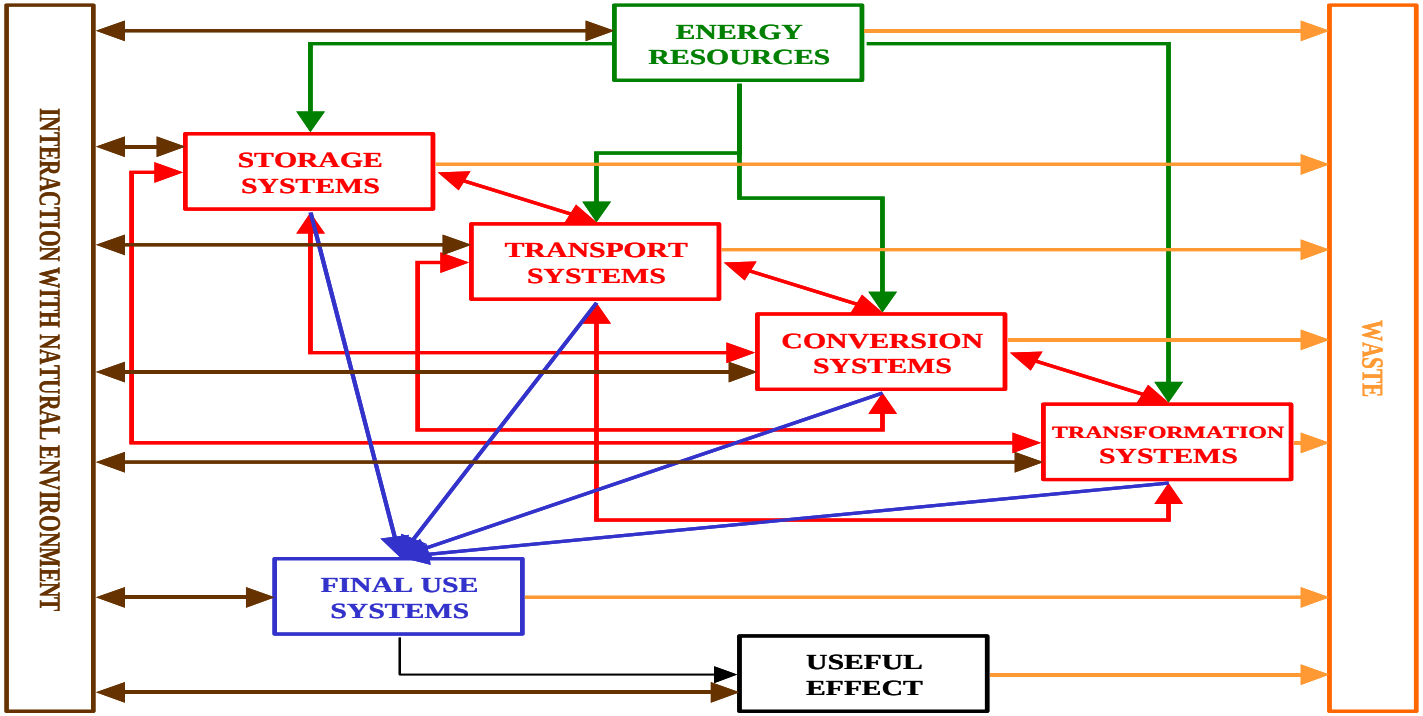
ENERGY SYSTEMS
Simple energy system / real

All that happens in real with a continuous interaction process with natural environment and – at the state of the art – with a waste production



ENERGY SYSTEMS
Complete energy system / real

In its most complete representation, an energy system is constituted by the set of primary energy resources, processes and technologies for conversion, transport, storage and final uses of energy, waste production and interactions with the environment in all the phases



THE NEED OF ENERGY TRANSPORTATION

- **The primary resource is generally available in a different place comparing with the energy demand.**
- **This imply the need of energy transportation.**
- **The need of continuously and instantly satisfying the energy demand makes necessary an energy storage.**

PRIMARY ENERGY RESOURCES

- **Renewable resources**
  - Direct solar energy
  - Water energy
  - Biomass energy
  - Wind energy
  - Earth energy
  - Sea energy
  - Biological and Bacterial energy
- **Non-renewable resources.**
  - Fossil fuels
    - Oil
    - Coal
    - Natural gas
  - Nuclear fuels

ENERGY VECTORS

The following is assumed as definition of an energy vector:

An energy vector allows to transfer, in space and time, a quantity of energy

So energy vectors allow to make energy available for use at a distance of time and space from the source, intended as the point of availability of the primary resource in nature

ENERGY VECTORS

- Fossil fuels
- Oil and derivatives
- Natural gas and derivatives
- Coal and derivatives
- Electricity
- Hydrogen and other synthetic fuels
- Heat exchanging fluids
- Mechanical transmissions
- Oil-dynamic transmissions
- Pressure-dynamic transmissions
- Radiation

ENERGY VECTORS

These vectors allow the transportation of different forms of energy:

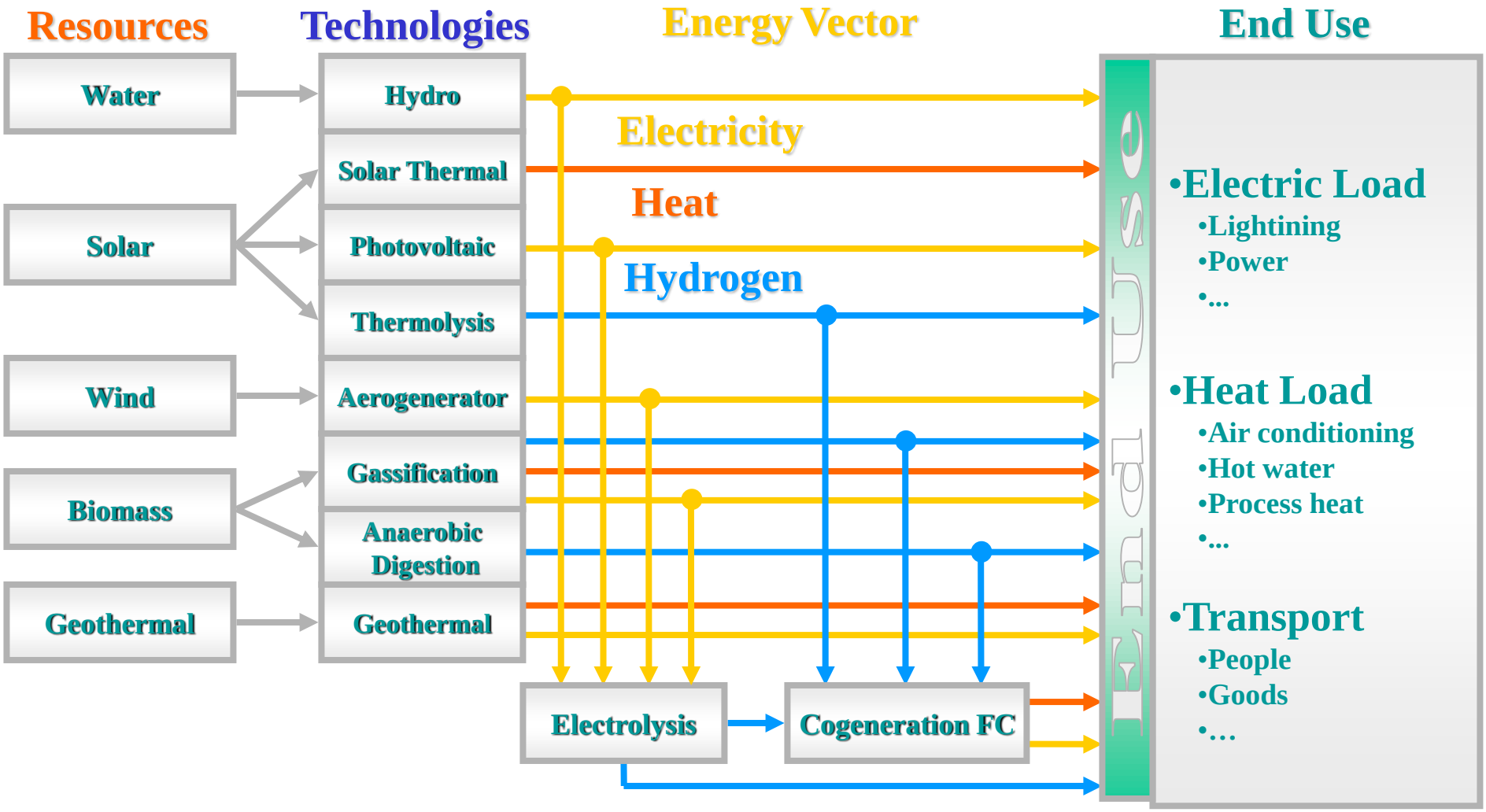
- **Fossil fuels → chemical energy**
- **Electricity → electric energy**
- **Heat exchanging fluids → thermal energy**
- **Hydrogen and other synthetic fuels → chemical energy**
- **Mechanical, oil-dynamic and pressure-dynamic transmissions → mechanical energy**
- **Radiation → radiation energy**

ENERGY VECTORS

What is crucial for energy vectors is the attitude to transfer and/or store energy, for short, medium, long term and for short, medium, long range.

Energy vector	Tranfer attitude	Storage attitude
Fossil fuels	Short, medium, long range	Yes, short, medium, long term.
Hydrogen	Short, medium, long range	Yes, short, medium, long term. (Cryogenic exception)
Heat exchanging fluids	Short range	Yes, short term
Electricity	Short and medium range	No (indirect methods)
Mechanical, oil-dynamic and pressure-dynamic transmissions	Short range	Yes
Radiation	Very long range in space Short range in atmosphere	No

Energy system design



THE ERA OF ENERGY VECTORS

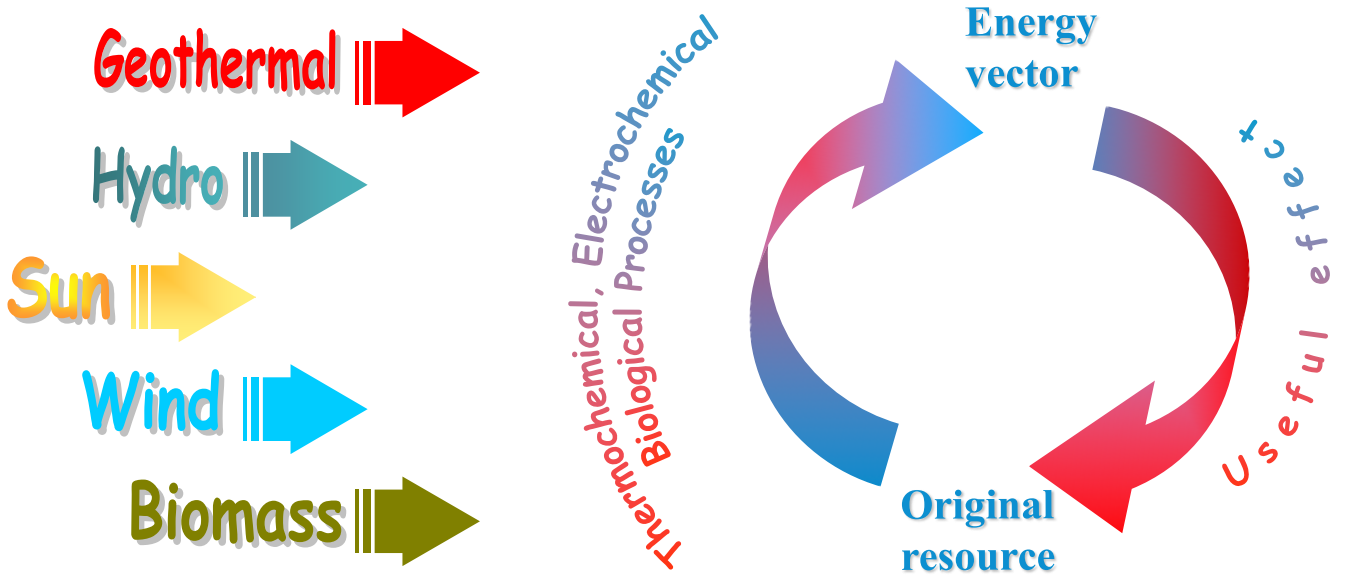
- **The concept of energy vector is basic for achieving the extremely challenging scenario of an energy system closed by definition.**
- **An energy scenario based on renewable resources and immune from the non-sustainable characteristics of consuming resources and producing waste.**
- **That scenario, becomes definitely possible when moving the attention "from sources to vectors" for planning and designing new energy systems.**

ENERGY SUSTAINABILITY

A definition of Energy Sustainability within the platform of Sustainability Science based on the following priorities:

- **Renewability of energy resources;**
- **Efficiency in energy conversion, distribution, use;**
- **Lowering of environmental impact;**
- **Increasing of energy access;**
- **Tailor making of energy systems on local social-economic-environmental conditions**

Energy Sustainability: Closed Cycles of resources and the role of Energy Vectors



A "MEASURABLE" DEFINITION OF SUSTAINABLE DEVELOPMENT

Sustainable development does not consume resources,

it use and reuse them - ideally endless.

CENTRO INTERUNIVERSITARIO
DI RICERCA PER LO SVILUPPO
SOSTENIBILE CIRPS

SAPIENZA
UNIVERSITÀ DI ROMA

Prof. Fabio Orecchini
Head of Energy and Environment Research Group
CIRPS – Interuniversity research centre for sustainable development
Sapienza University of Rome – Italy
fabio.orecchini@uniroma1.it

THANK YOU FOR YOUR ATTENTION

THANKS TO MY RESEARCH GROUP

Energy Sustainability in the framework of Sustainability Science.
Closed cycles of resources and their application to energy systems