Reducing CO_2 Emissions with Rational Exergy Management

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World Environment Day

Melting Ice - A *Hot* Topic?

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Opening Remarks

Our challenge is to redirect the increasing levels of CO_2 emissions that endangers our **central relation** with Nature.

This calls for a new approach that allows us to engage in a new **balancing act** to correct the mismatches between the supply and demand of resources;

And allows us to steer a change in a way that will reduce global warming in the narrow window of opportunity.

Pursuit of the Balancing Act

The *building sector* is the largest contributor of CO_2 emissions that continues to upset the delicate solar radiation balance of the Earth.

An approach to correct the mismatches between the supply and demand of resources can **guide** the sector to move out of its present case.

This is possible by **rewiring** the supply of resources to matching demands and vice versa based on exergy, the useful work potential of a given energy source.

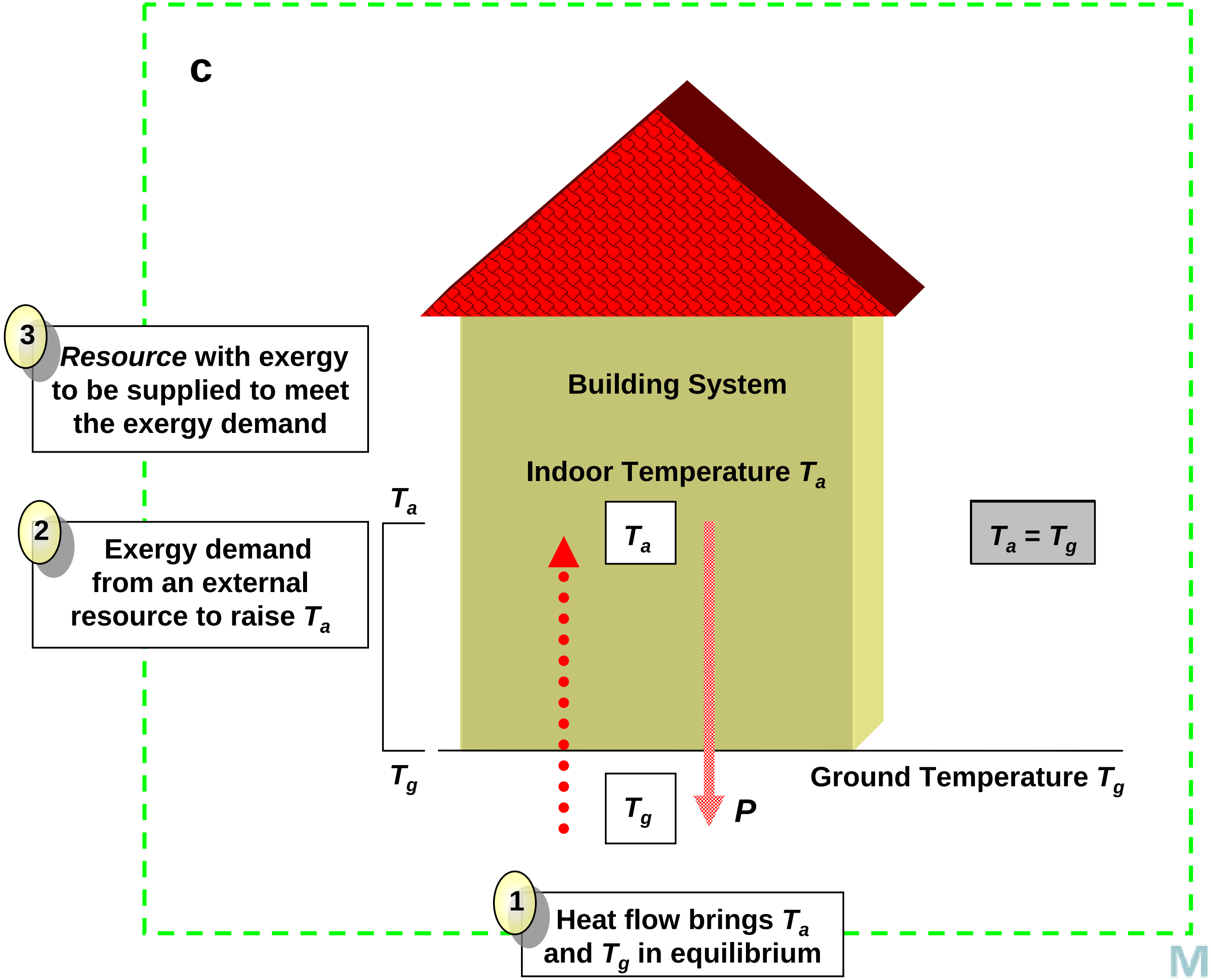
Supply and Demand of Exergy

Lets treat the building as the most basic unit and as a **system** that has a certain supply and demand of exergy.

Its **exergy demand** is due to the need to compensate for the heat flow from the higher indoor air temperature to the lower reference ground temperature.

A resource that has at least this much exergy is to be supplied to meet this demand as its **exergy supply**.

Supply and Demand of Exergy



Rational Exergy Management

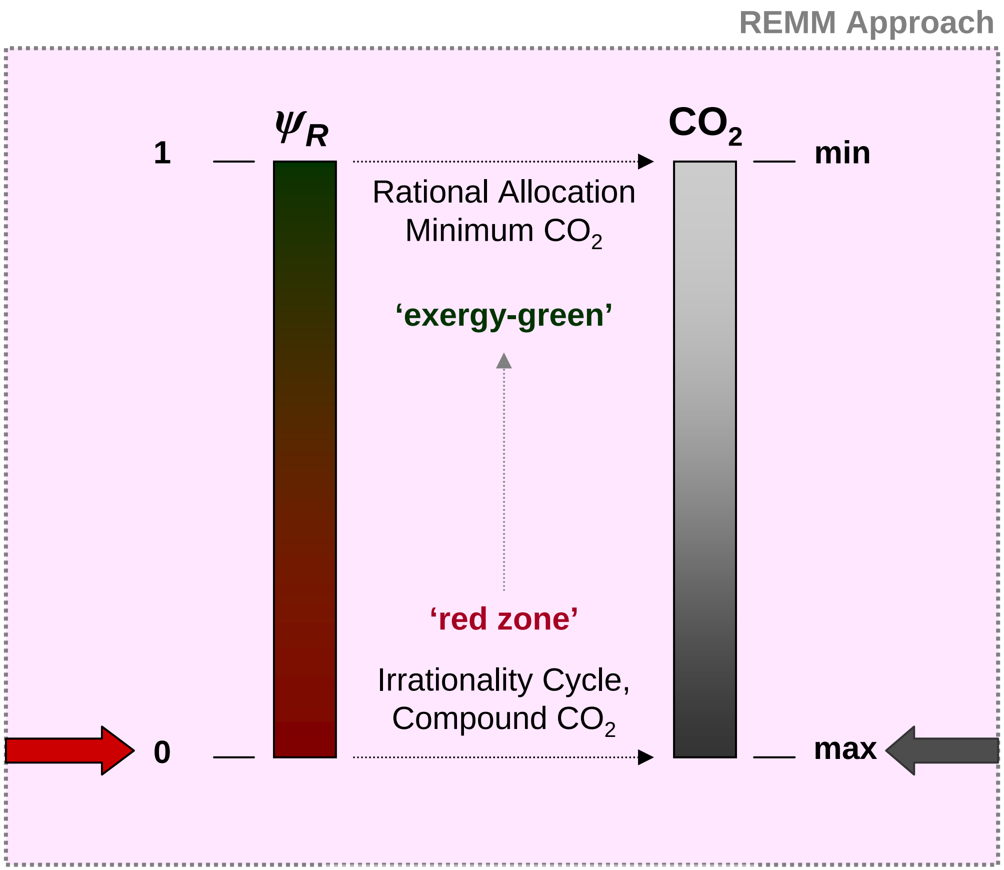
The new ***parameter*** ψ_R measures the level of match between the supply and demand of exergy.

It is defined to guide an increase in the *level of exergy rationality* in supplying resources to the building system.

It provides a *mechanism* to manage a better allocation of resources by improving the possible "global" exergy matches and hence, to reduce CO_2 emissions.

Rational Exergy Management

The parameter ψ_R indicates the level of exergy rationality, i.e., the level of match in the supply and demand of exergy, and any level of impact on CO_2 emissions.



Present Characteristics

As measured by the parameter ψ_R , the level of exergy rationality in a “base case” building is only 0.04.

The **base case** is a building that is supplied a resource that has a high flame temperature, such as natural gas, to meet the exergy demand of the building for space heating.

The exergy of the resource is almost entirely *destroyed* as it is directly downgraded to be used to heat the building.

Present Characteristics

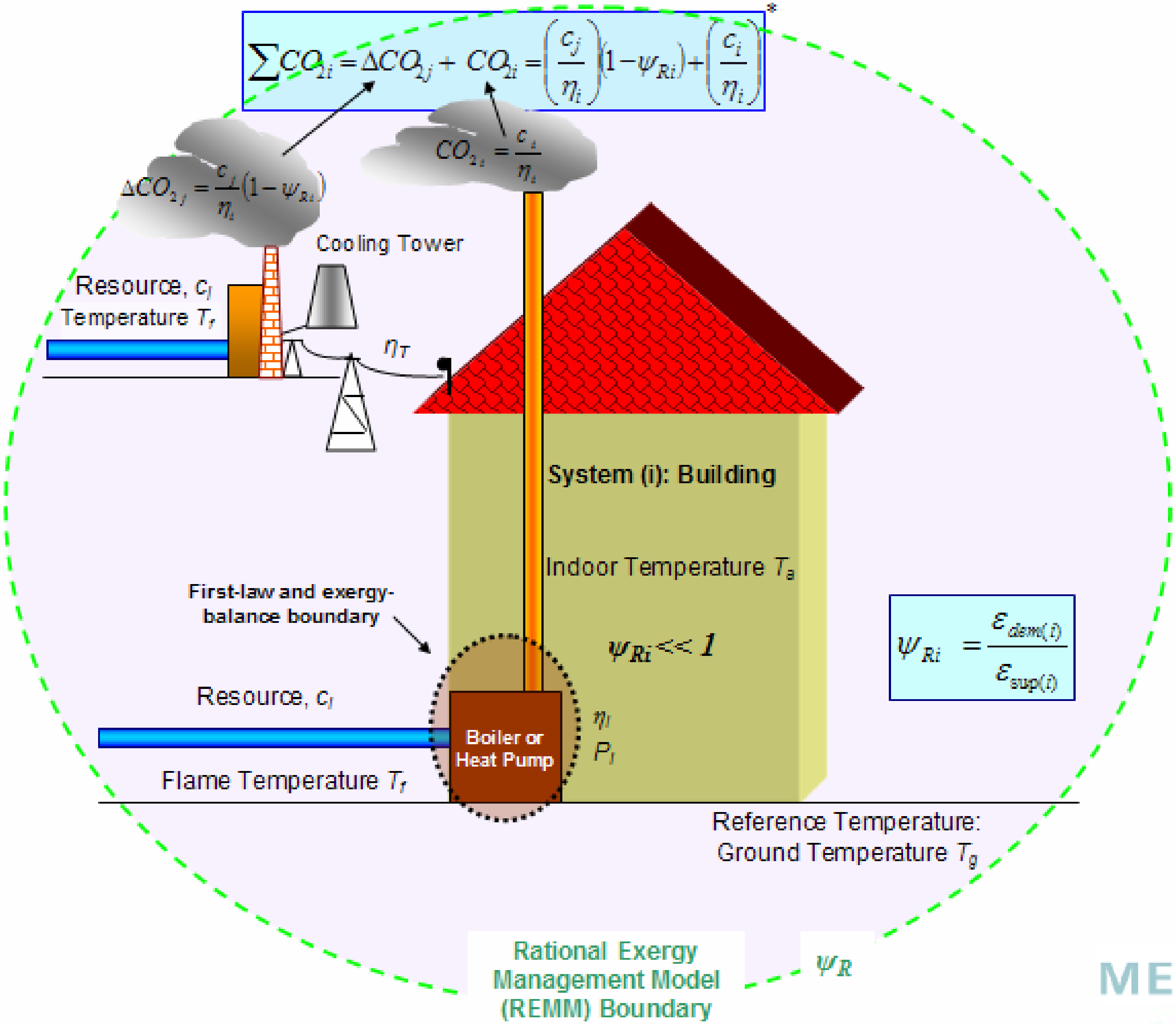
Still more exergy is destroyed by the need for another system that can be assumed to be a central power plant.

The mismatch in the supply and demand of exergy in the building has simultaneous **impacts** on a further misuse of resources from a broader perspective.

A low level of exergy rationality leads to **compound CO_2 emissions** that are composed of both direct and indirect emissions, which are *avoidable*.

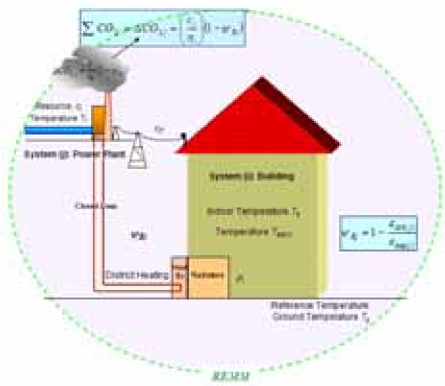
The Compound Impacts

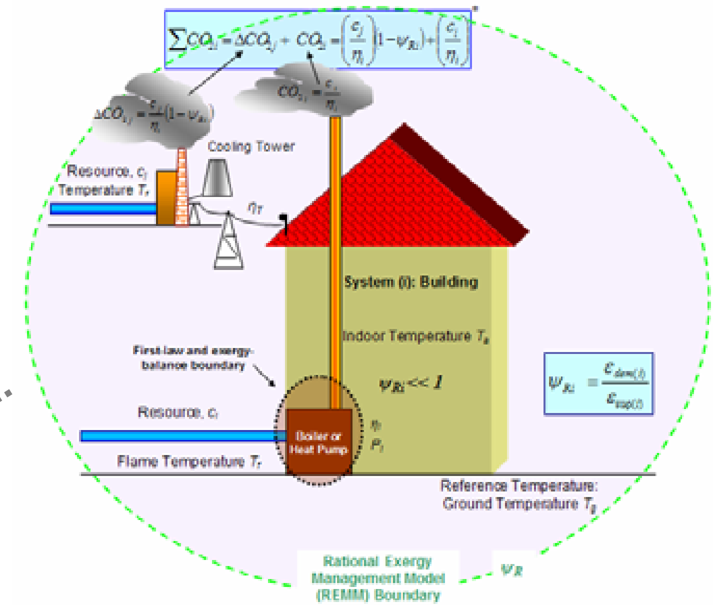
Business as Usual Supply of Resources in the Base Case

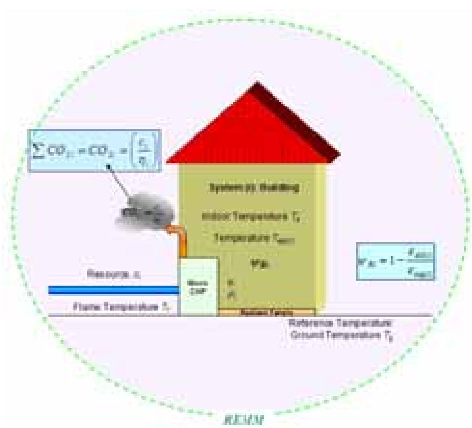


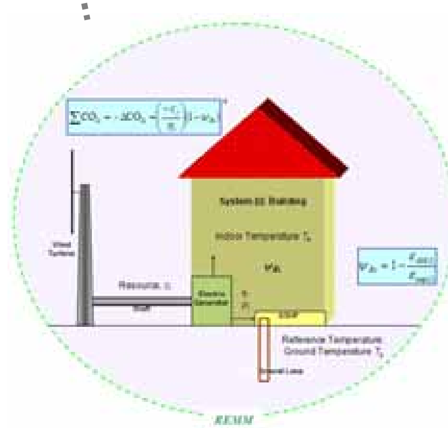
Rewiring with Exergy Matches

Rewiring the Supply of Resources with Global Exergy Matches



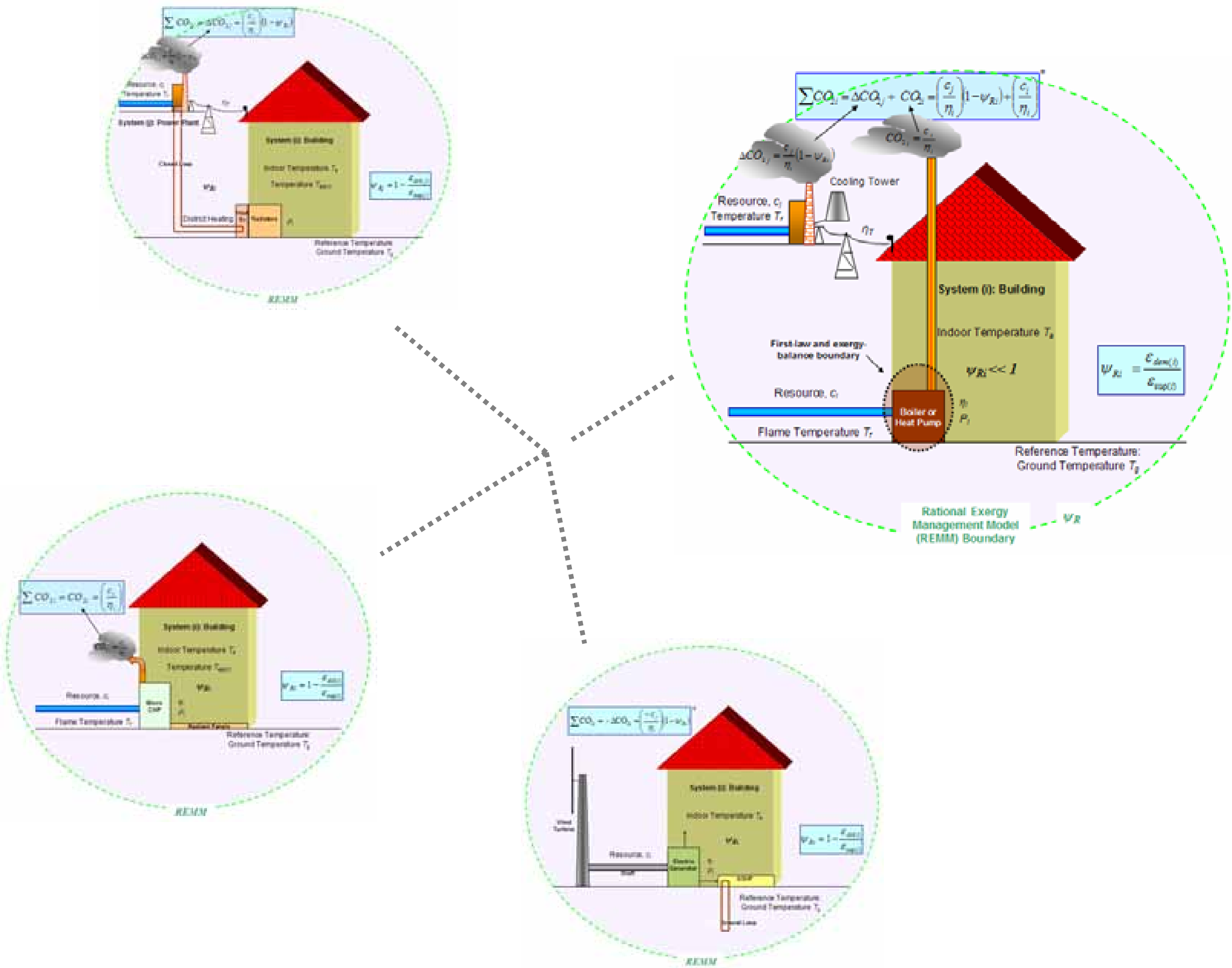






Rewiring with Exergy Matches

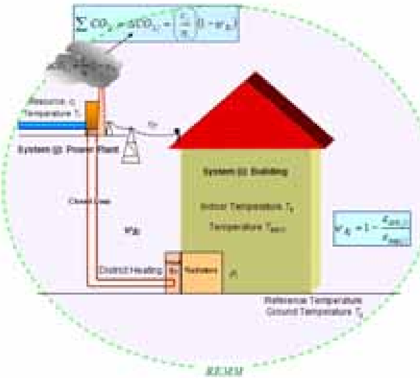
Rewiring the Supply of Resources with Global Exergy Matches



Alternative Case Studies

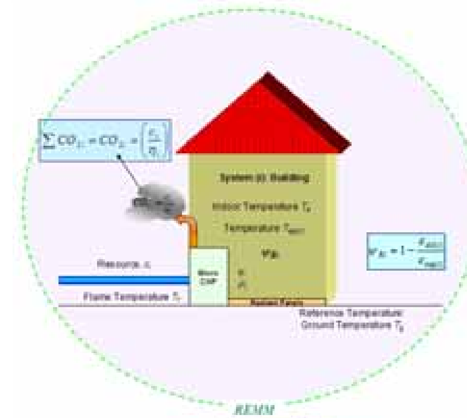
Case One: Provides a *supply-driven* approach on the side of the power plant to balance the supply and demand of exergy.

District Heating



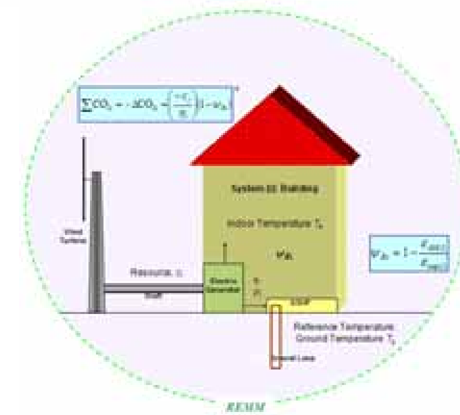
Case Two: Provides a *supply-driven* approach on the side of the building to balance the supply and demand of exergy.

Micro-CHP



Case Three: Provides a *demand-driven* approach on the side of the building to balance the supply and demand of exergy.

All Renewables



Alternative Case Studies

Case One manages the exergy that would otherwise be destroyed in the power plants to alter the base case.

Case Two *manages* the exergy of the resources that is being supplied to the building to satisfy global demands.

Case Three *integrates* renewable energy resources to fit the exergy demand profile of the building.

Alternative Case Studies

Case	*REME, $\psi_{Ri\ or\ j}$*	*Compound Impacts*	*CO_{2i}*	*ΔCO_{2j}*	*REMM, $\sum CO_{2i}$*
Base	0.04	Yes	*x*	*x*	$3.3 \times c_i$
One	0.75	No	-	*x*	$1.8 \times c_i$
Two	0.80	No	*x*	-	$1.1 \times c_i$
Three	0.91	No	-	-	0 or $-1.4 \times c_i$

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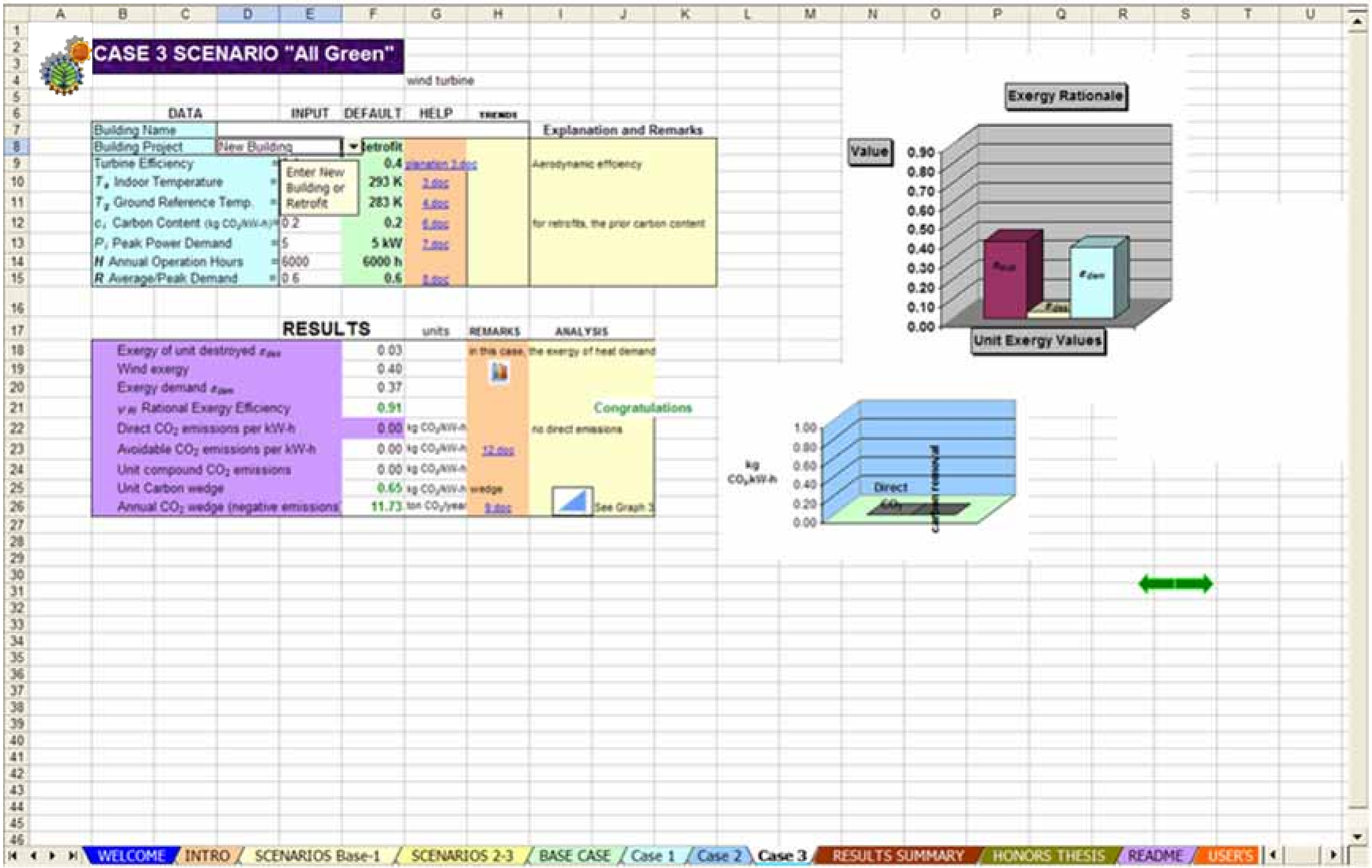
Includes 0.2 kg CO_2/kWh for natural gas

Wind energy and ground source heat

REMM Analysis Tool



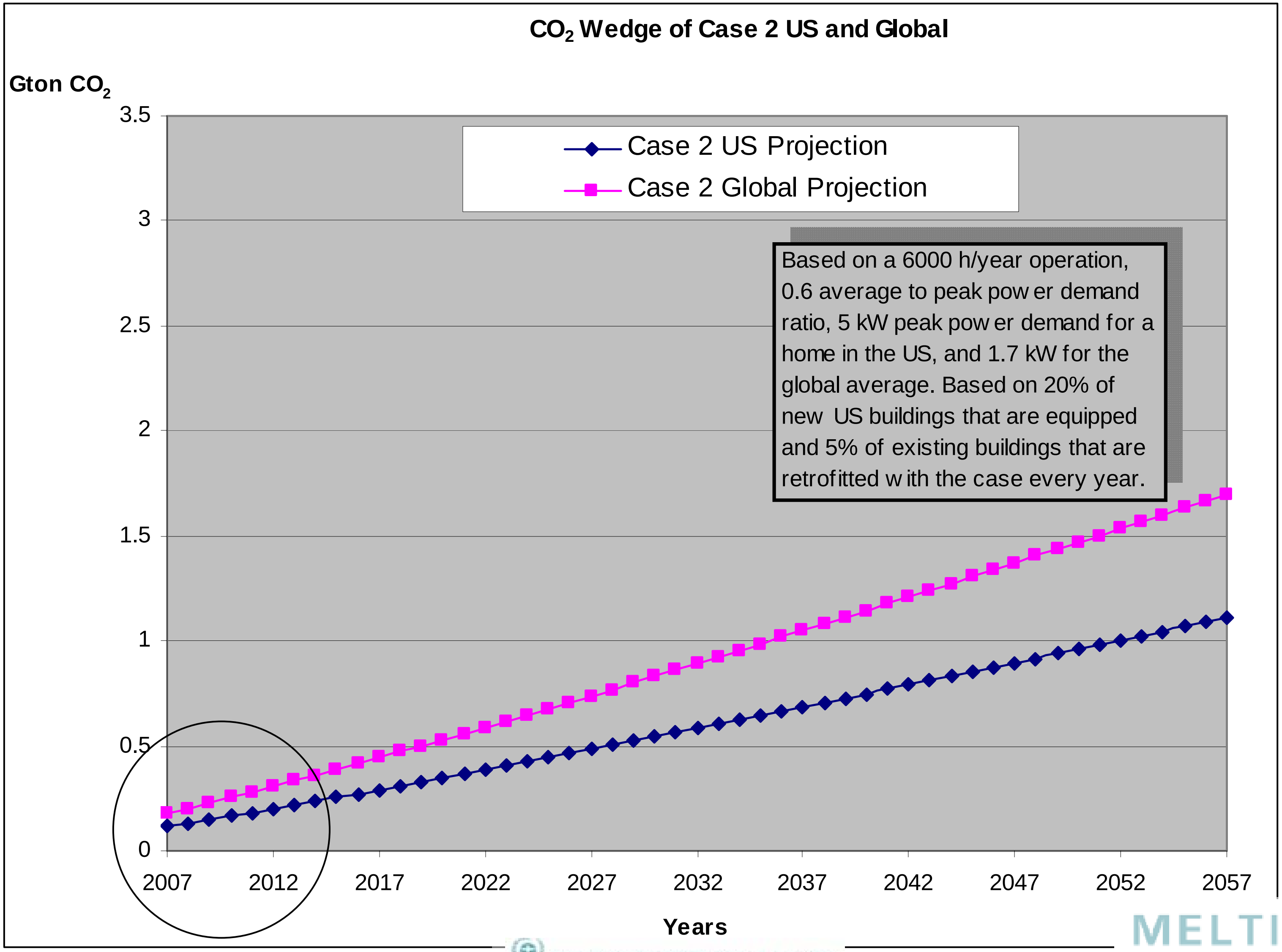
REMM Carbon Wedges

We can compare the carbon reductions of the alternative cases relative to the base case with carbon wedges.

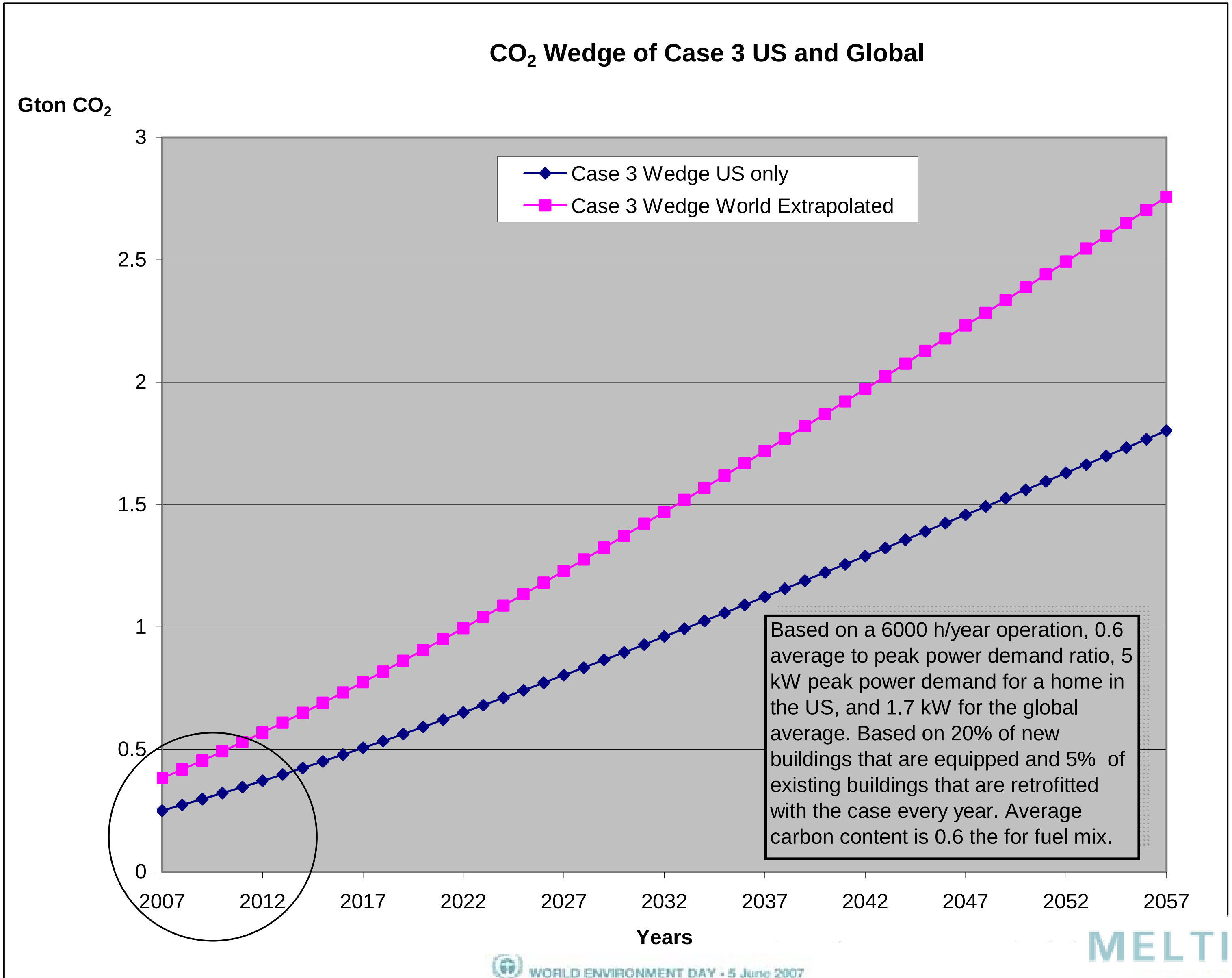
Each of the alternative cases that improve the exergy matches of buildings are considered as a CO_2 reducing measure to produce **REMM carbon wedges**.

20% of new buildings and 5% of the total existing buildings in that year are to adopt and integrate technologies to implement one of the alternative cases.

Case Two to Year 2057



Case Three to Year 2057



REMM Carbon Wedges

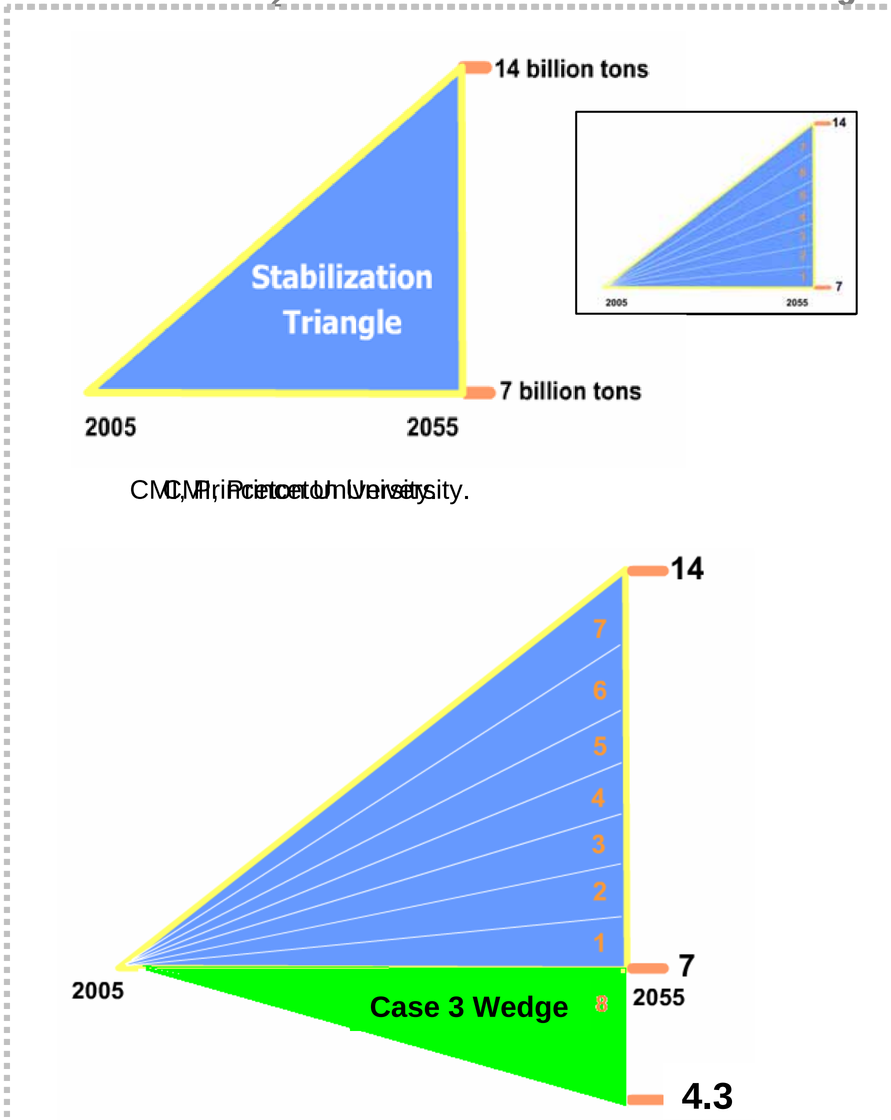
The approach of balancing the supply and demand of exergy also provides a much needed capacity to reduce CO_2 emissions in the narrow window of opportunity.

The Carbon Mitigation Initiative projects the annual CO_2 emissions of the year 2055 at the alarming level of 14 gigatons if no CO_2 reducing measures are taken.

The approach *adds* on to the seven carbon wedges of one gigaton of CO_2 emissions each where buildings have only one wedge from basic energy conserving measures.

REMM Carbon Wedges

CO_2 Reductions and REMM Carbon Wedges



Case 3 Wedge

Concluding Remarks

We have the technology to address the crisis of global warming; all we need is the **will** to take action <u>and</u> engage in an act of *balancing* the supply and demand of exergy.

We can all be **pioneers** to *rewire* the supply of resources to matching demands of exergy and vice versa, an approach that effectively reduces CO_2 emissions with a new wedge.

We can all do so much together for *global* sustainability given that we *steer* a change in our homes and communities to increase the level of exergy rationality.