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Retrofit design of energy efficient buildings using Life Cycle Assessment case study on research institute building

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In the name of God

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Life Cycle Assessment and Other Assessment Tools for Waste Management and Resource Optimization
9-June, 2016,Cetraro, Italy.

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Engineering Conferences International

Energy consumption of building

- Introduction
- LCA method
- Methodology
- Case study
- Result and discussion

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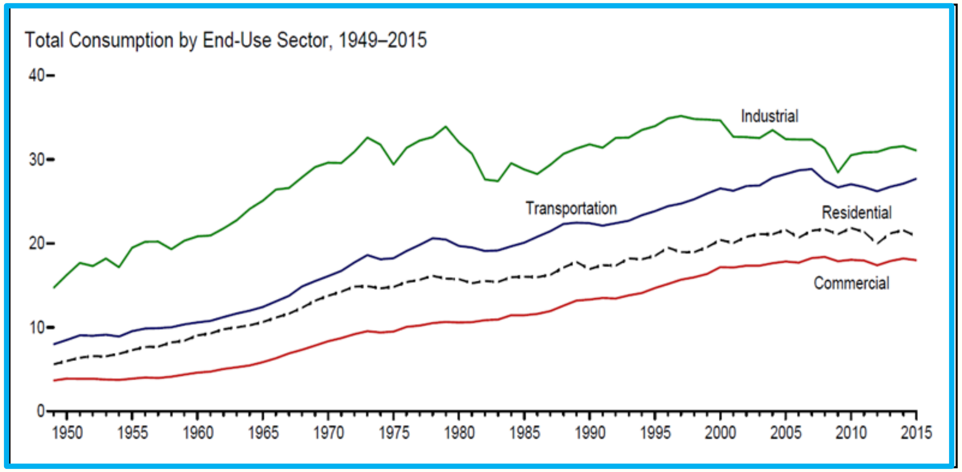
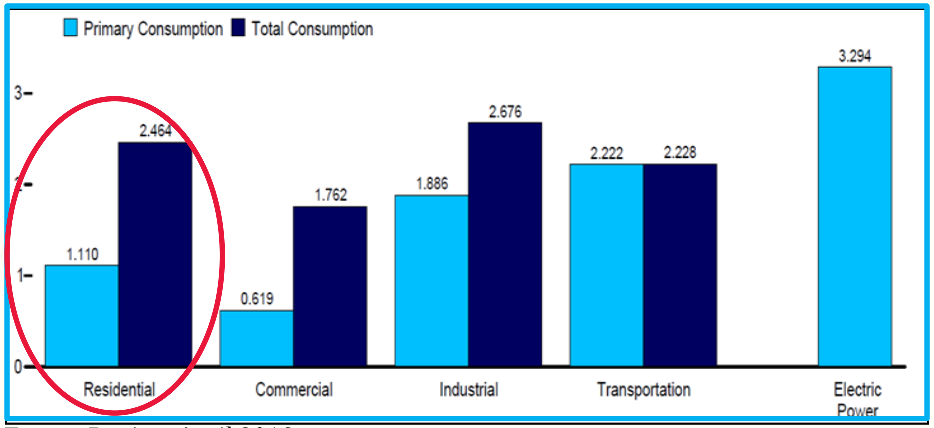
▪ Statement of problem

Energy consumption raising in building section





U.S. Energy Information Administration / Monthly Energy Review April 2016

Energy consumption analysis in the buildings

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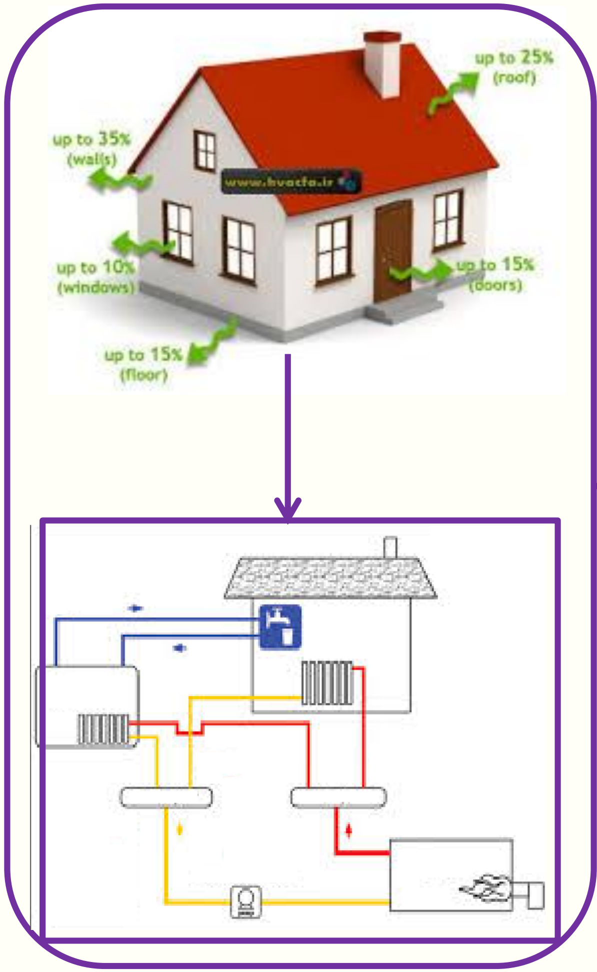

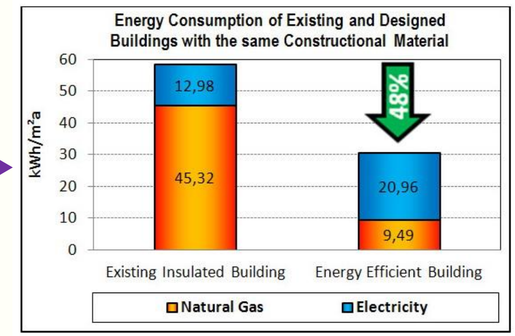

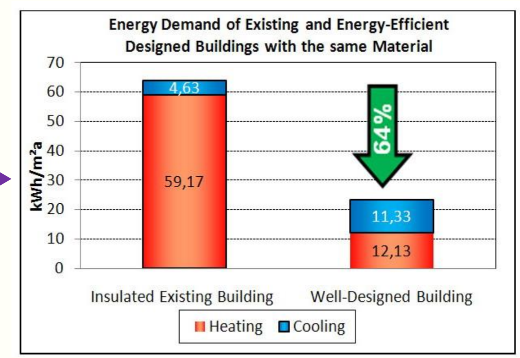

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Toward a Green" or "Sustainable" buildings

"Green" or "Sustainable" buildings are characterized by:

- efficient management of energy and water resources
- management of material resources and waste
- restoration and protection of environmental quality
- enhancement and protection of health and indoor environmental quality
- reinforcement of natural systems
- analysis of the life cycle costs and benefits of materials and methods
- integration of the design decision-making process

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Impact of the built environment

Impact of the built environment

- ❑ 40% of the world's energy
- ❑ 25% of the timber harvested
- ❑ 16% of the fresh water used
- ❑ 50% ozone depleting CFC's
- ❑ 30% of raw materials used
- ❑ 35% of CO_2 emissions
- ❑ 40% of landfill waste

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Life cycle assessment

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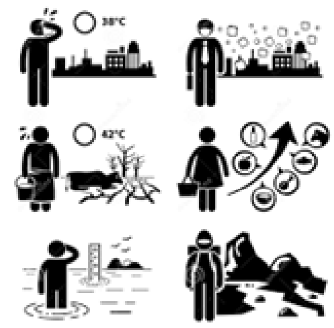
"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle"

This establishes an environmental profile of the system!



ISO = International Organization for Standardization
Ensures that an LCA is completed in a certain way.

WHAT CAN BE DONE WITH LCA?

1. Product or project development and improvement
2. Strategic planning
3. Public policy making
4. Marketing and eco-declarations

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Literature review of LCA in buildings

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Reference	Content, country and year	Categories	Result
R. Azari	Integrated energy and environmental life cycle assessment of office building envelope, USA, 2014.	A 2-story office building	Scenarios with low to medium window-to-wall ratio WWR and fiberglass window frame result in the lowest impacts on life cycle energy and environmental performance of building envelopes. life cycle is the primary contributor to most environmental impact categories for all scenarios.
Amir Safaei et al.	A model for optimal energy planning of a commercial building integrating solar and cogeneration systems, Portugal, 2013.	A commercial building	Analyzing the combination of each type of cogeneration technology with other energy systems at the current stage ICE, and in near future, MT engines are economically viable cogeneration solutions. Solar thermal systems also represent cost-effective solutions, while SOFC is not yet commercial to deploy.
Amir Safaei	A lifecycle cost optimization model with environmental impact assessment for energy management of service buildings, Portugal, 2012.	A service building	Analyzing the combination of each individual cogeneration technology with other energy systems. varied operating discussing the cost-effectiveness of solar and cogeneration technologies and the application of the model in long term planning for commercial building sector in Portugal

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Reference	Content, country and year	Categories	Result
M. G. Ehsan Asadi	Multi objective optimization for building retrofit, Portugal, 2012.	A residential buiding	Minimizing the energy use in the building in a cost effective manner, while satisfying the occupant needs and requirements by a multi-objective optimization model and highlight potential problems that may arise.
Ehsan Asadi et al.	A multi objective optimization model for building retrofit strategies using Trnsys simulations, Genopt and Matlab, Portugal, 2012.	A residential building	The practicability of the alternative materials for the external walls insulation, roof insulation, different window types, and installation of a solar collector in the existing building and highlight potential problems that may arise.
Kofoworola and Gheewala	determine the embodied energy coefficients of key building materials utilized in ,Thailand, 2009.	A 38-story typical office building	Analyzing The entire life cycle of the office building
Ayat Osman et al.	Life cycle optimization of building energy systems, USA, 2008.	commercial building	Cogeneration systems appeared to be an attractive alternative to conventional systems considering life cycle environmental criteria Internal combustion engine and Microturbine (MT) cogeneration systems resulted in a reduction of up to 38% in global warming, solid oxide fuel cell and MT cogeneration systems resulted in a reduction of up to 94% in tropospheric ozone precursor potential

Statement of research

Developing a Model for assessing Building's base load Energy Demand

Developing a model for implementing retrofit options in buildings using Life cycle assessment

Presenting Optimal Retrofits

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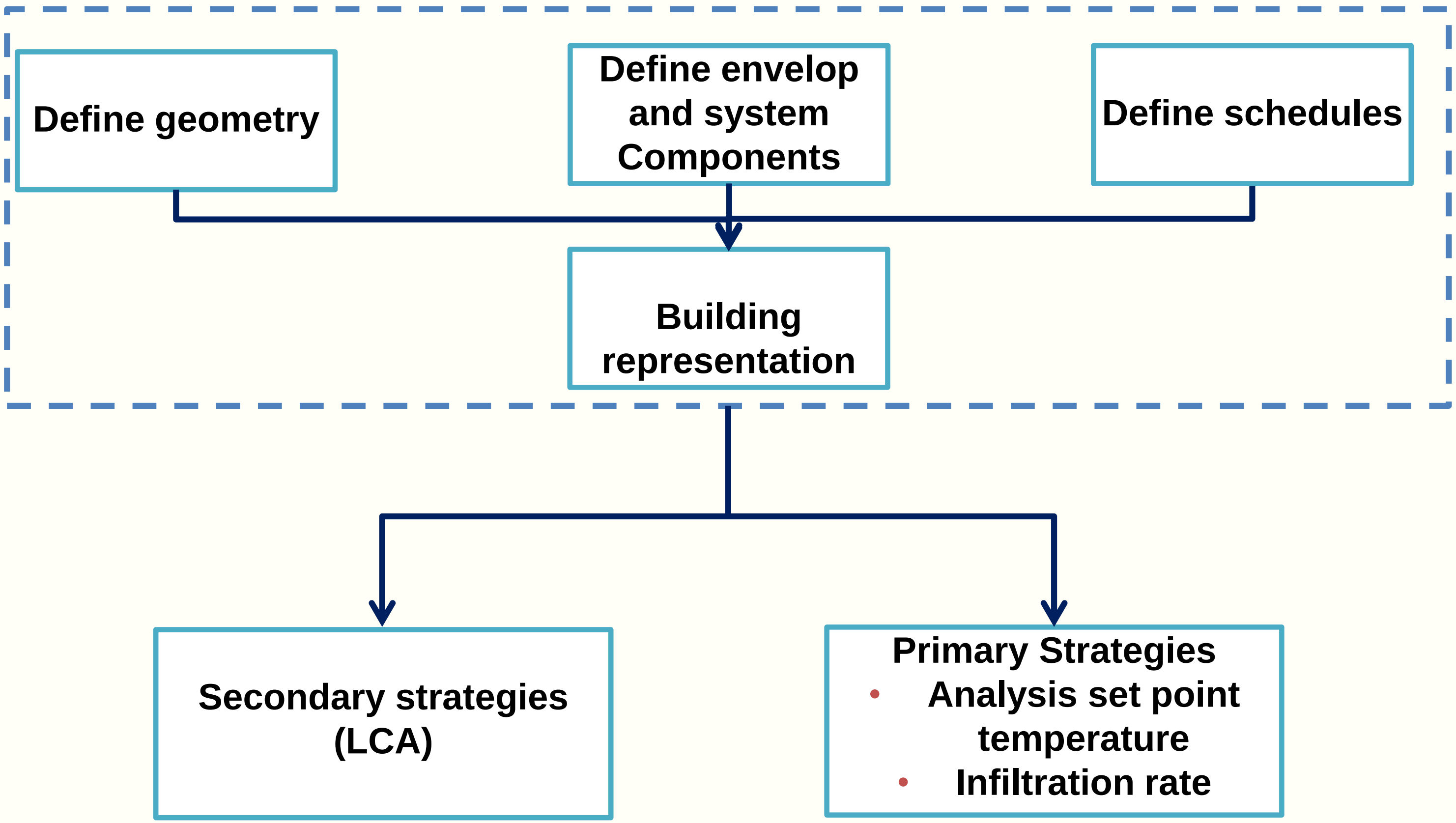
Methodology



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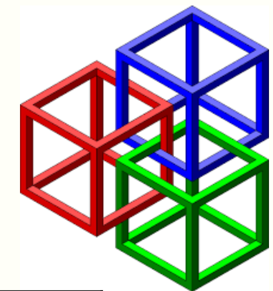
Define geometry



Sharif Energy research institute(SERI)	**Property**
Building dimension	18width×58Length×12Hieght
Building rotation	+0/5 Rotation (North to east)
Building Location	2/51 latitude 41/35 longitude
Building Floor area	5550 m2
Building structure	Steel skeleton
Building Envelope	Brick WWR:50%
Building windows	Double Glazing

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Define envelope and system Components

Sharif Energy research institute(SERI)	Property
External wall	Thickness: 5/35 cm Layers: • Brick • Mortal of Cement • Cement Coating • Yonolit Plaster Coating • Clay
Internal Wall	Thickness:10 cm Layer: • Plaster Coating • Yonolit Plaster Coating
Roof	Thickness:56 cm Layer: • Concrete • Air • Plaster
Compressor Chiller	Cop: 1.02
Boiler	Efficacy:0.85

Define schedules

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Working days Schedule	Day to night	
Working days	From Saturday	To Wednesday
Working Hours	From 8:00 Am	To 5:00 Pm
Equipment Schedules	Day to night	
from	6:00 AM	On
Until	18:00 PM	On
from	18:00 PM	Off
Until	6:00 AM	Off
Average of person per zone	10	

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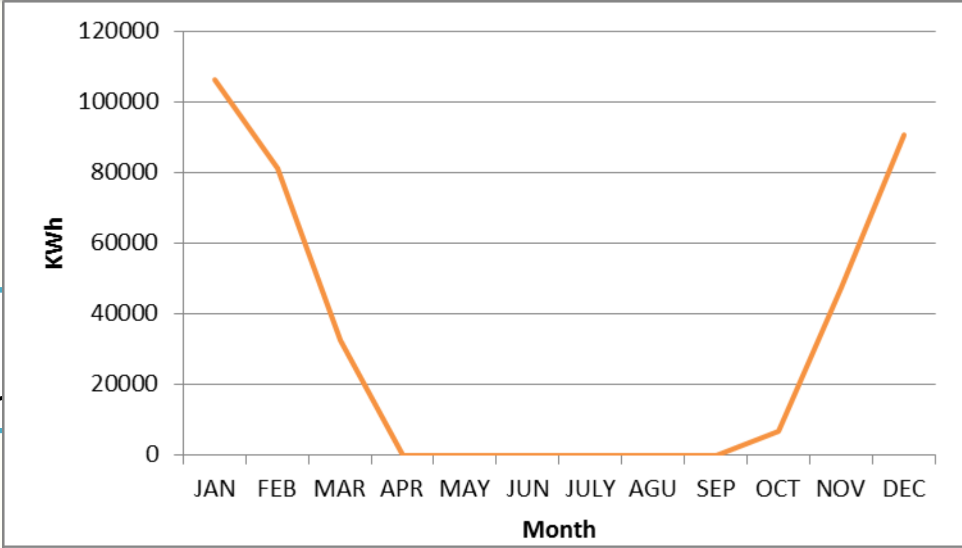

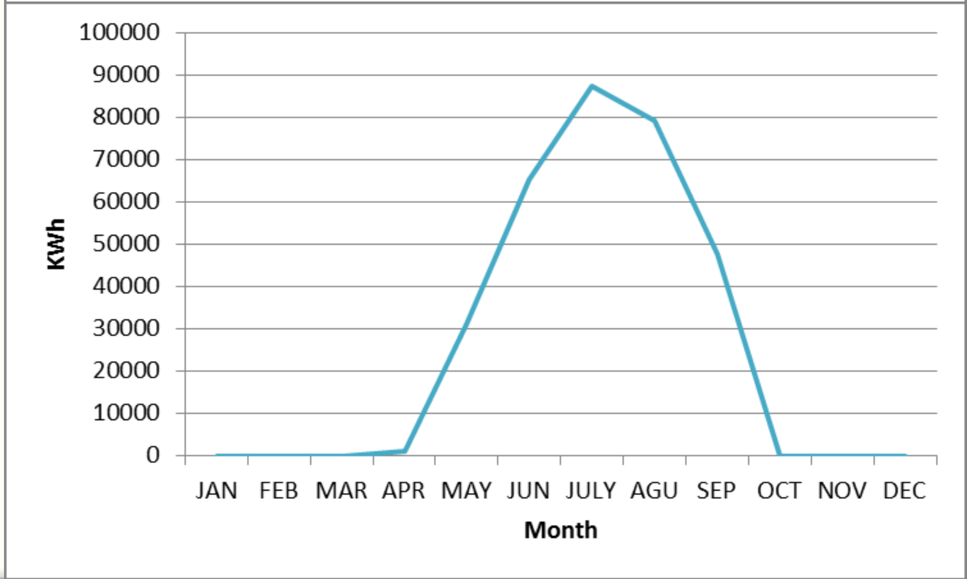

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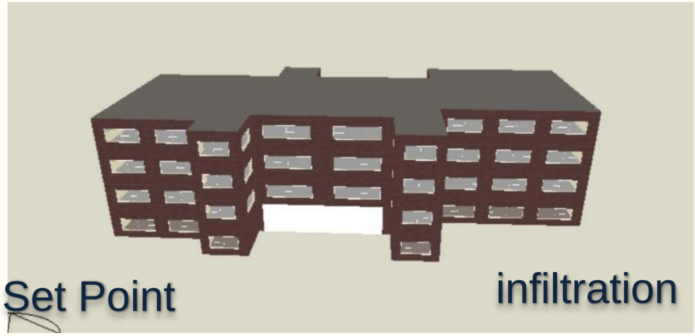
Building simulation

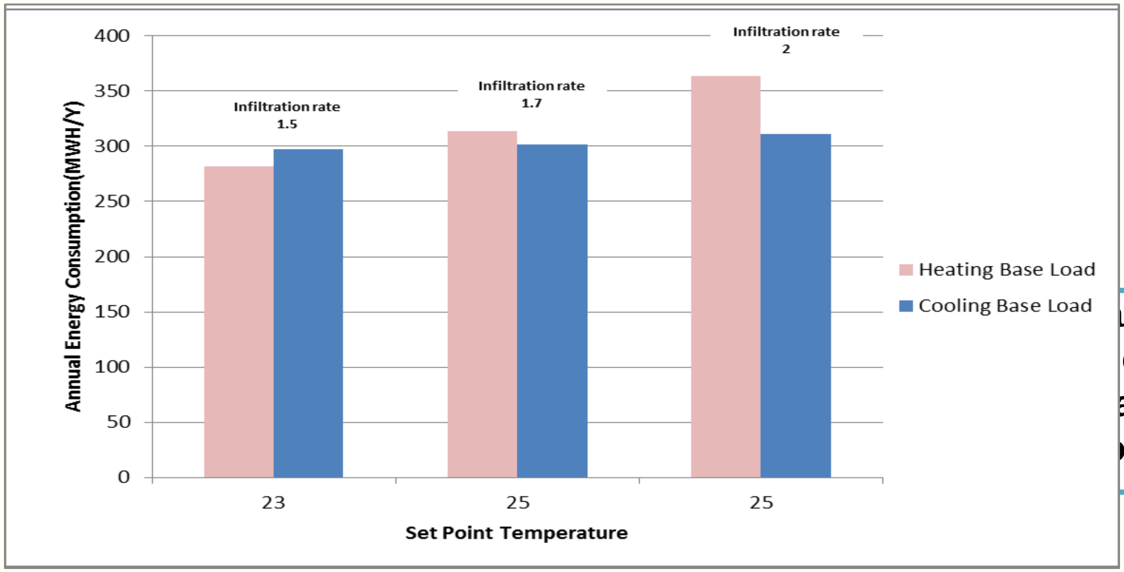
Define geometry and Construction

Activity definition

HVAC definition



Optimization



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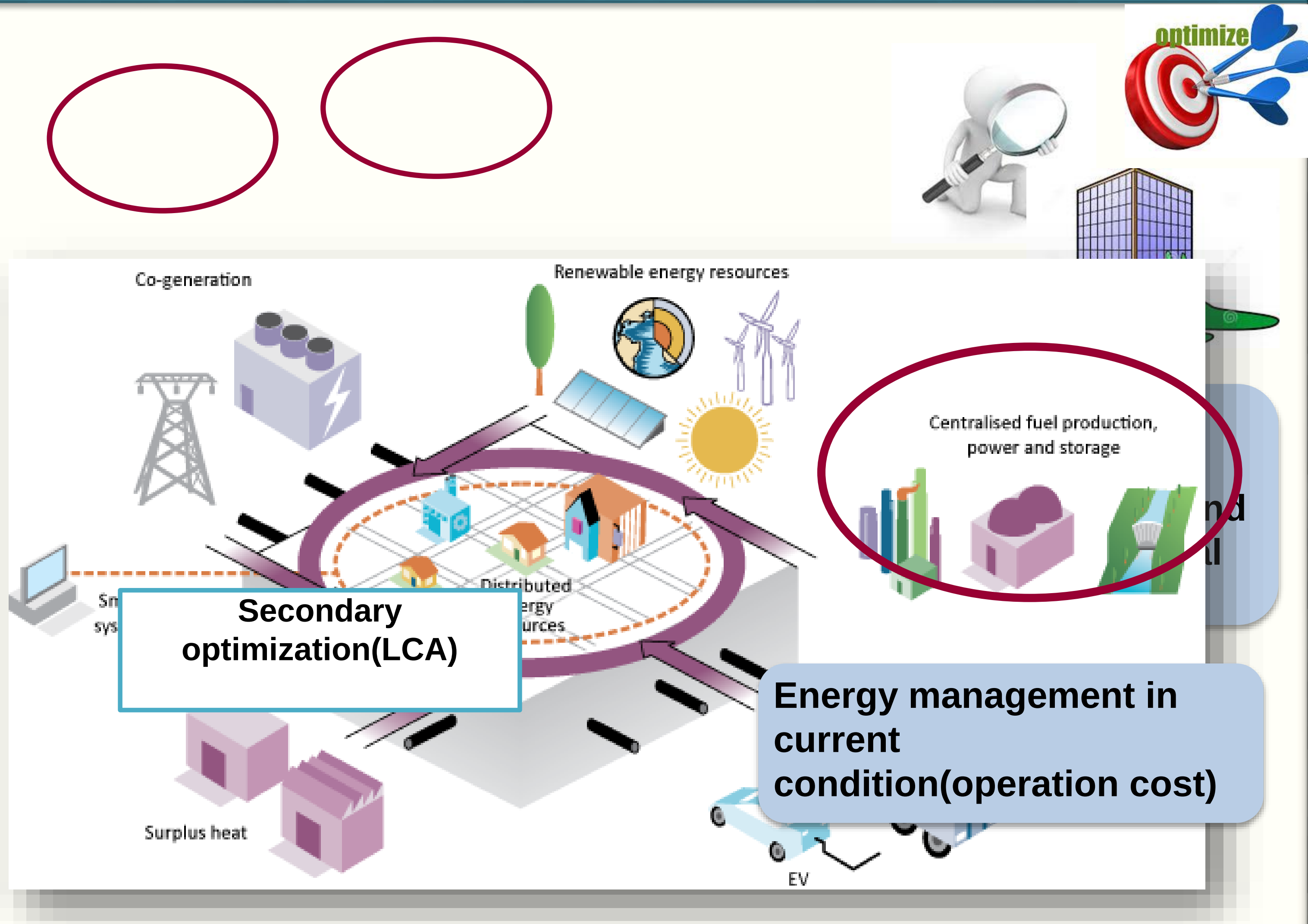

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Methodology

Objective Functions:

- **Minimizing Life Cycle Emission:**

$Emission_{grid} + Emission_{boiler} + Emission_{PV} + Emission_{WT} + LCA_{Internal\ engine} + LCA_{MicroTurbine}$

- **Minimizing Total Cost:**

$Electricity_{cost} + Boiler_{operation\_cost} + Photovoltaic\ Pannel_{investmentcost} + Wind\ Turbine_{investmentcost} + CCHP_{Internal\ combustion\ engine\_total\ cost} + CCHP_{MicroTurbine\_total\ cost}$

Constrains:

- **Meeting Heating demand:**

$Heating_{Boiler} + Heating_{CCHP} = Heating_{demand}$

- **Meeting Cooling demand:**

$Cooling_{Absorptionchillerchiller} + Cooling_{CCHP} = Cooling_{demand}$

- **Meeting electricity demand:**

$Grid_{elec} + Windturbine_{elec} + Photovoltaic_{elec} + InternalCombustionEngine_{elec} + MicroTurbine_{elec} = Electricity_{demand}$

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Assumption:

- ✓ Distributed Generation Systems are not Grid-Connected.
- ✓ Storage Unit is not assumed.
- ✓ 4 Peak days in Each Season are Selected for Design Capacity of DG.

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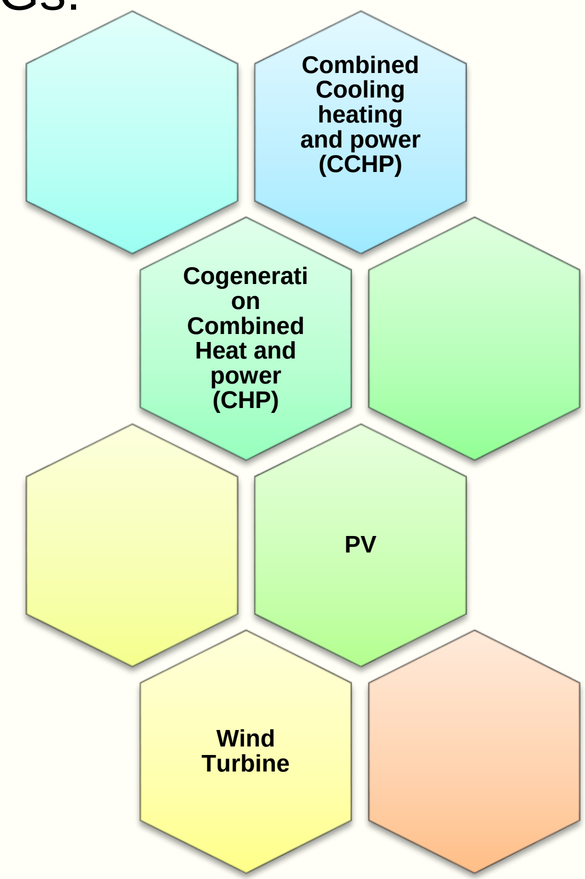
Distributed Generation Systems

Technologies for DGs:



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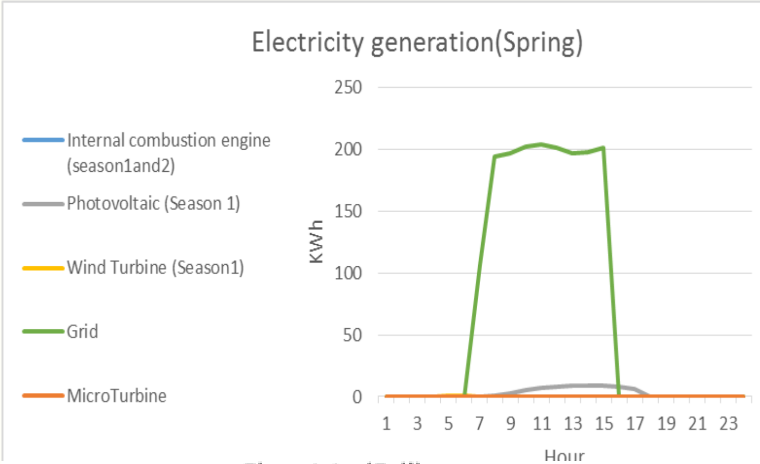
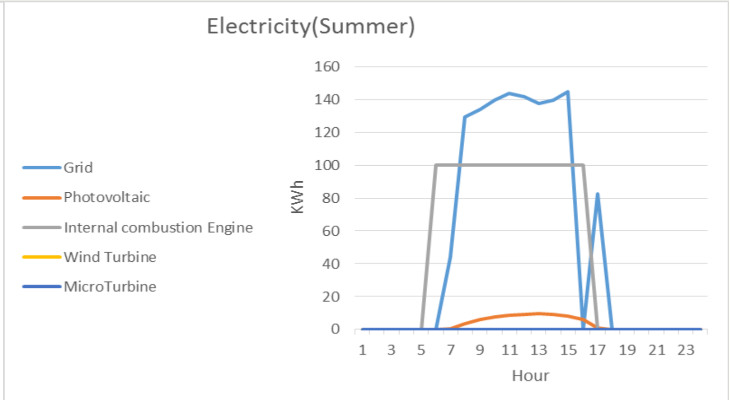
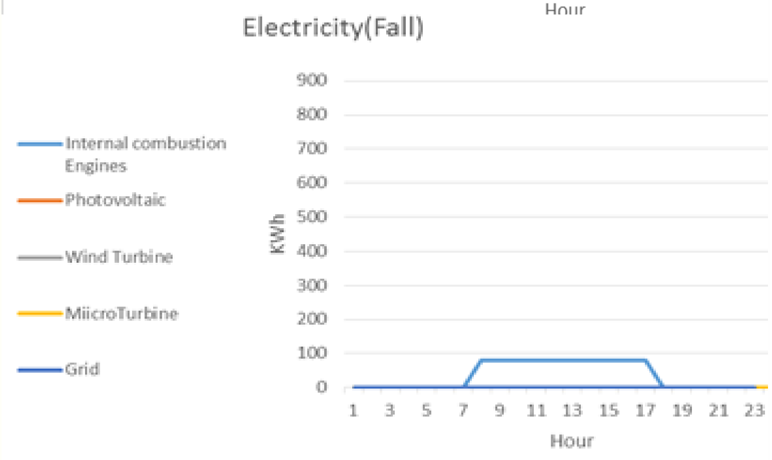
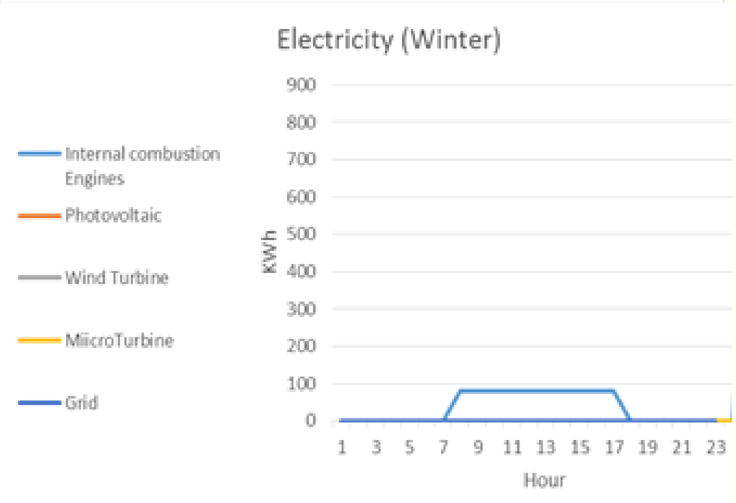
·Optimal Capacity of DGs for Supplying Electrical Demand in Case Study Building:









Result and Discussion

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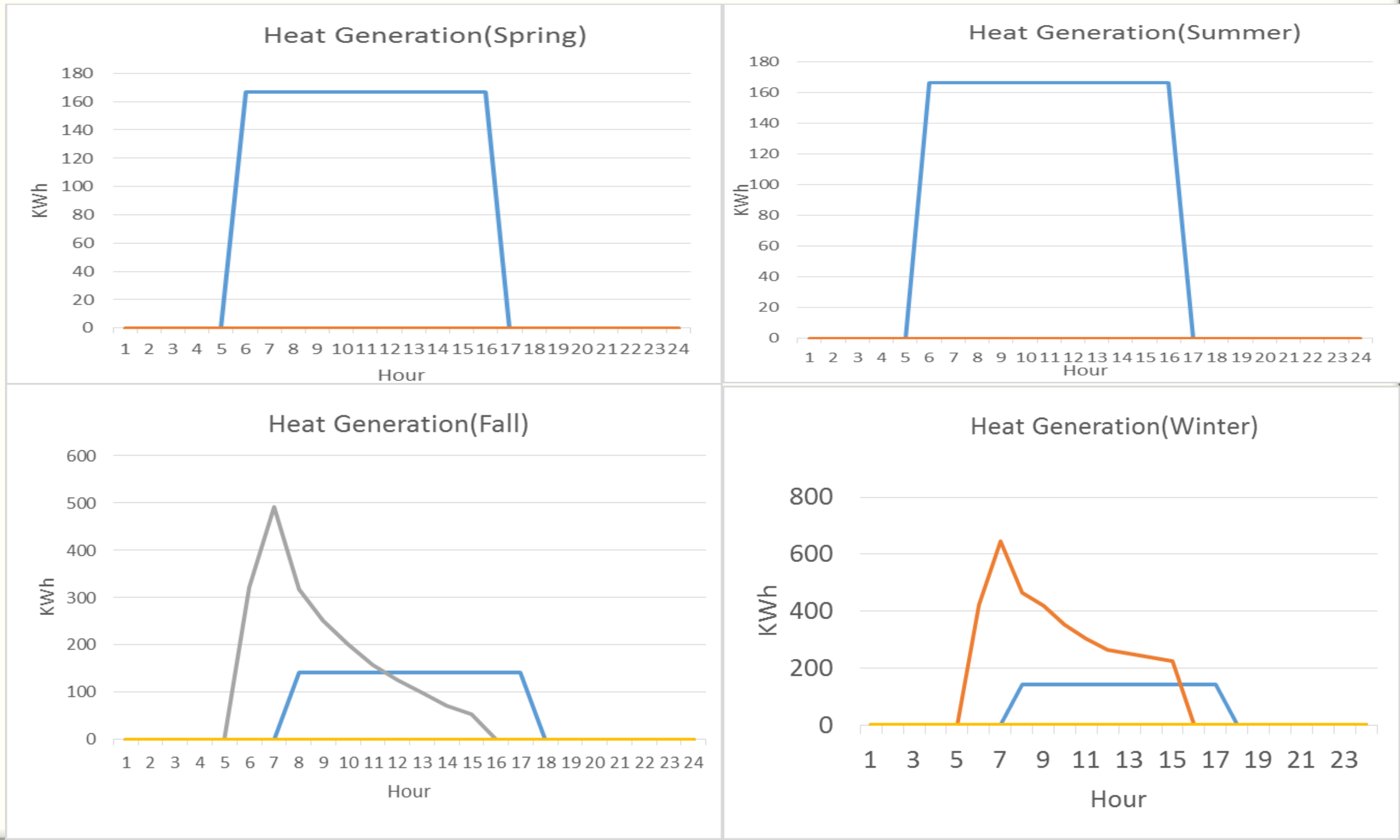
- Optimal Capacity of DGs for Supplying Heating Demand in Case Study Building:



Choose of The best scenarios

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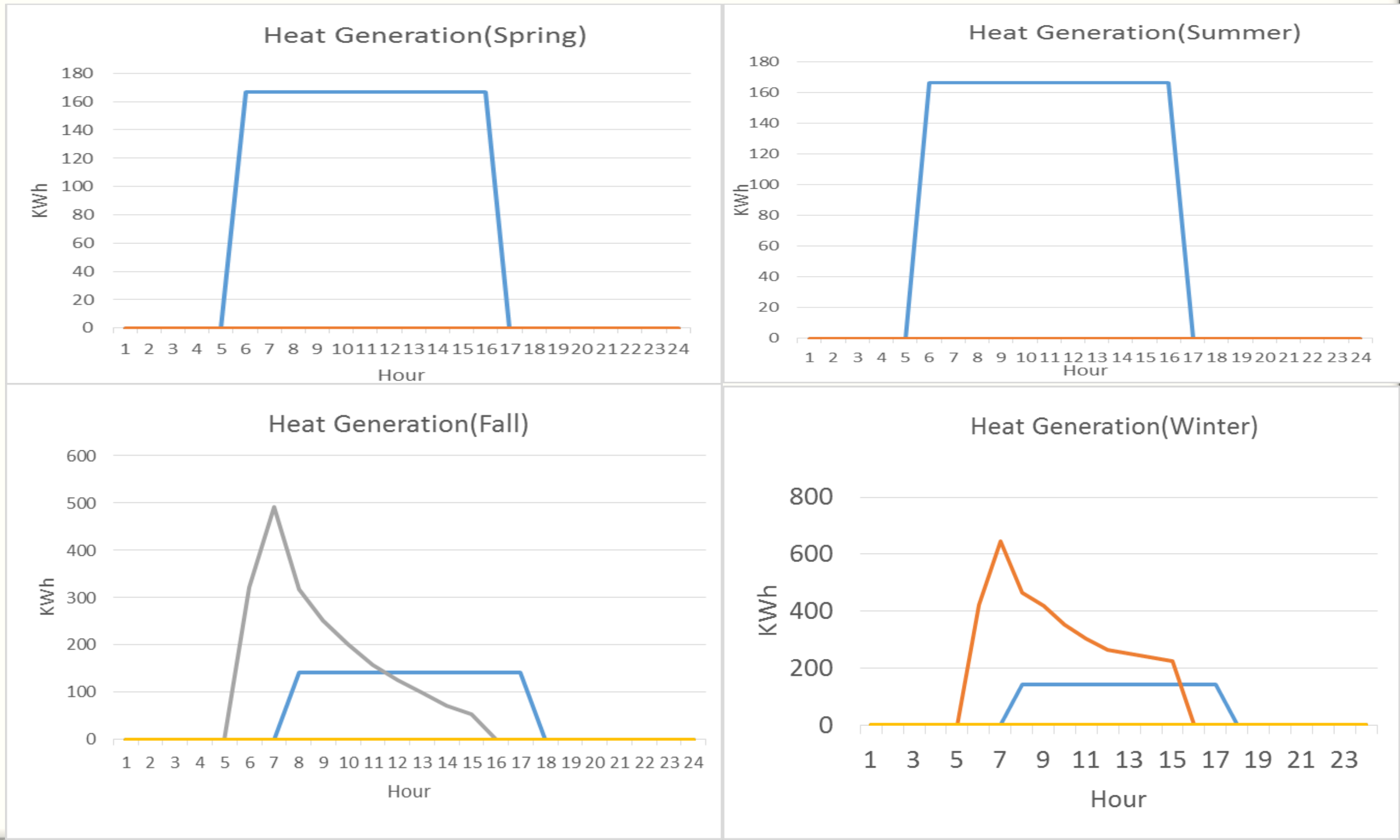
·Optimal Capacity of DGs for Supplying Heating Demand in Case Study Building:

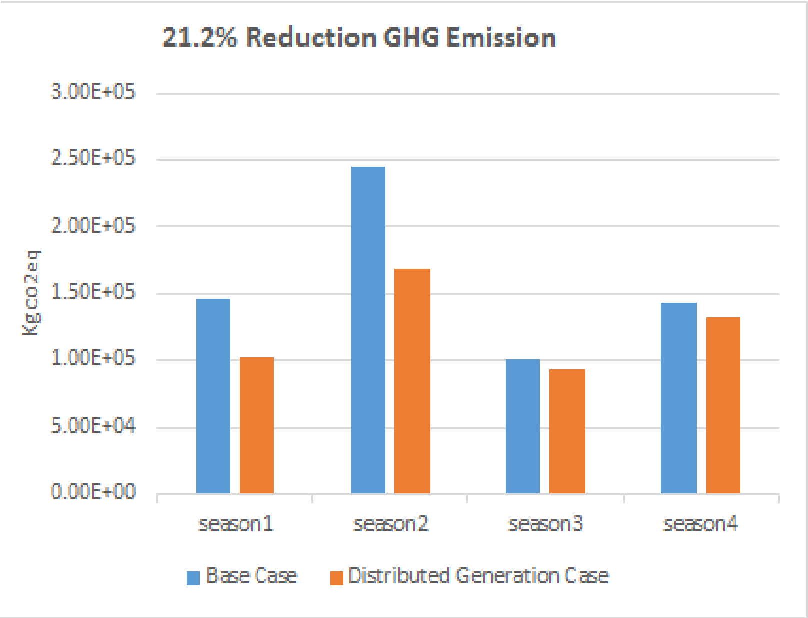


Result and Discussion

Choose of The best scenarios

Distributed Generation Case	
Spring: Cooling Demand: %58 Electricity: %0.45 ICE, %0.001 WT, %0.027 PV, %0.51 Gr	**Summer:** Cooling Demand: %48 Electricity: %0.38 ICE, %0 WT, %0.023 PV, %0.59 GR
Fall: Heating Demand: %40 Electricity: %0.89 ICE, %0.001 WT, %0 PV, %0.1GR	**Winter:** Heating Demand: %28 Electricity: %0.89 ICE, %0 WT, %0 PV, %0.1GR

Base Case	
Spring: Cooling Demand: %46	**Summer:** Cooling Demand: %47
Fall: Cooling Demand: %59	**Winter:** Cooling Demand: %48



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Thank you for your kind attention

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