Energy Modelling of Supermarkets

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Contents

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1.- Introduction.

Several parameters show the growth of supermarkets in Europe as the increasing number of hypermarkets, supermarkets and the increasing total food retail surface area

New Directives and regulations have been implemented in EU to improve efficiency in energy use and stimulate the use of renewable energy and to reduce emissions of greenhouse gases

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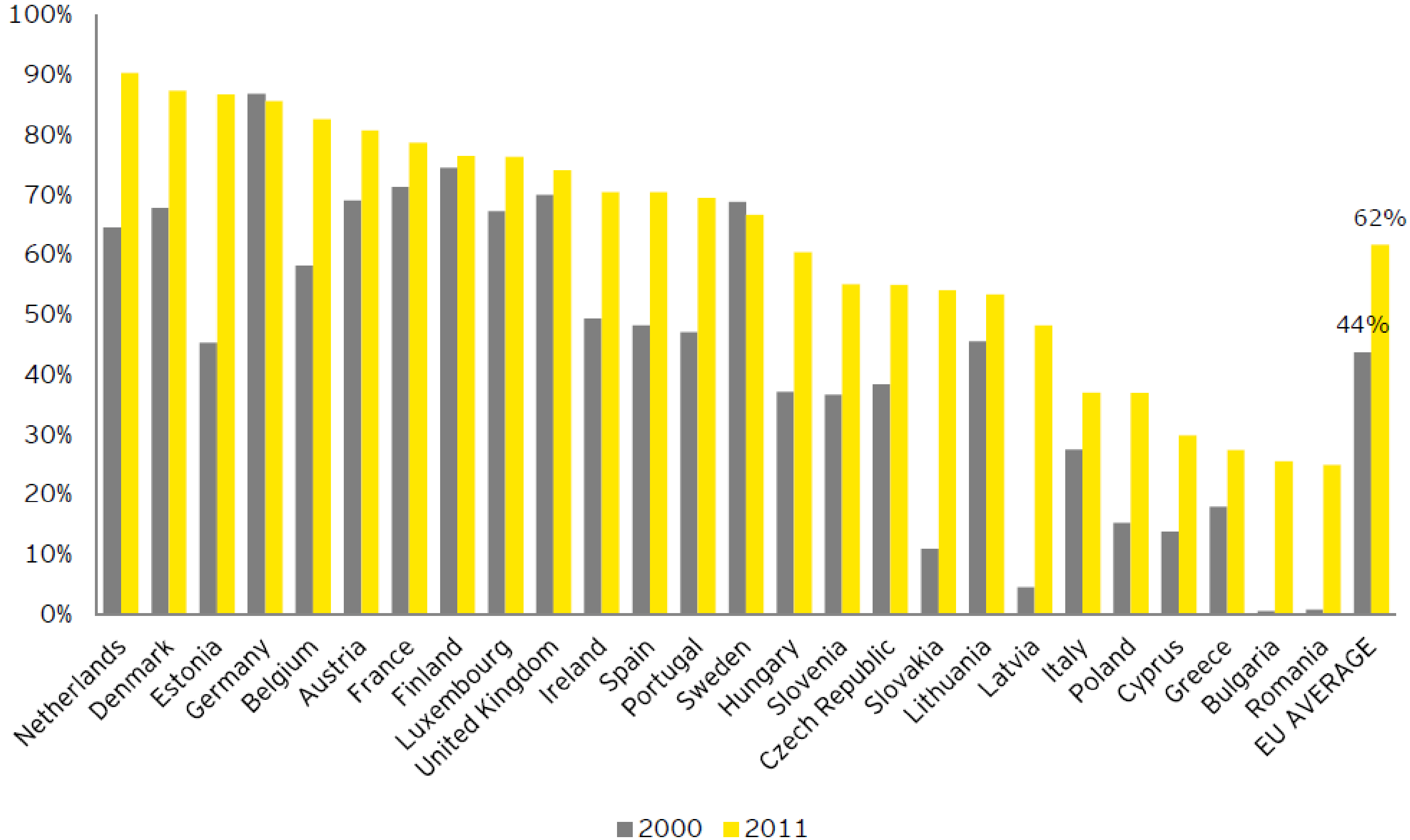
1.- Introduction.

Increasing number of hypermarkets, supermarkets in Europe



EU average:
44% (2000)
62% (2011)

Source: SuperSmart project http://www.supersmart-supermarket.info/

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1.- Introduction.

The Energy Performance of Buildings Directive requires all new buildings to be nearly zero-energy by the end of 2020. All new public buildings must be nearly zero-energy by 2018.

But there is no clear and standardized definition and it is left to the member states to define nearly ZEBs according to their own country specific conditions

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1.- Introduction.

The F-Gas Regulation strengthens the existing measures by:

- **Limiting the total amount of the most important F-gases that can be sold in the EU from 2015**
- **Banning the use of F-gases in many new types of equipment such as fridges in homes or supermarkets, air conditioning and foams and aerosols**
- **Preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.**

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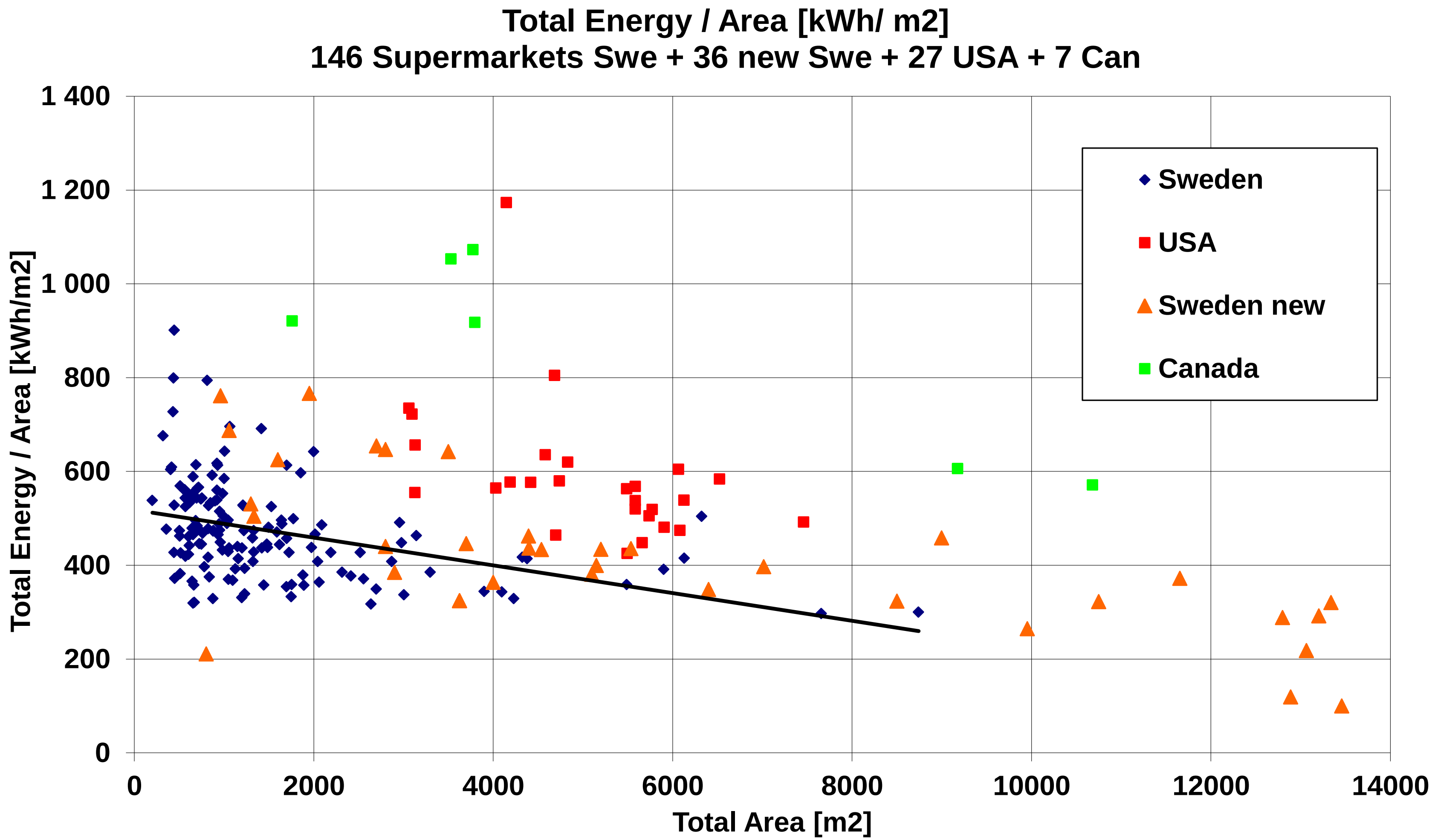
1.- Introduction.

The energy consumption of an average supermarket in Sweden is 350-450 kWh/m^2. In Canada the figure is 800 kWh/m^2, in USA around 600 kWh/m^2 and in the UK 800-1000 kWh/m^2.

Share of national energy use of electricity in Supermarkets

USA: 4% (Orphelin, 1997)
UK: 3% (Tassou, 2011)
France: 4% (Orphelin, 1997)
Denmark: 4% (Reinholdt and Madsen, 2010), and
In Sweden approximately 3%

1.- Introduction.



(Source Annex 31 report, 2011)

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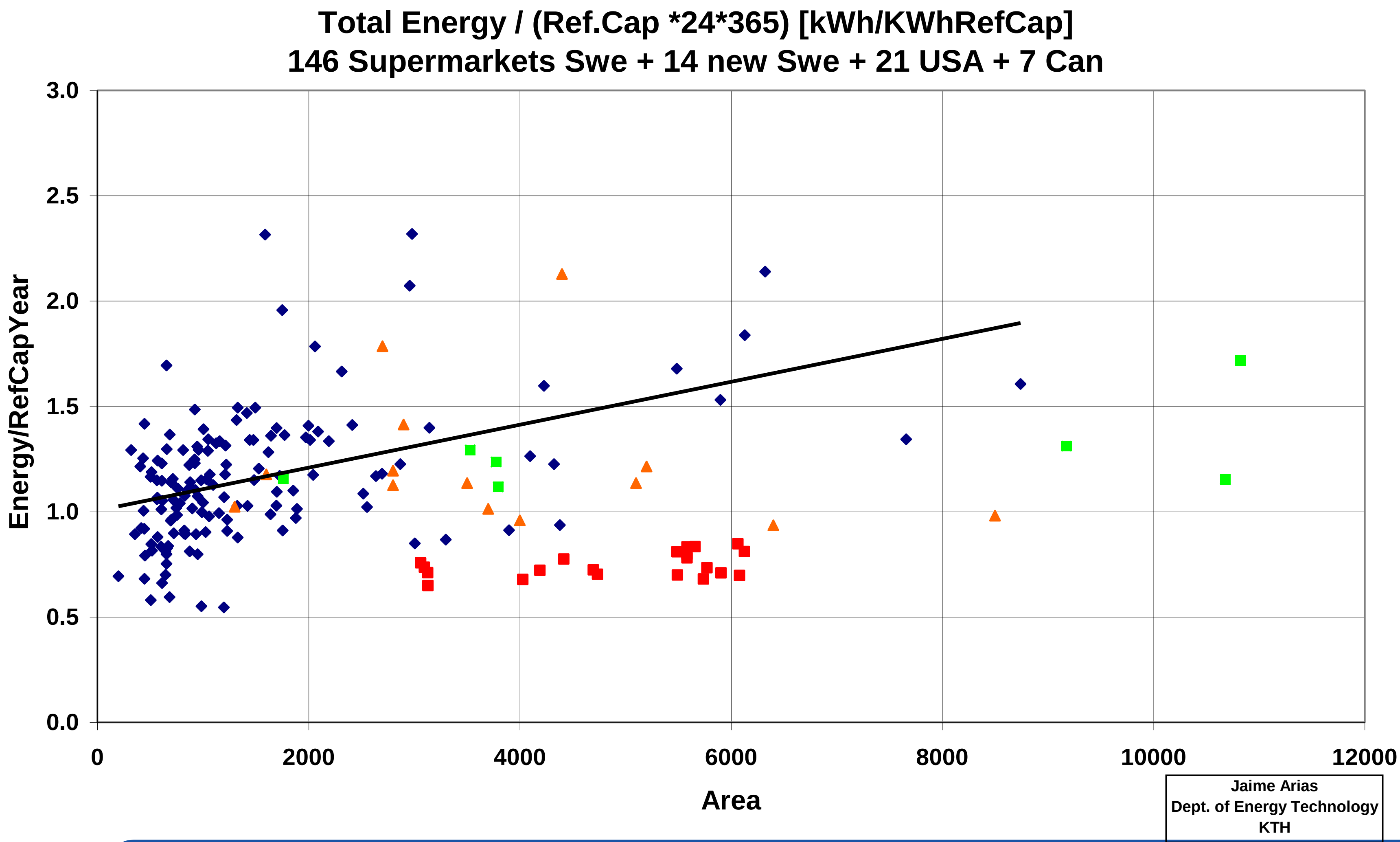

(Source Annex 31 report, 2011)

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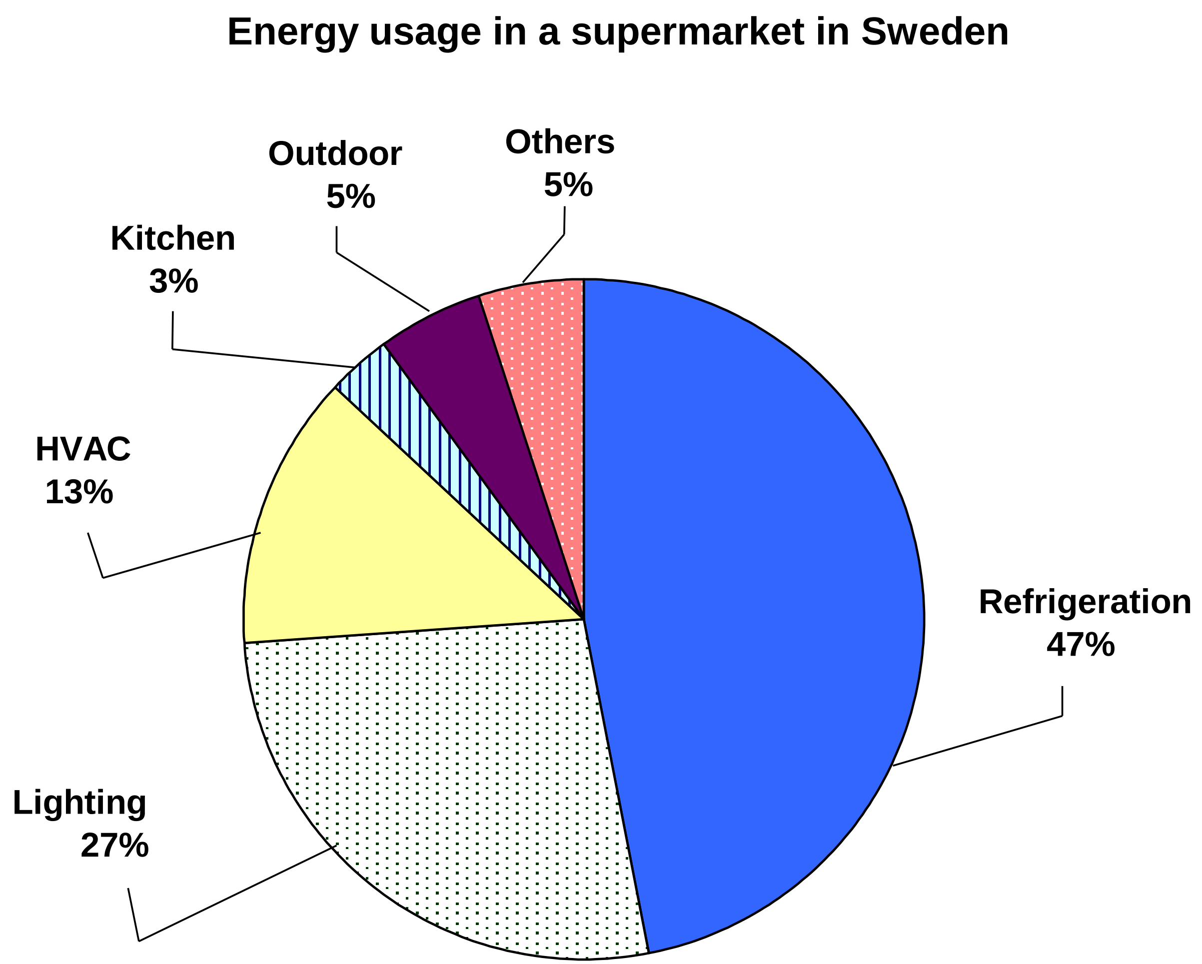

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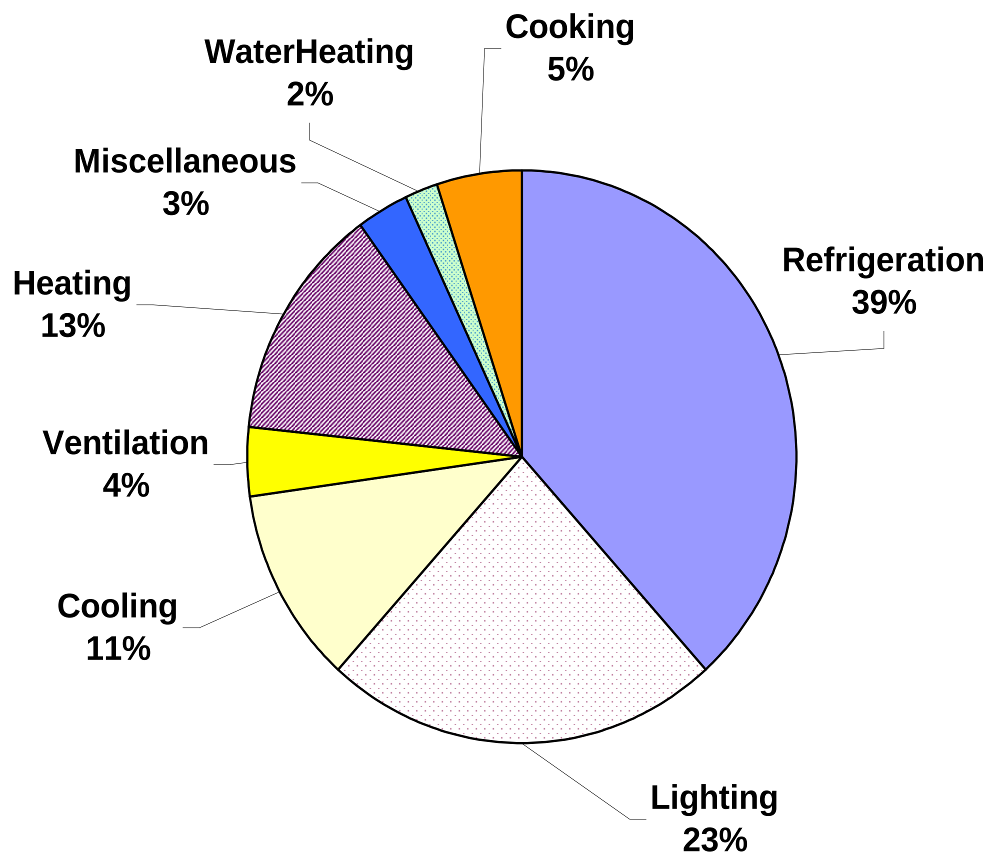
1.- Introduction.

Typical Electric Energy Usage in A Grocery Store in U.S.



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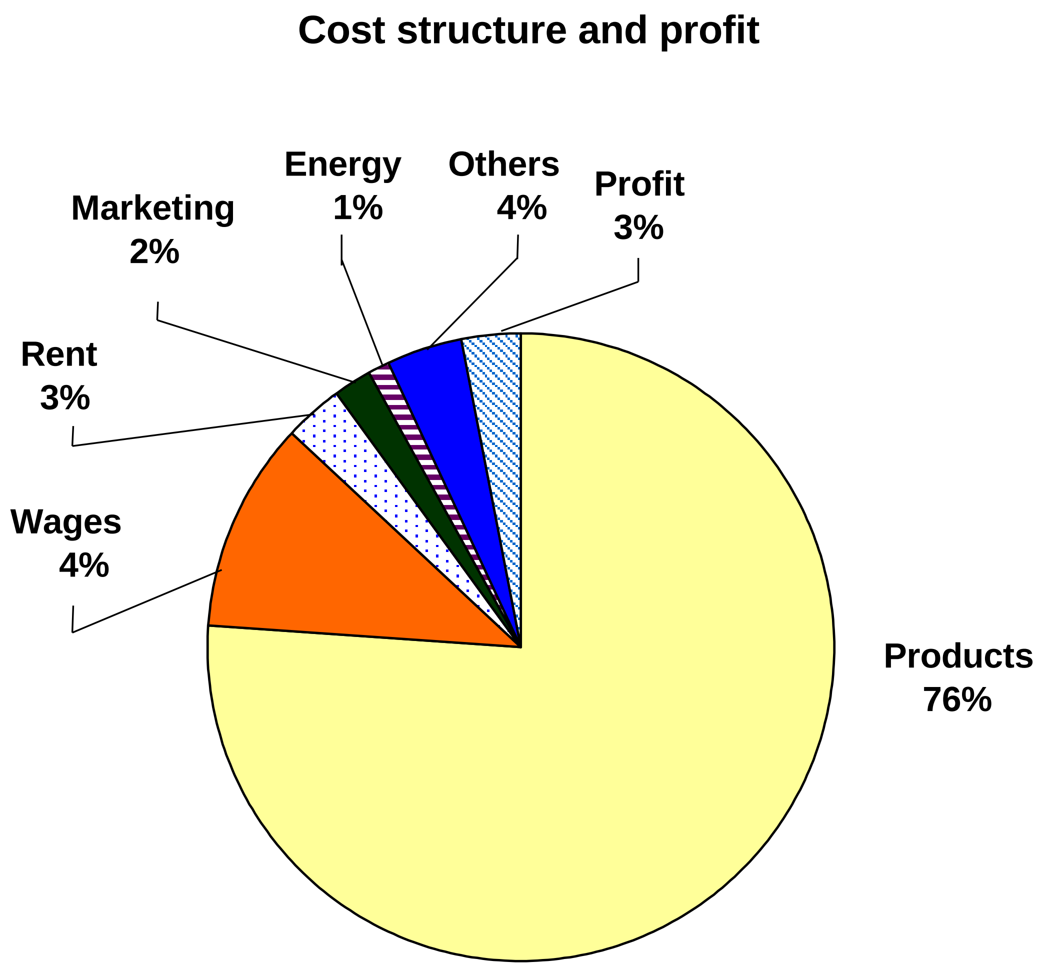

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2.- Building Energy Simulation.

Energy-saving technologies as heat recovery, floating condensing temperature, energy efficient lighting, energy efficient display cases have been implemented in several supermarkets.

New refrigeration system solutions using CO2 as the refrigerant have been introduced in supermarkets to lower F-gas emissions.

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2.- Building Energy Simulation.

The supermarket branch has more and less used the trial and error approach to implement and evaluate new ideas and concepts.

A systems model is necessary to be implemented in order to predict and evaluate the introduction of new concepts and ideas in supermarkets.

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2.- Building Energy Simulation.

There are many models for evaluation of energy efficiency, renewable energy and sustainability of buildings.

In the Building Energy Software Tools Directory on the homepage of the U.S. Department of Energy, there is information about 67 Whole Building Energy Simulation.

The majority of those Whole Building Energy simulation tools are able to model Building and HVAC performance but not refrigeration system performance or the interaction between cabinets and the surrounding environment

Source: https://www.buildingenergysoftwaretools.com/

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3.- Project SuperSmart.

SUPERSMART

Source: http://www.supersmart-supermarket.info

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3.- Project SuperSmart.

SUPERSMART

SuperSmart was a EU funded Horizon 2020 Project

- **Started: 1st of February 2016**
- **Project Partners:**
  - SINTEF (coordinator)
  - Shecco
  - CNR
  - Umweltbundesamt
  - KTH
  - TUBS
  - CIRCE
  - Energija doo
  - IIR

3.- Project SuperSmart.

1. **Identify market barriers**
2. **Removing non-technical market barriers.**
3. **Supporting the introduction of a new European Ecolabel for supermarkets**
4. **Reduction of environmental impact of supermarkets**

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3.- Project SuperSmart.

SUPERSMART

Mapping and segmentation of barriers & description of supermarket sector

Report 1

Eco-friendly supermarkets - an overview

Report 2

How to build a new eco-friendly supermarket

Report 3

How to refurbish a supermarket

Report 4

Computational tools for supermarket planning

Report 5

Eco-friendly operation and maintenance of supermarkets

Report 6

EU Ecolabel for food retail stores

Report 7

Source: http://www.supersmart-supermarket.info

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3.- Project SuperSmart.

SUPERSMART

Report 5: Computational tools for supermarket planning

List of Computational Tools:

CoolPack: is a “collection of simulation programs that can be used for designing, dimensioning, analysing and optimizing refrigeration systems”. (https://www.ipu.dk/products/coolpack/)

CoolTool: is a software for planning and calculation of refrigeration- and air conditioning systems developed by CoolTool Technology GmbH (http://www.cooltool-software.com/)

Pack Calculation Pro is a simulation tool which compare the annual energy consumption of refrigeration systems and heat pumps (https://www.ipu.dk/products/pack-calculation-pro/)

3.- Project SuperSmart.

SUPERSMART

Report 5: Computational tools for supermarket planning

List of Computational Tools:

EnergyPlus is “a whole building energy simulation program”. It is free and open source and financed by the U.S. DOE. There are several third party graphical user interfaces available. (https://energyplus.net/)

TRNSYS (TRaNsient System Simulation program). It is commercial software which is widely used especially for building simulation. The supermarket system models have to be created by the user.

(http://www.trnsys.com/)

CyberMart is a tool for estimating the annual energy consumption of an entire supermarket. Developed by KTH

3.- New Project at KTH

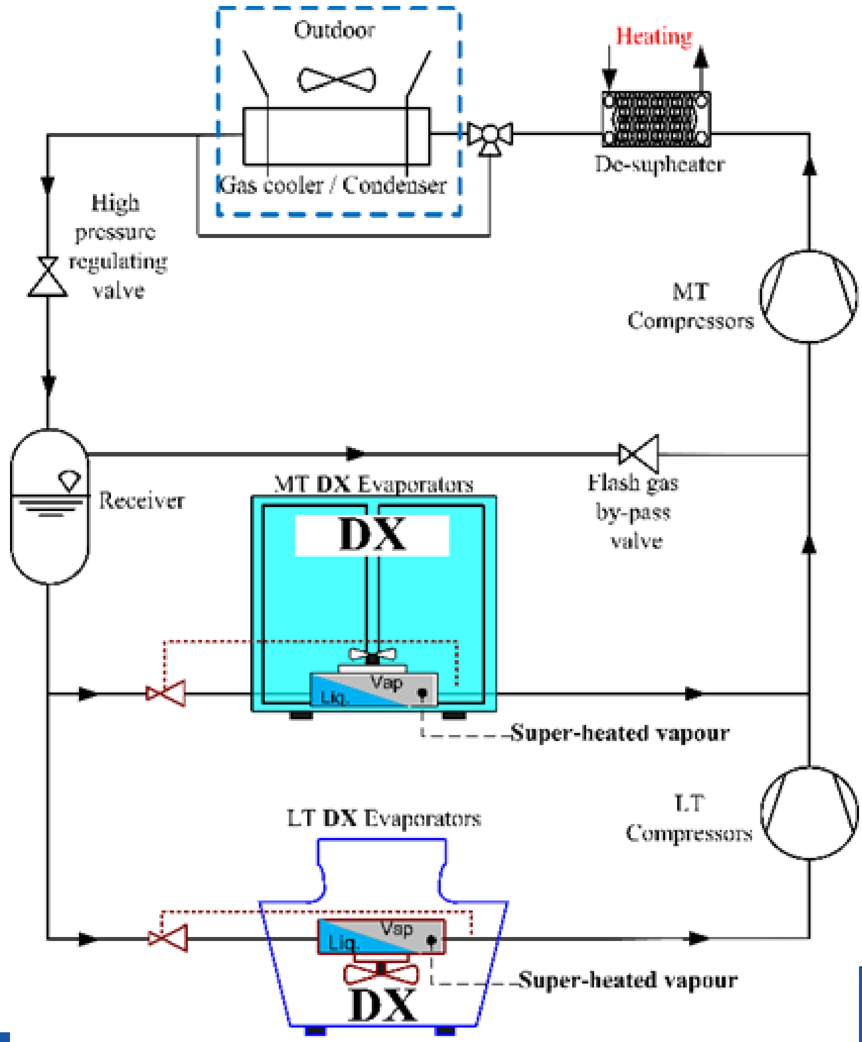
"Building state of the art supermarket-put theory into practice"

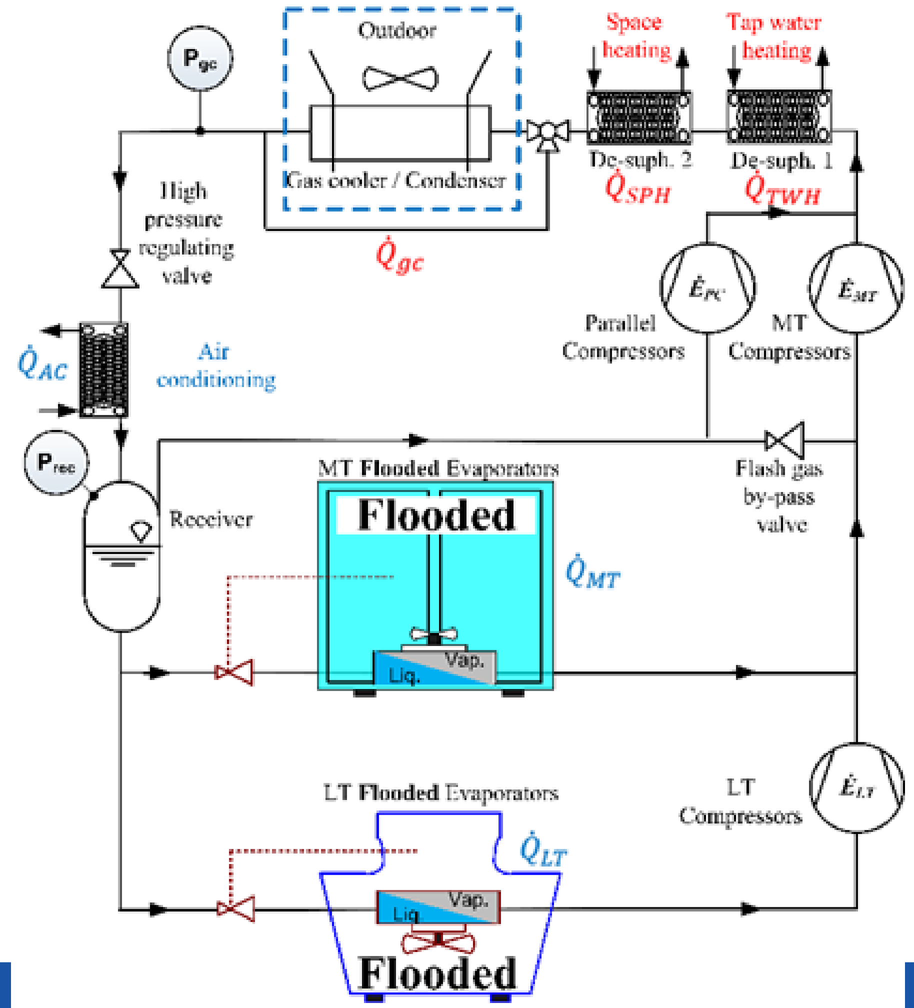
Project Leader: Samer Sawalha
PhD. Student: Sotirios Thanasoulas (soth@kth.se)

The proposed system offers:

- **At least 15% annual energy savings compared to standard CO2 system.**
- **At least 25% annual energy savings compared to conventional systems**
- **The system is the most efficient and cost effective that can be installed in Sweden today.**

3.- New Project at KTH





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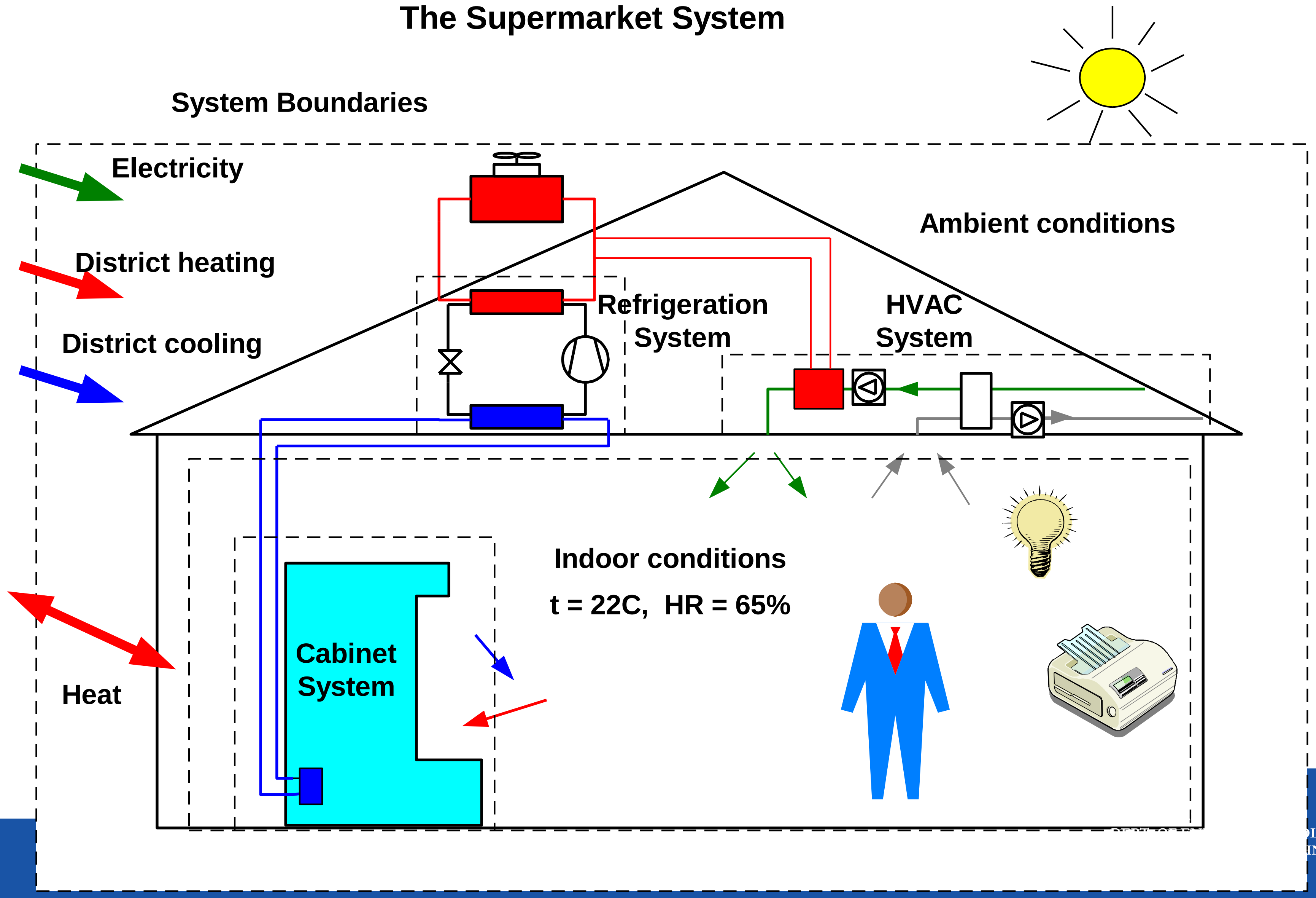
4.- Systems and Models for Supermarkets.

The Supermarket System



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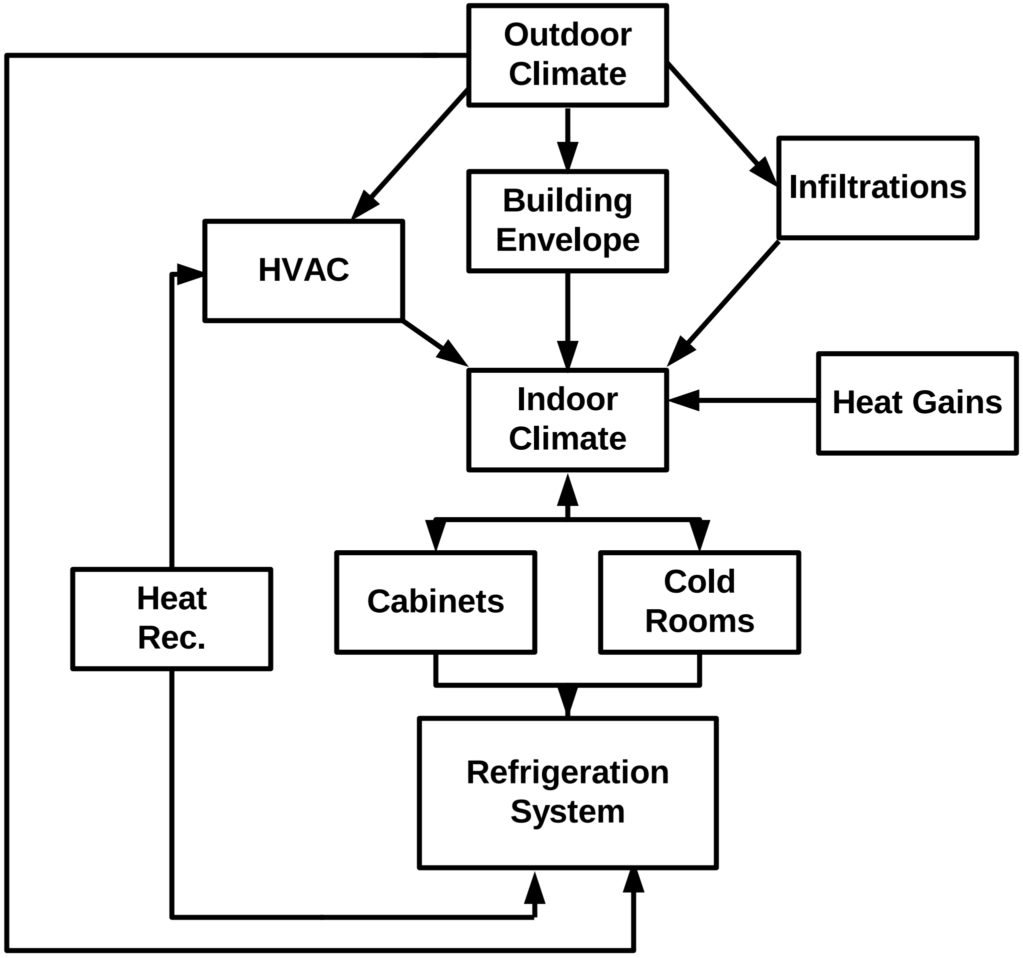

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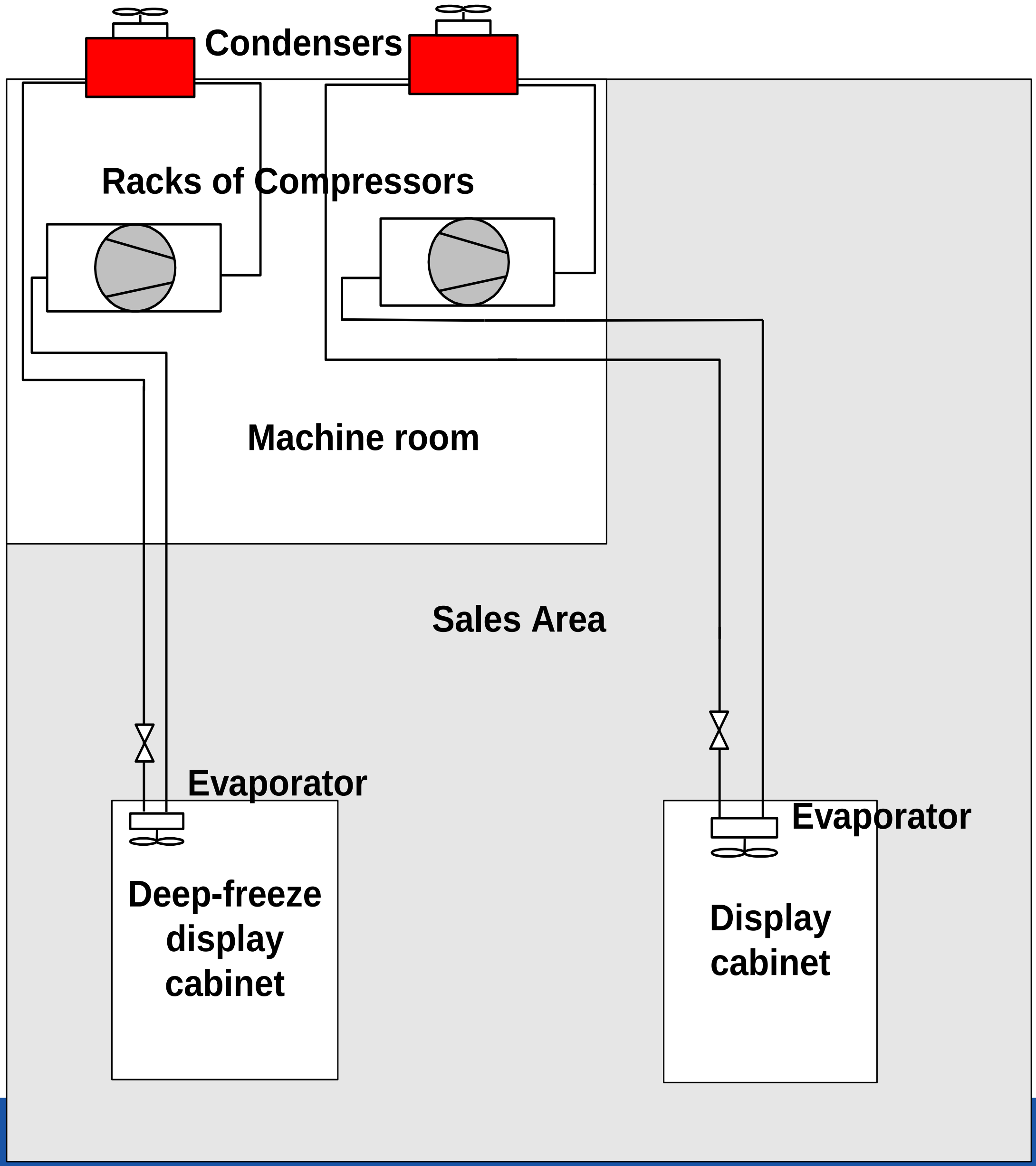
Direct system



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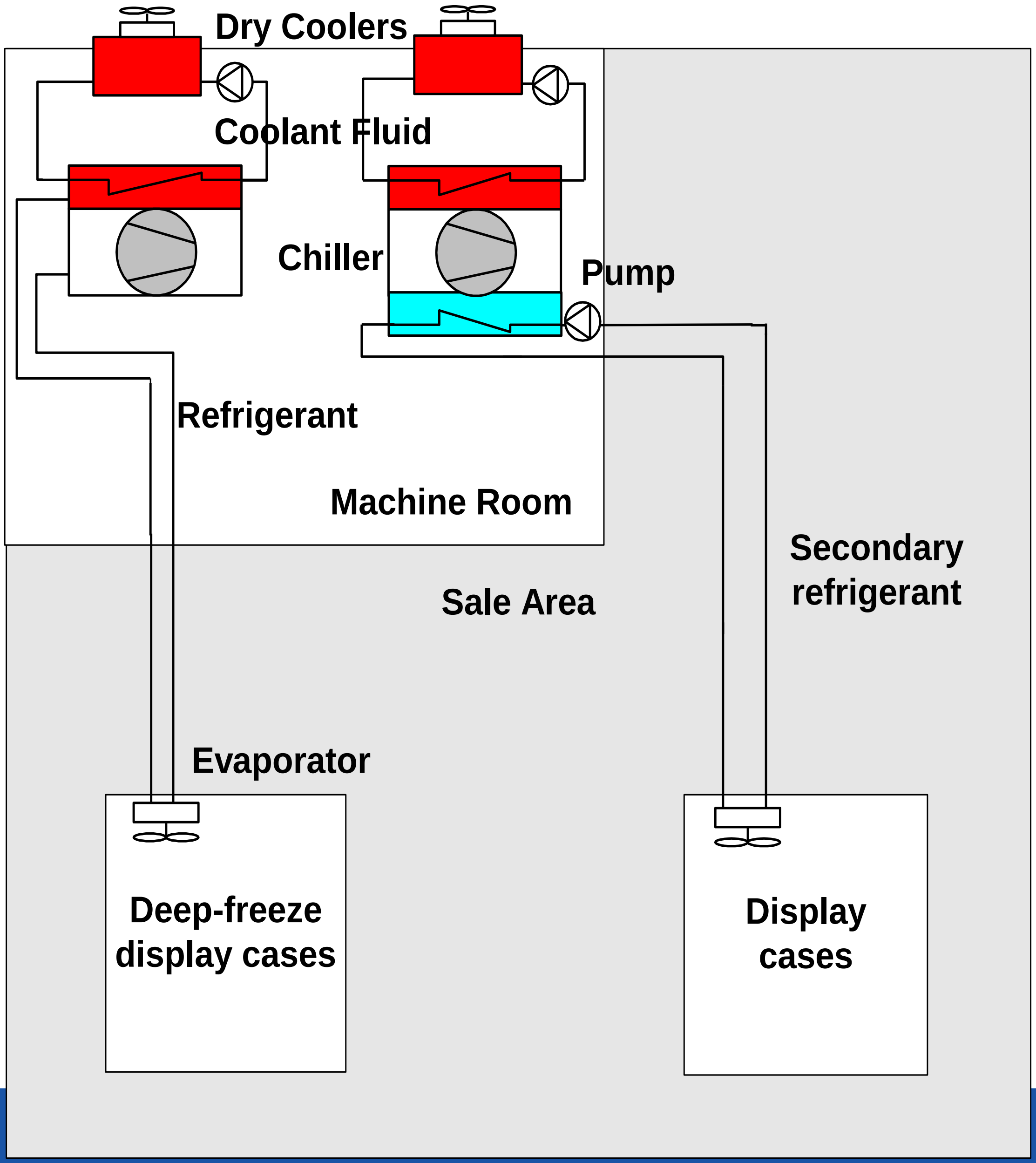
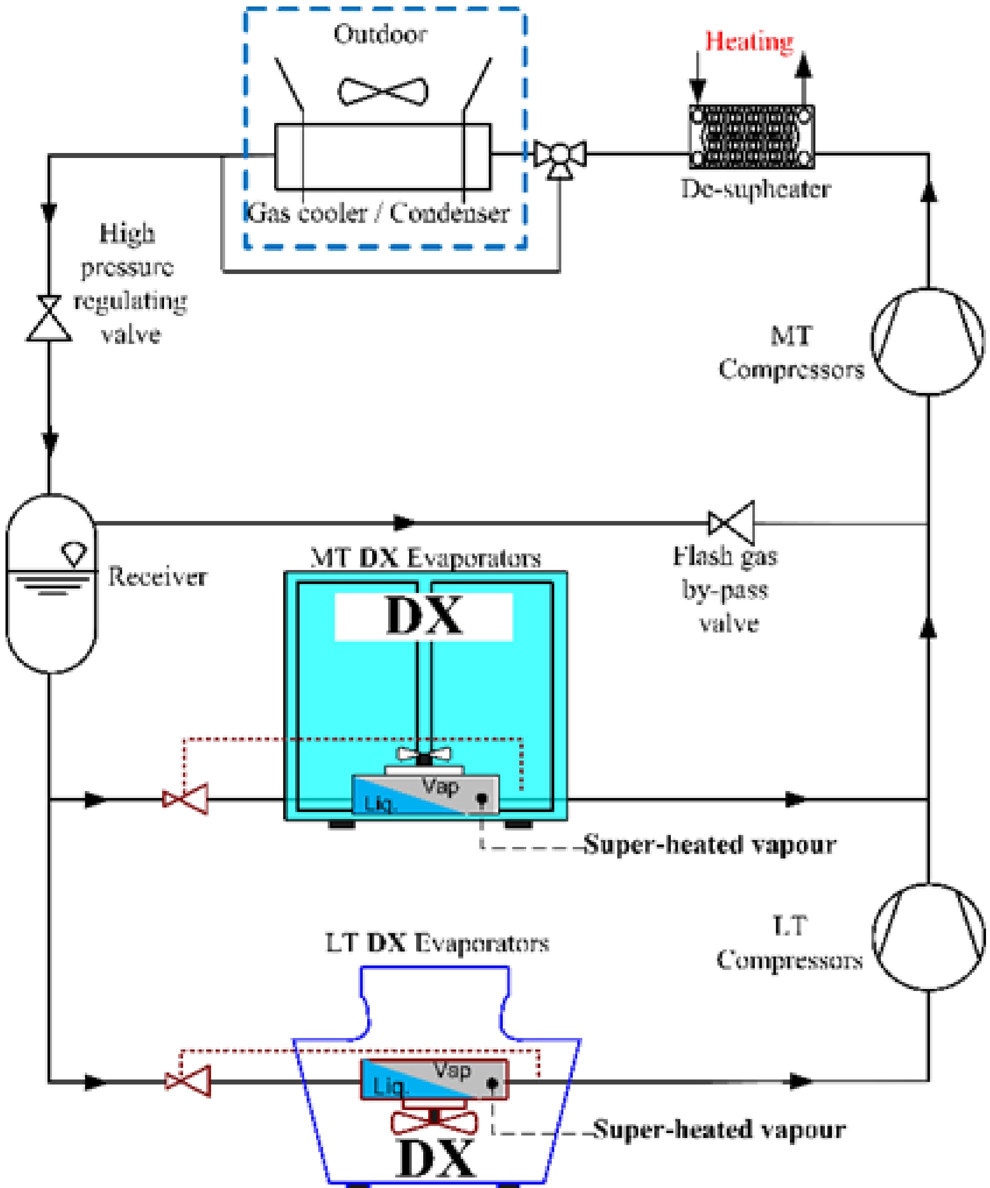
Partially Indirect System





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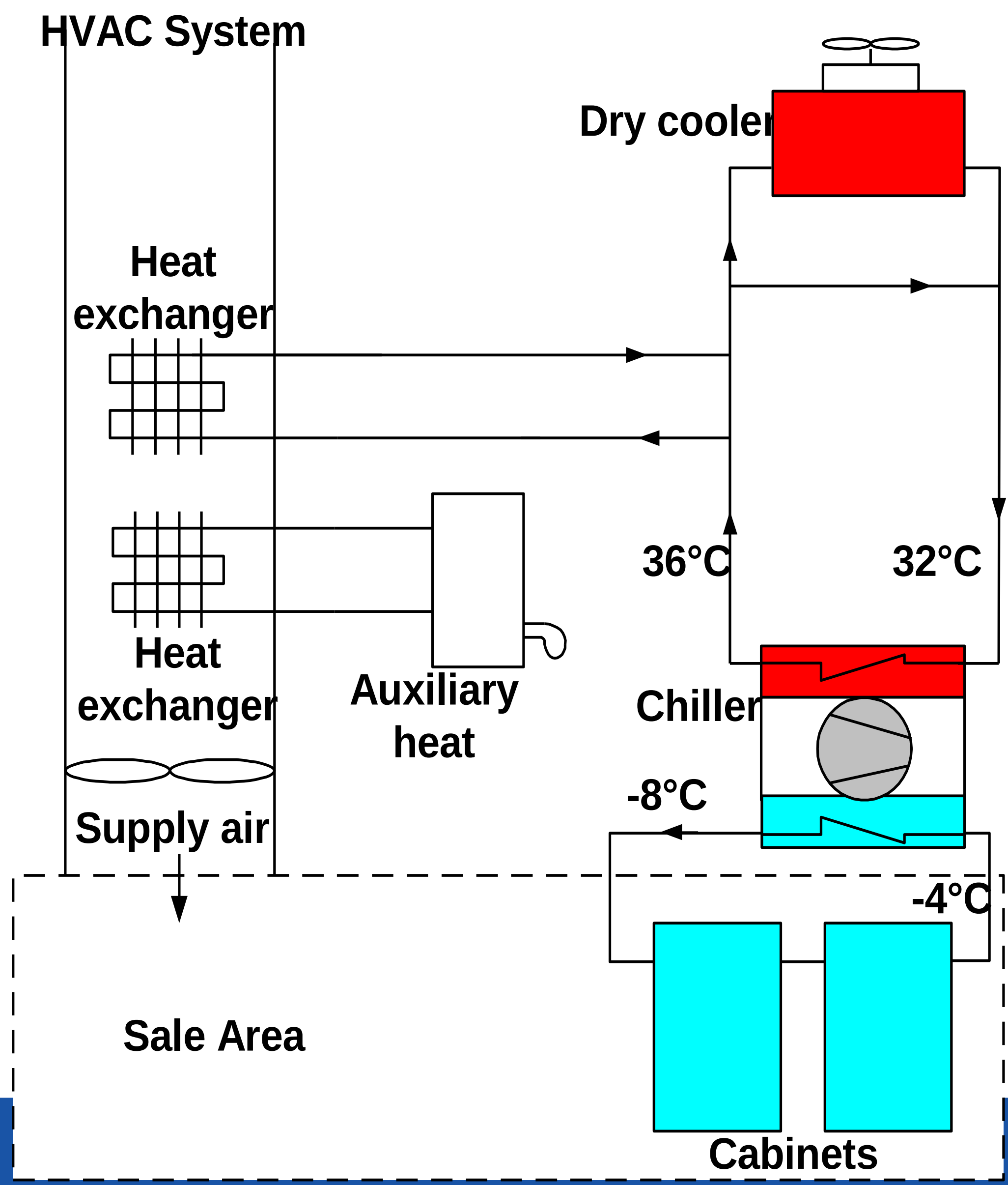
Heat recovery
System 3



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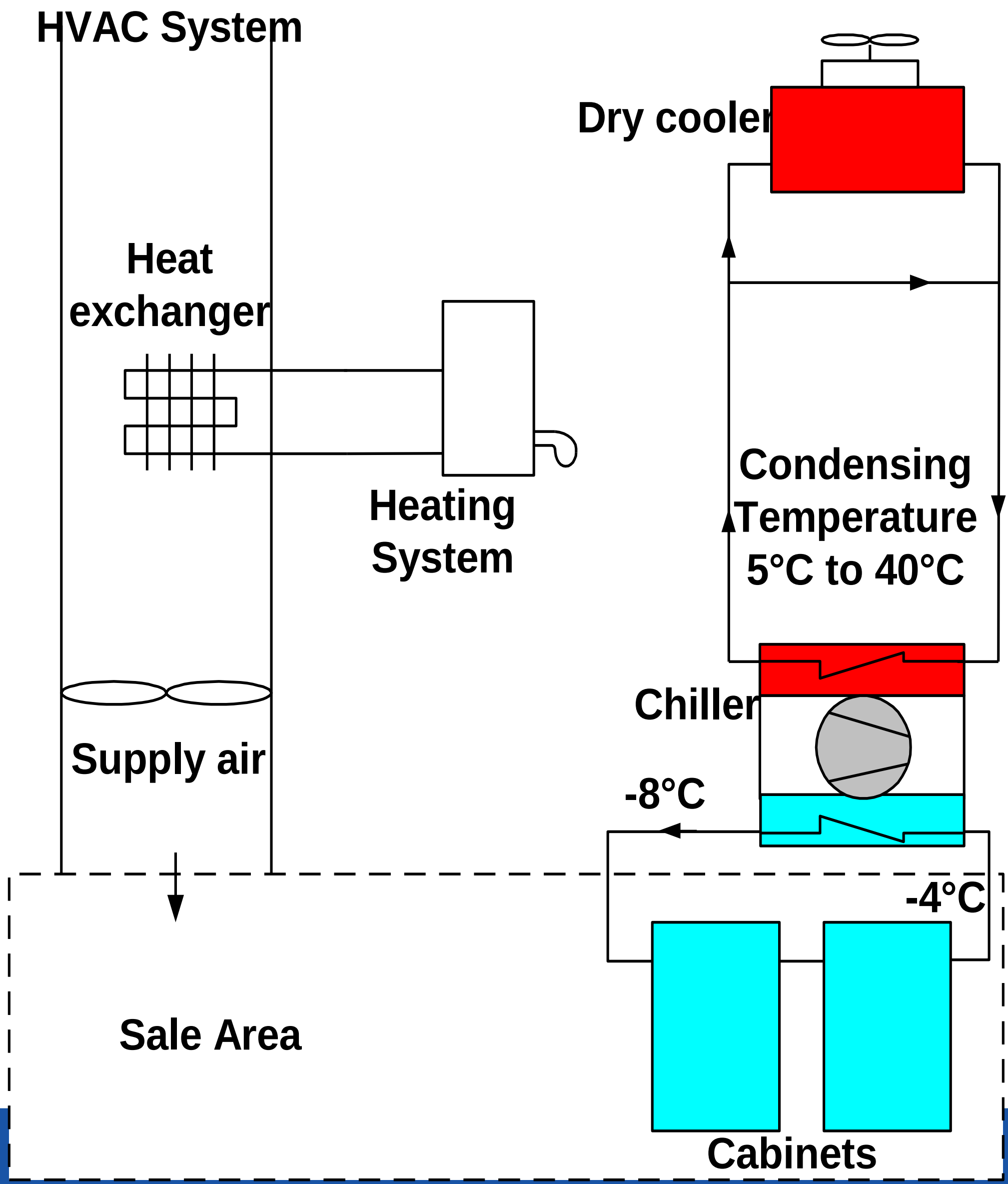
Floating Condensing System



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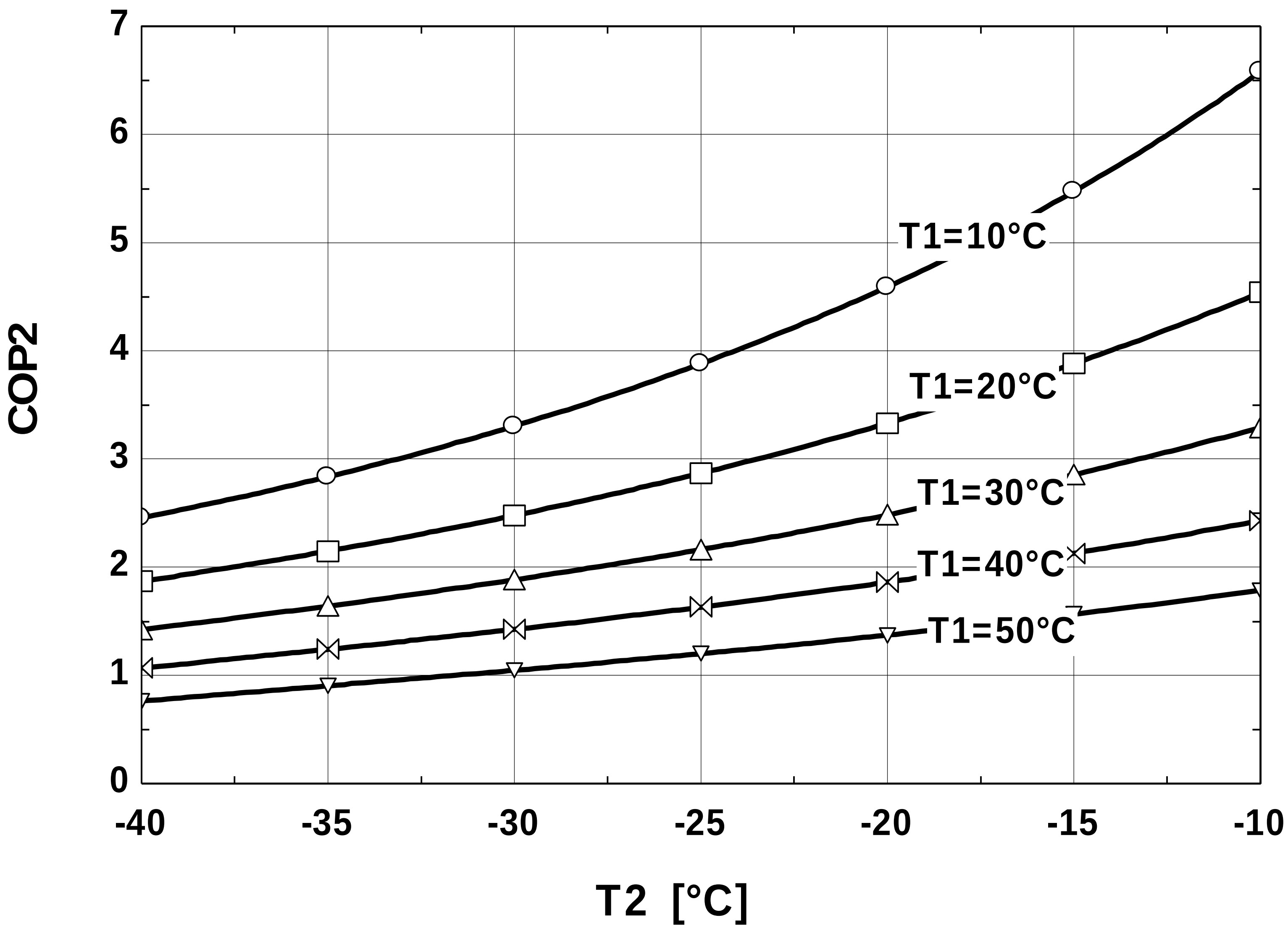

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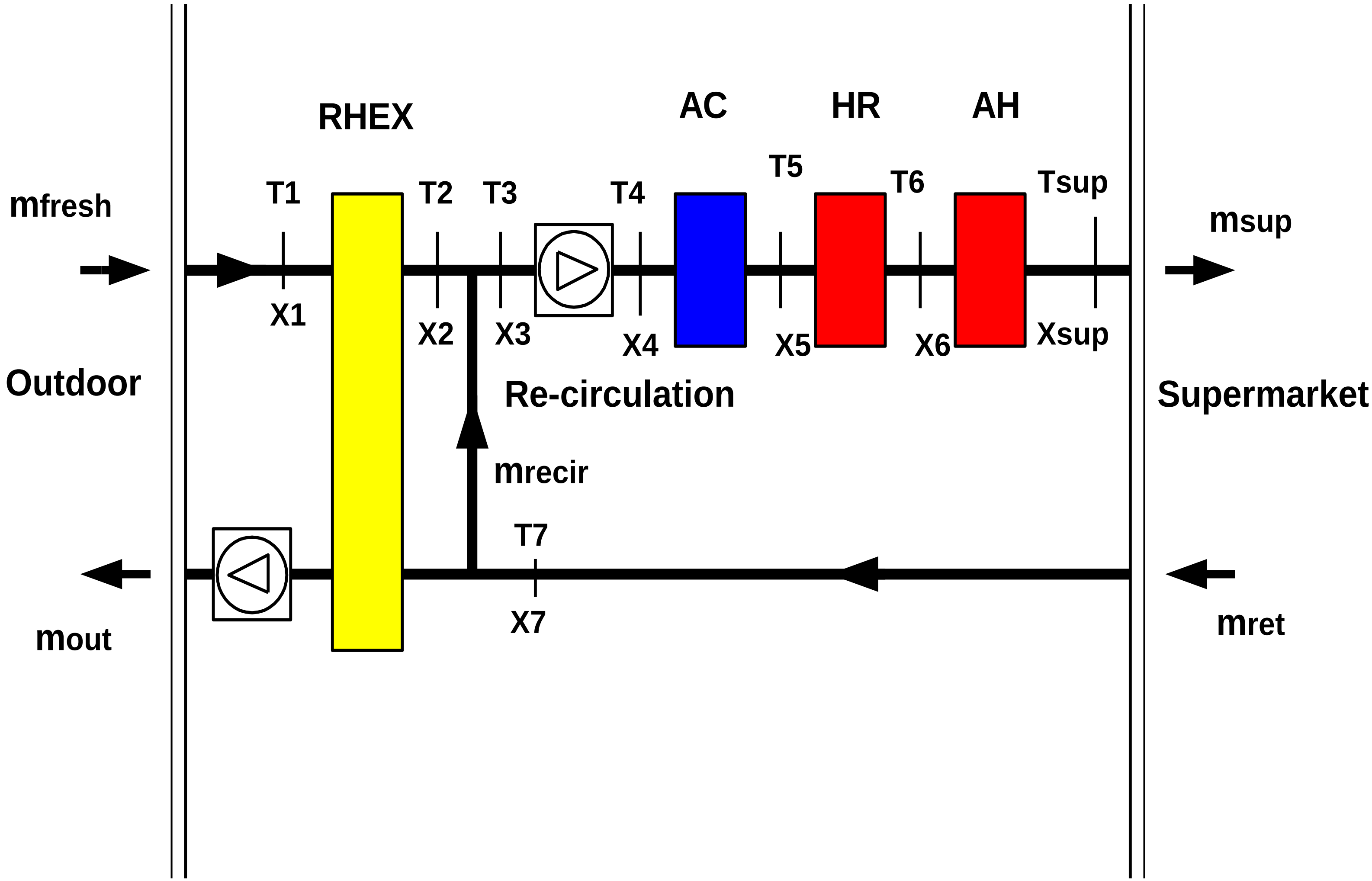
HVAC Model



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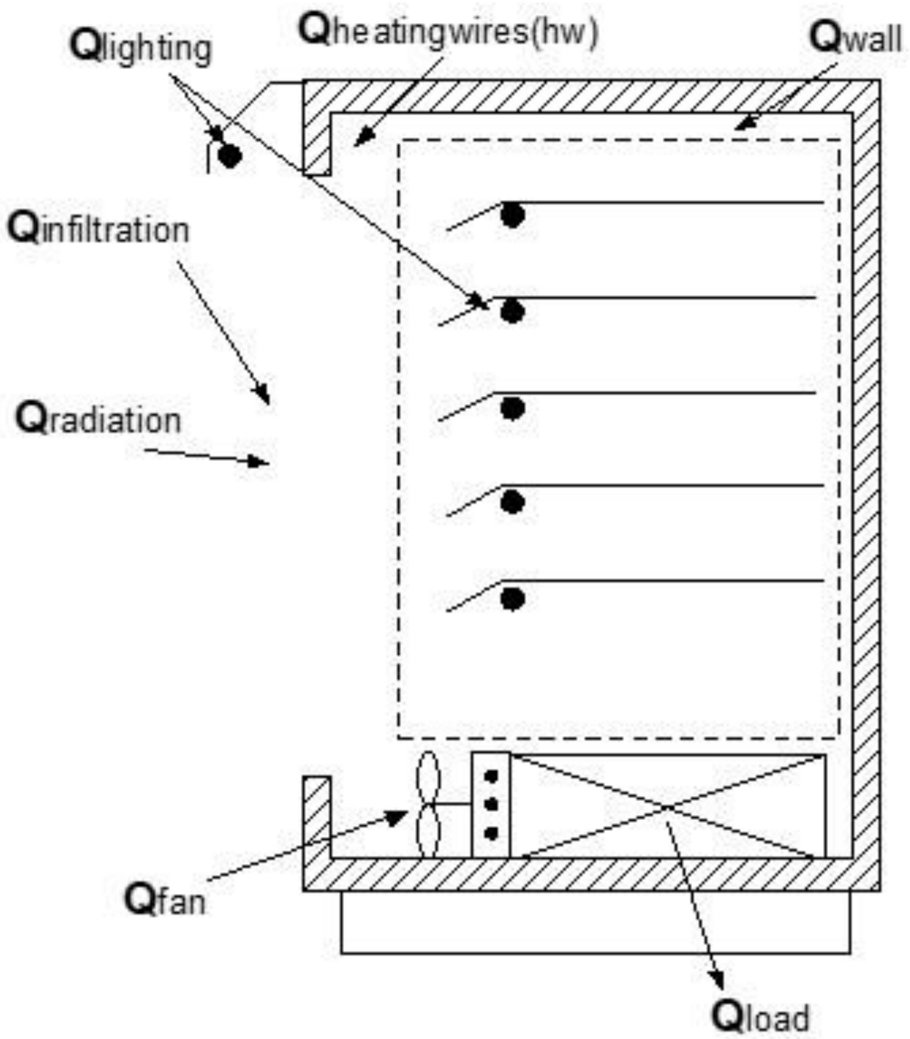
4.- Systems and Models for Supermarkets.



Qwall = 7 %

Qinfiltration = 64 %

Qradiation = 11 %

Qlighting = 11 %

Qfan = 5 %

Qhw = 2%

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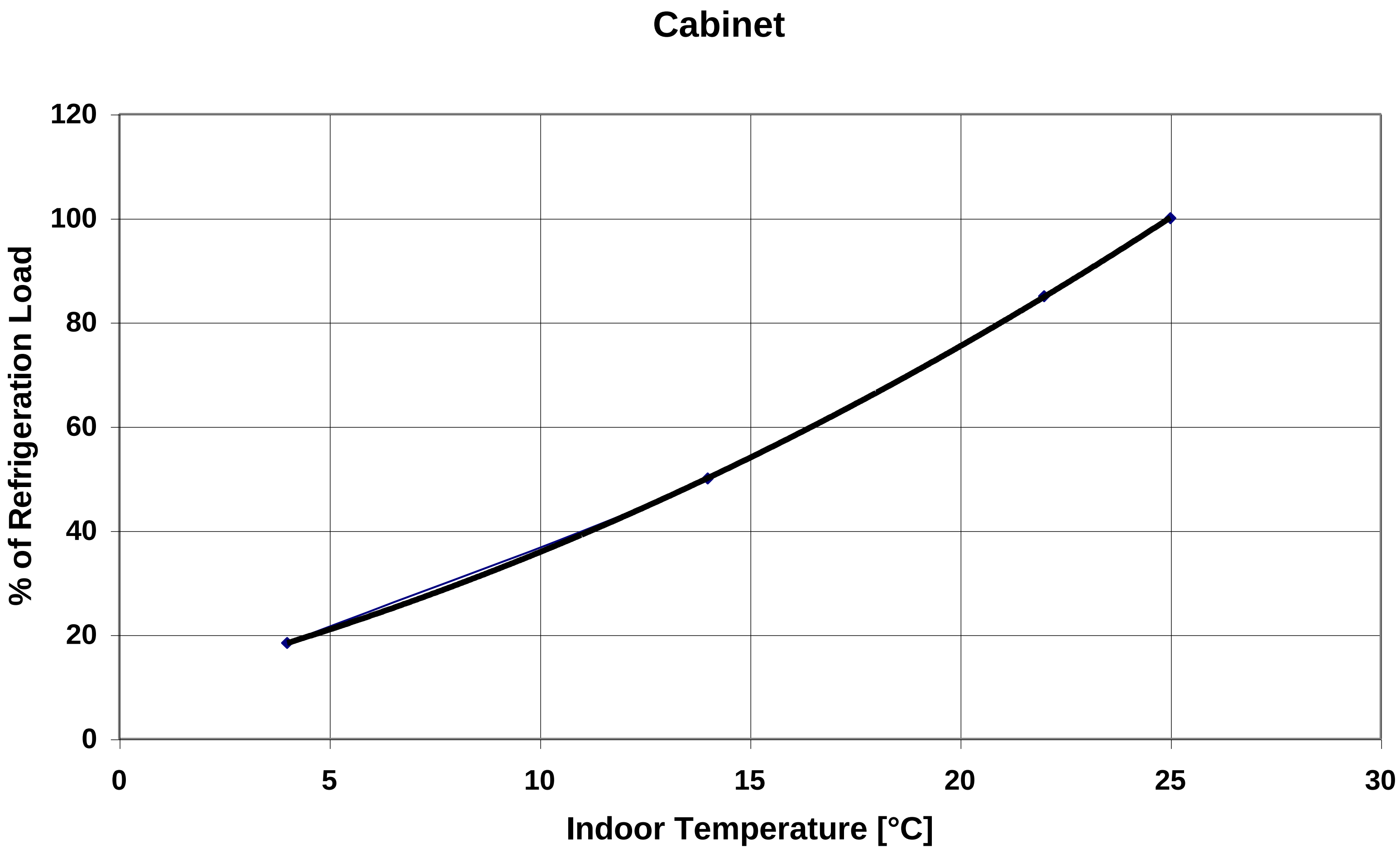
4.- Systems and Models for Supermarkets.



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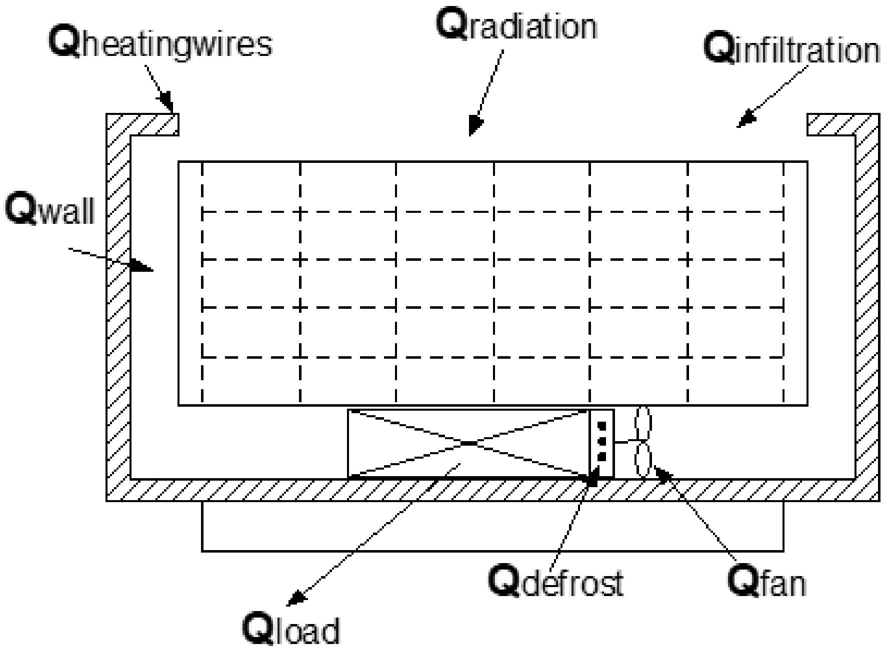
4.- Systems and Models for Supermarkets.



Qwall = 11 %

Qinfiltration = 23 %

Qradiation = 46 %

Qlighting = 0 %

Qfan = 8 %

Qhw = 9 %

Qdefrost = 4 %

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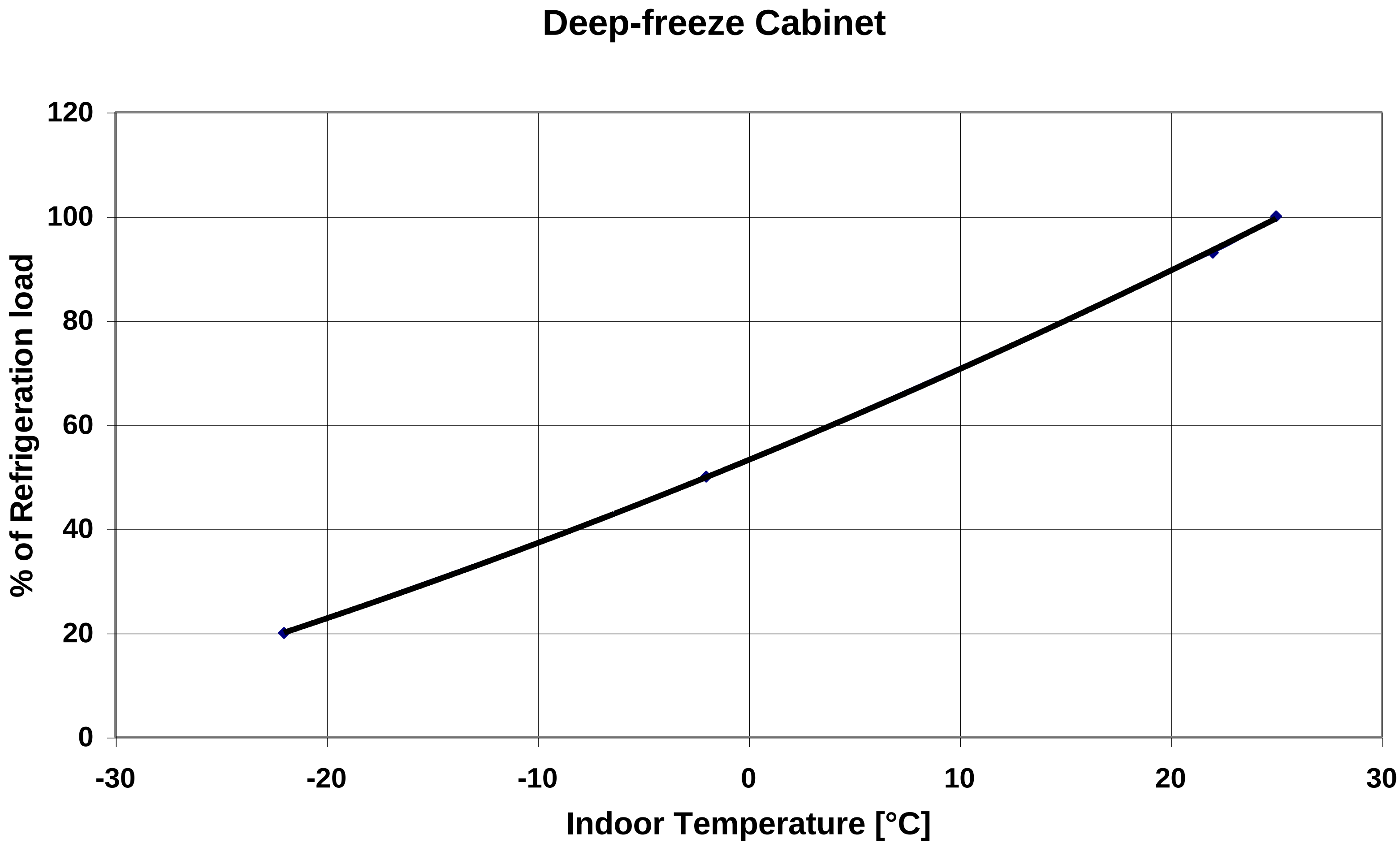
4.- Systems and Models for Supermarkets.



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5.- CyberMart

CyberMart

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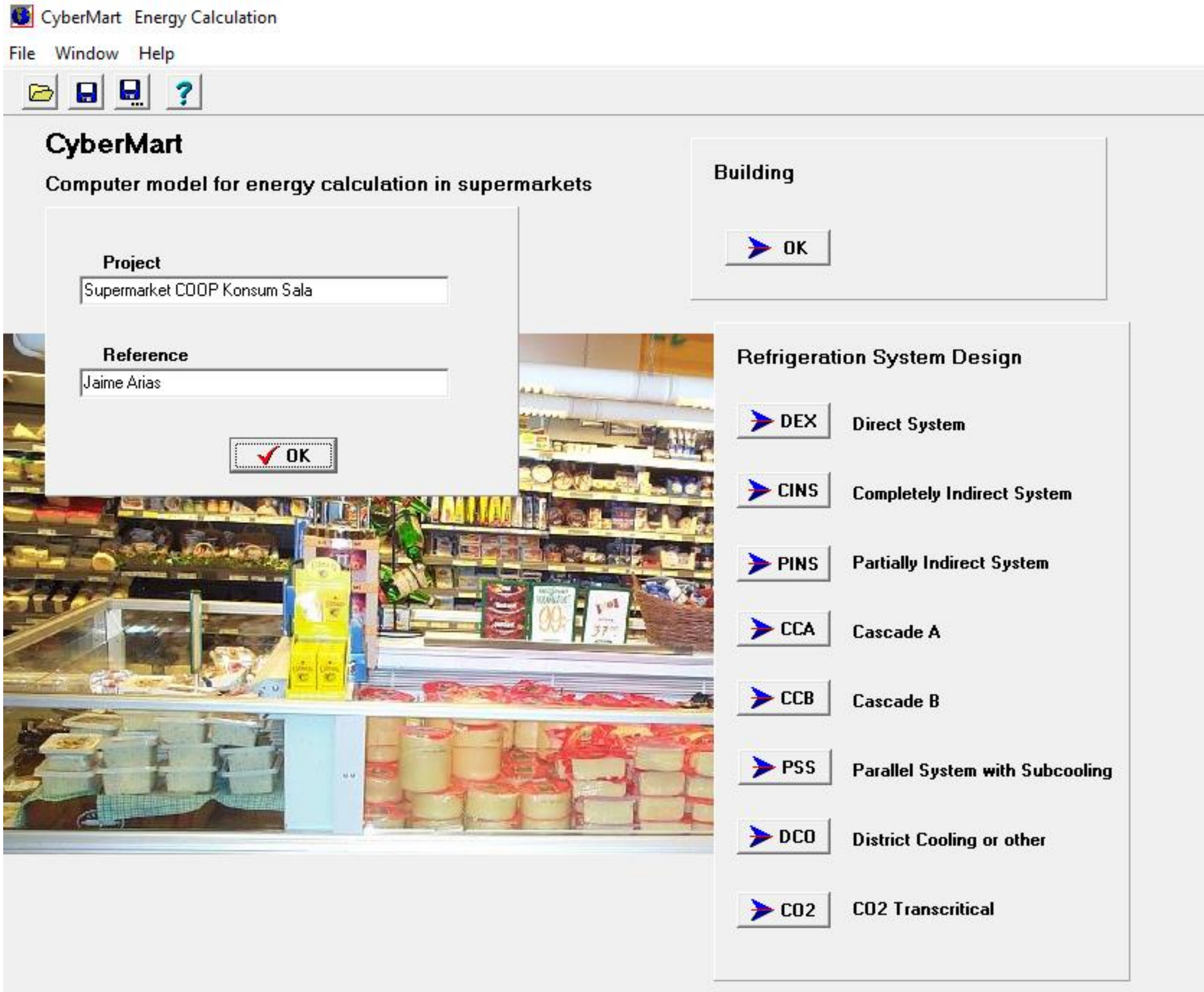

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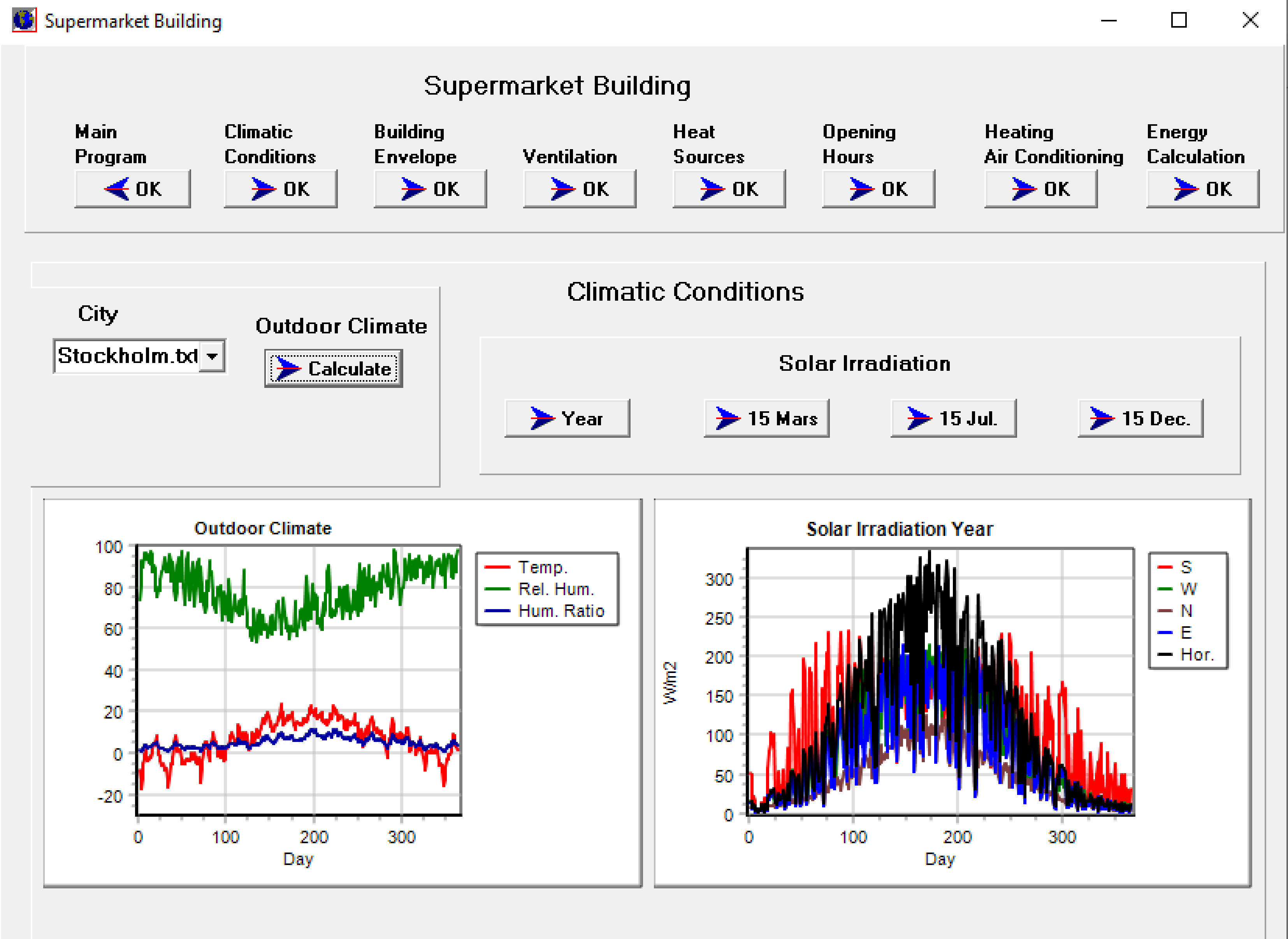

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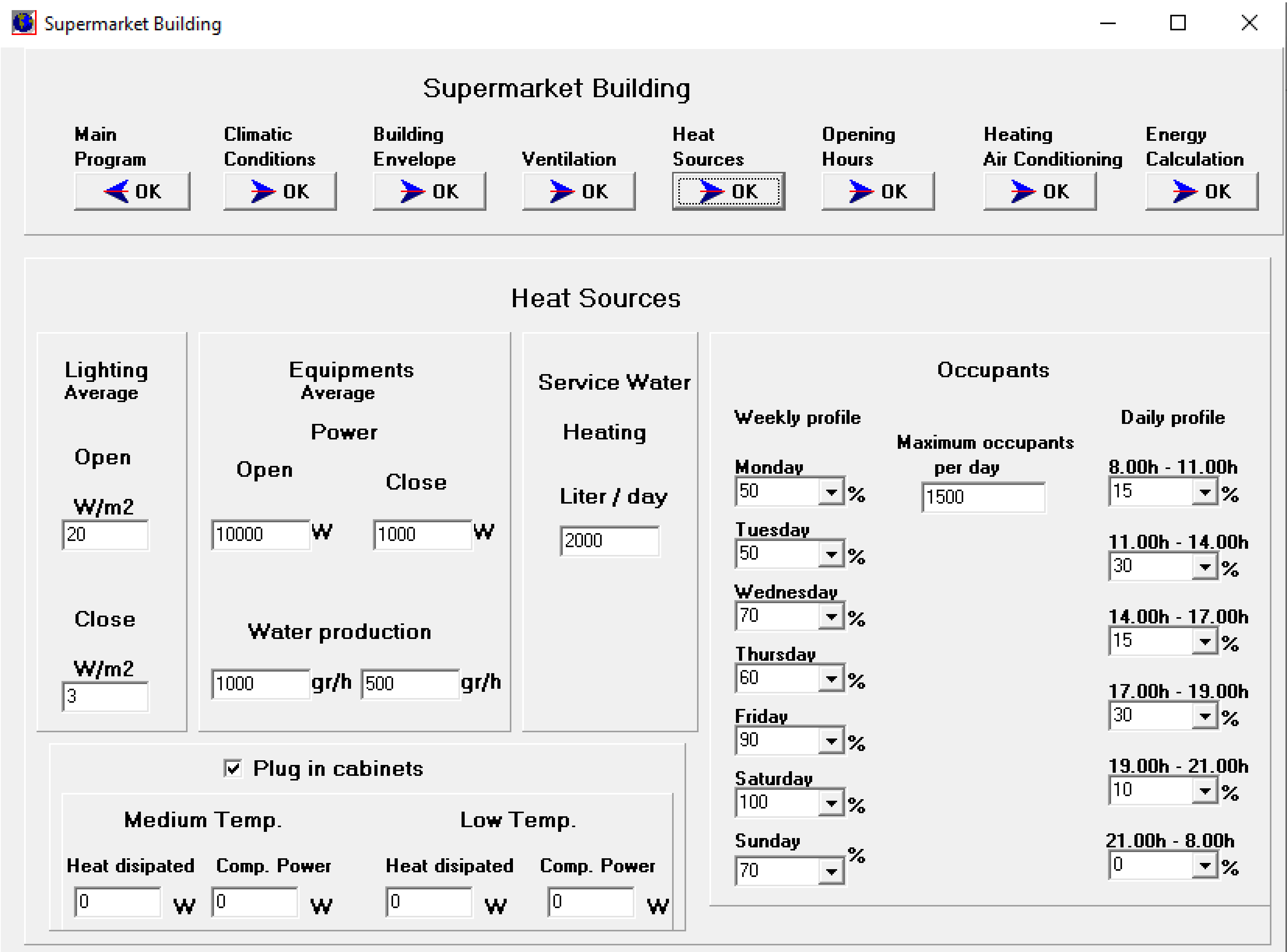

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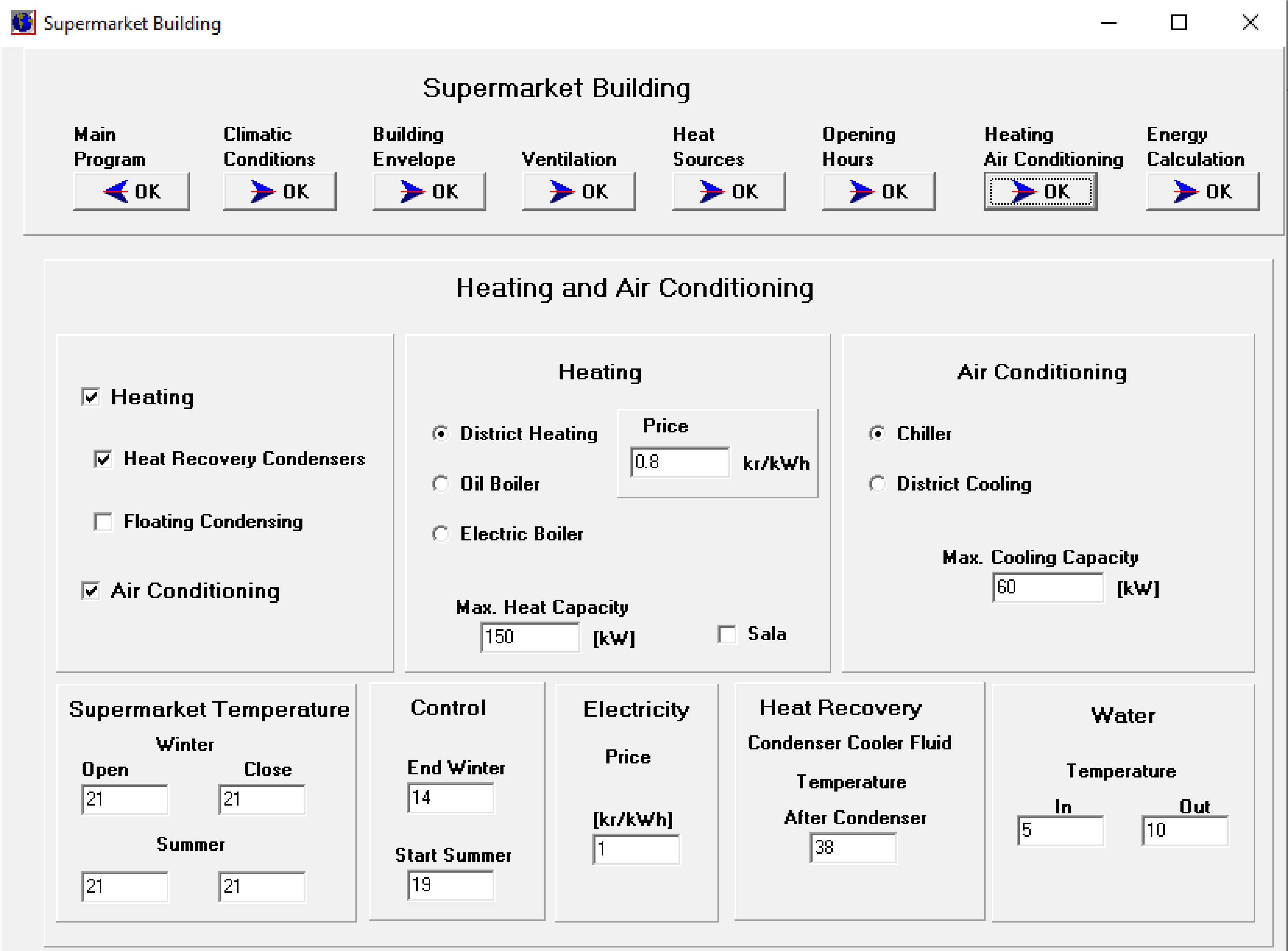

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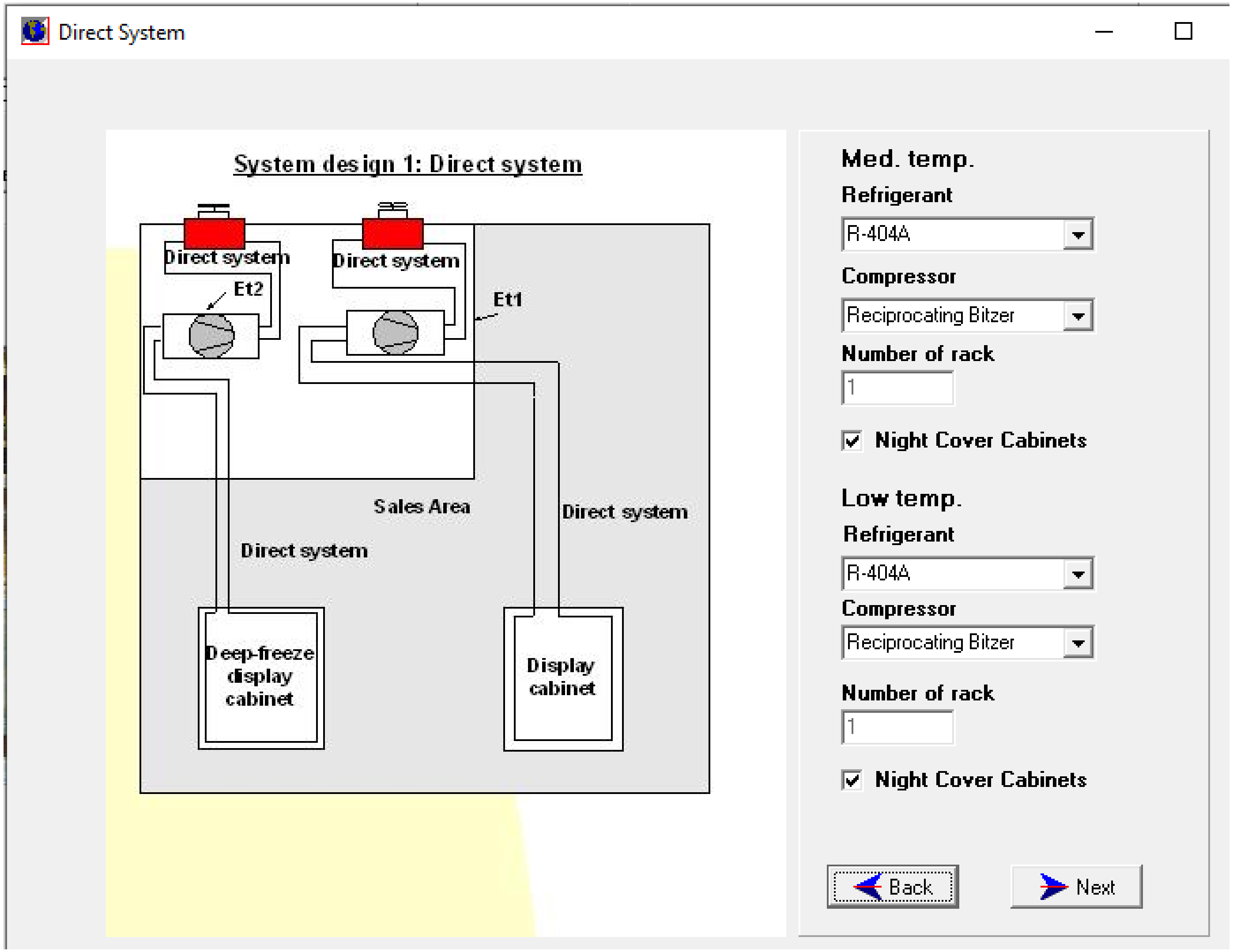

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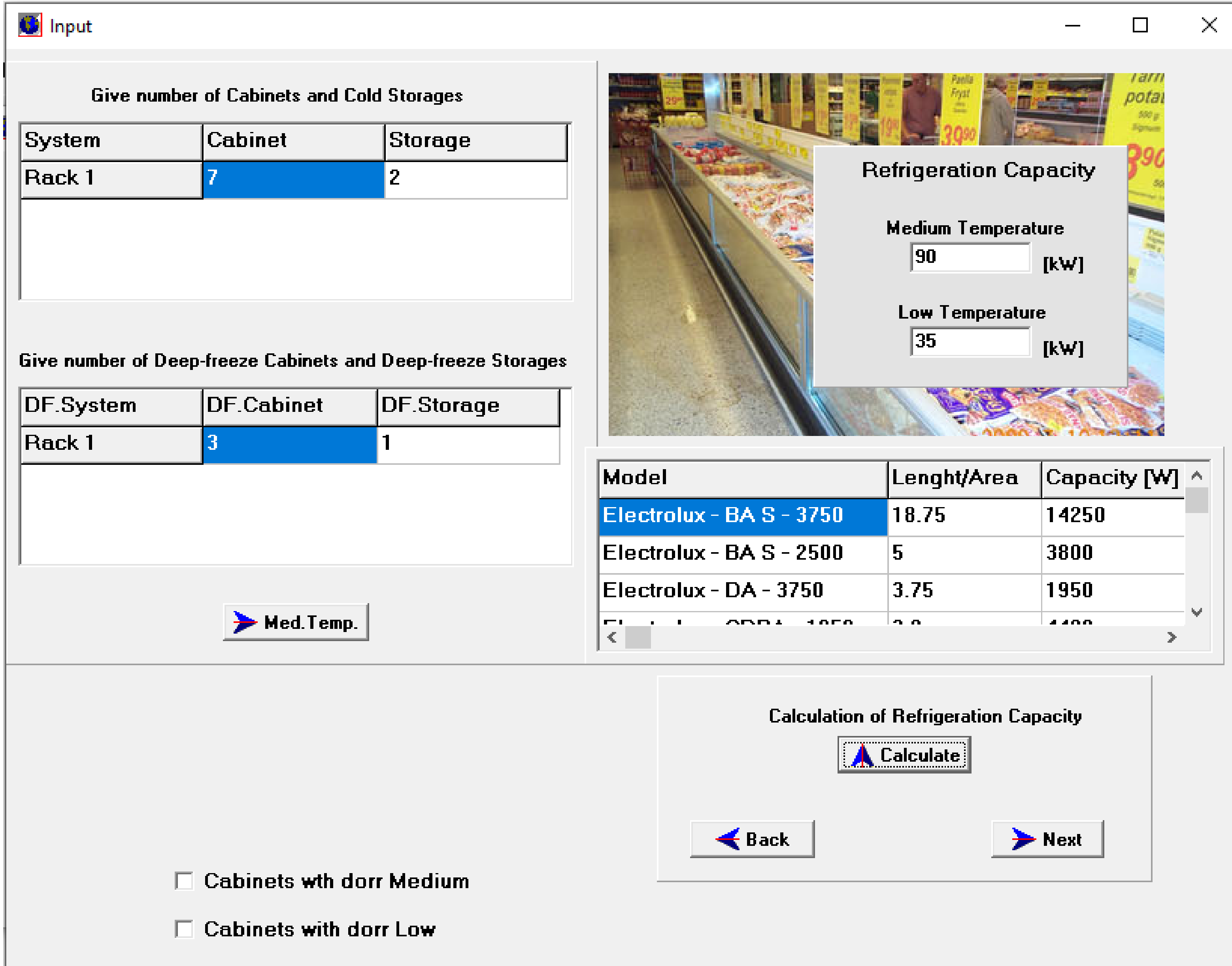

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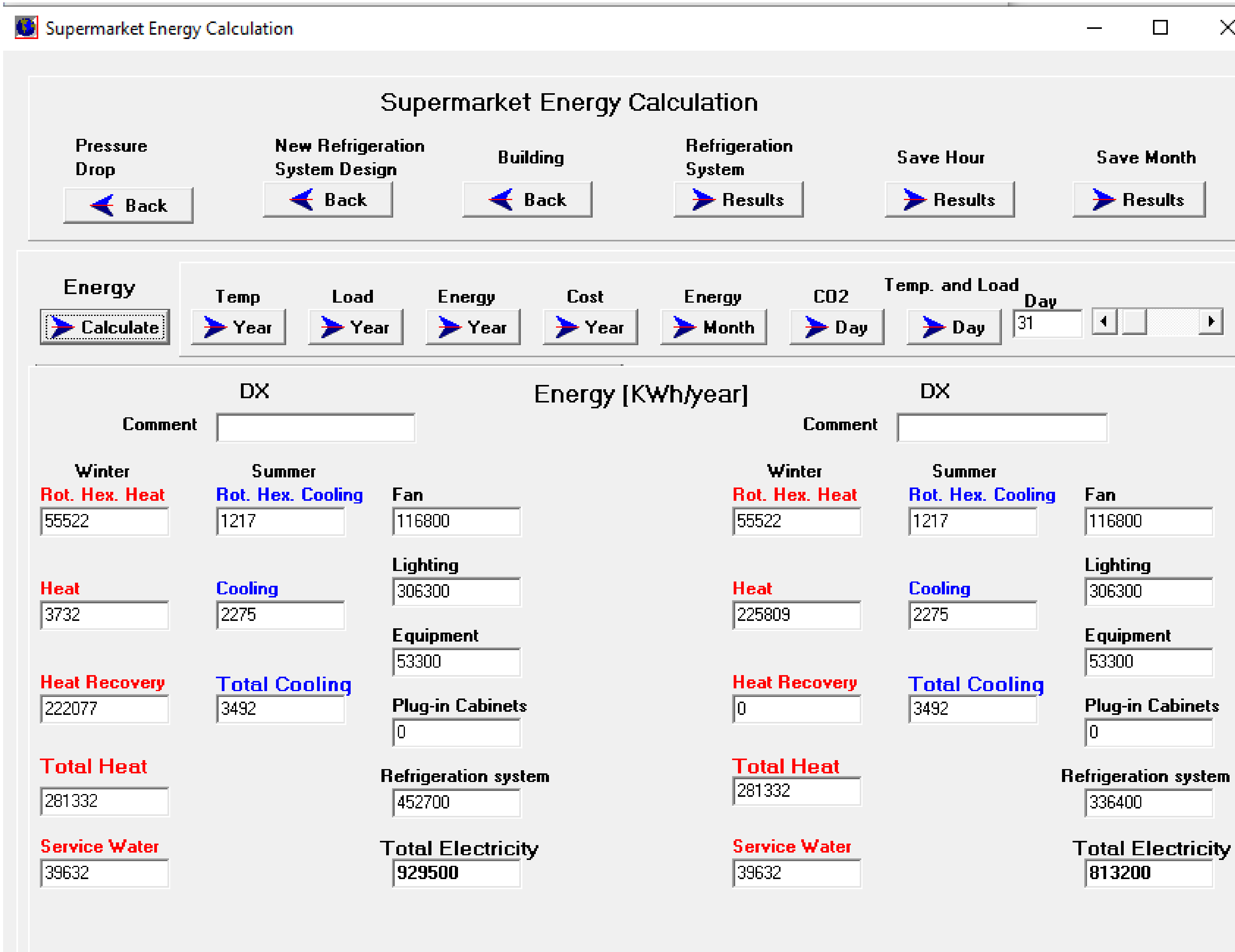

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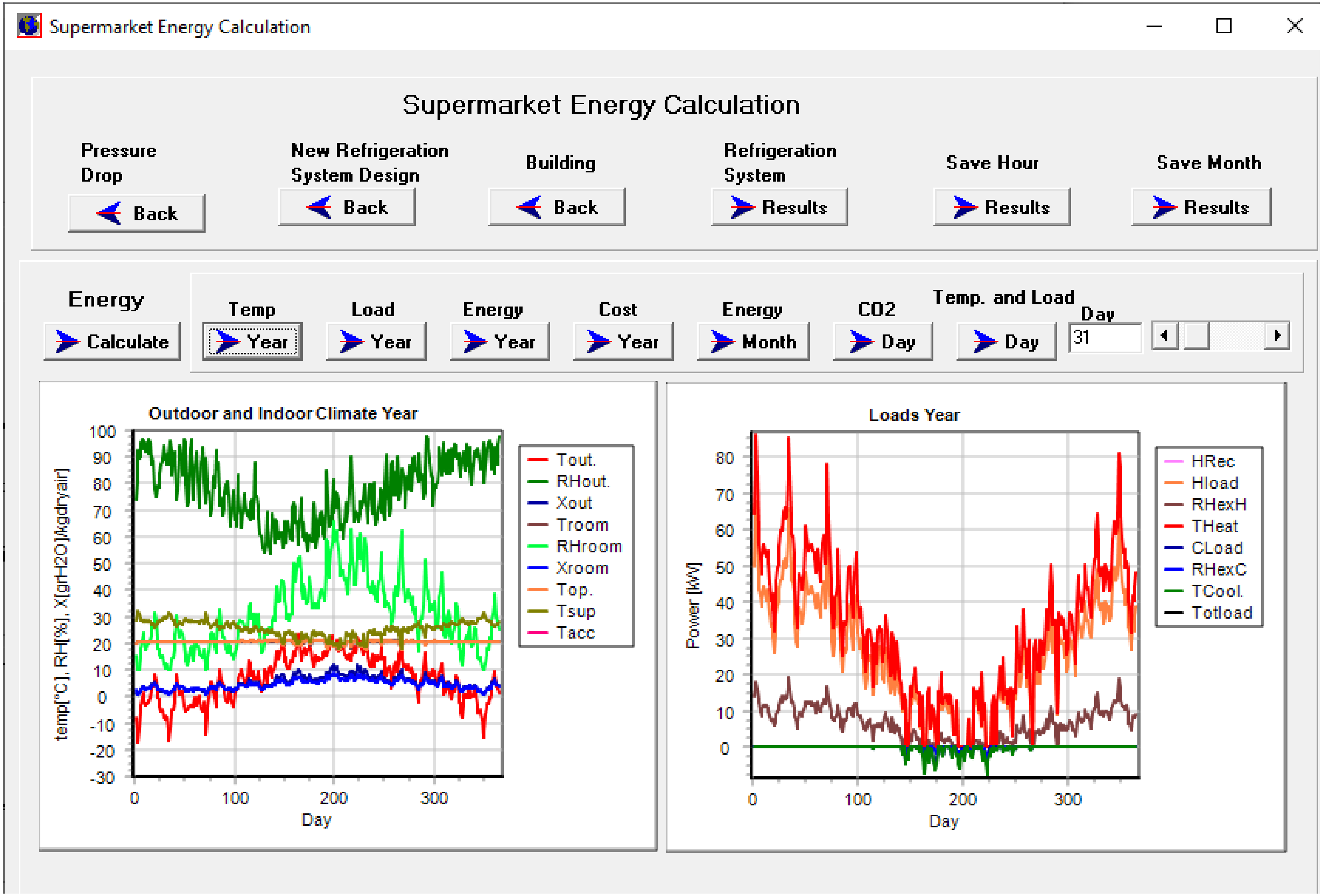

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5.- CyberMart

Lambohov Total Energy Usage

	Measurement	CyberMart	
January	54193	47290	12,7%
February	46811	42449	9,3%
Mars	50733	47102	7,2%
April	50317	47062	6,5%
May	54180	50950	6,0%
June	54761	52692	3,8%
July	58830	57220	2,7%
August	56983	55113	3,3%
September	52538	51358	2,2%
Total	**479348**	**451235**	**5,9%**

6.- Discussion and Conclusions

There is a great potential for improvement of energy systems in supermarkets.

A system model is necessary to predict and evaluate the introduction of new concepts and ideas in supermarkets.

A particular energy efficient solution for each supermarket is possible to achieve only when there is a balance between Energy Performance, Costs, and Environmental Impact

6.- Discussion and Conclusions.

The implementation of new energy saving technologies in supermarkets requires an extensive analyse of energy performances.

This analysis should be done during a long period to evaluate and compare the real energy performance with the theoretical values calculated.

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Thank You!

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