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DETERMINATION OF THERMAL NEED FOR NAVAL MACHINERY AND EQUIPMENT DEPARTMENT

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***Abstract**: The main goal of this paper is to determine the thermal need of the Naval Machinery and Equipment Department in order to ensure thermal comfort parameters of the building. The results will be used in further analyses of a project focus upon renewable energy sources based system – "Green Department" Project.*
***Keywords:** thermal, heat demand, renewable*

1. INTRODUCTION

1.1 Current status

Currently, thermal comfort parameters for department building are assured by classical source in such cases, namely RADET Constanta. Also in the second phase of the project we want to do a comparison term for at least 10 years between actual costs and the potential costs in case of using renewable energy sources.

1.2 Calculation of energy need for meeting the comfort parameters in Naval Machinery and Equipment Department

Getting started

The analysis that follows is performed in the international context in which the concepts of energy conservation, reduction of emissions and pollutants, energy independence, environmental impact and other significance becomes increasingly important. In Romania, most of the buildings were made without significant concern for the quality of their energy, but in recent years have been introduced specific regulations in this area and there is a growing concern for issues close thermal and effective solutions for thermal energy production.

In order to achieve the objectives set by analyzing the heating of buildings, the heat was parameterized to influence each factor could be identified on the heat and even on costs. Developed mathematical model was made in order to allow minimizing heat load requirements of housing, parameter which, if properly led, allows the correct selection of heating equipment.

1.3 Description of Naval Machinery and Equipment Department building

Department building consists of ground floor and one floor. The room's situation in terms of surface and volume of each - values required for calculation - is as follows:

Table 1 Ground floor

No.	Room code	Destination	Number of seats	Total surface (sq.m)	Volume (m^3)
1.	EP 24	Engine room simulator	11	49,59	173,57
2.	EP 25	Tank simulator	13	49,59	173,57
3.	EP 26	Engine laboratory	61	263,34	921,69
4.	EP 27	Hydraulics laboratory	35	129,96	454,86
TOTAL			120	**492,48**	**1723,69**

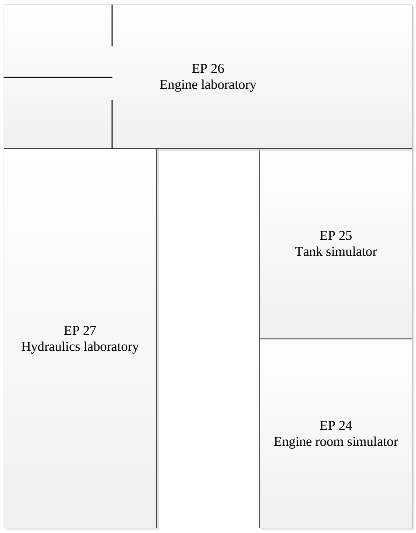

Figure 1 Layout of the ground floor

Table 2 1st floor rooms

No.	Room code	Destination	Number of seats	Total surface (sq.m)	Volume (m^3)
1.	EP 121	Thermotechnics Laboratory	41	133,38	533,52
2.	EP 122	A.M.N. Laboratory	32	66,1	264,4
3.	EP 123	I.F.A.G. Laboratory	51	66,1	264,4
4.	EP 124	Teachers office	7	53,58	214,32
5.	EP 125	Teachers office and classroom	16	53,58	214,32
6.	EP 126	Teachers office and classroom	12	53,58	214,32
7.	EP 127	Teachers office and classroom	12	53,58	214,32
8.	EP 128	Department director office	1	22,27	89,08
9.	EP 129	Mechanical Measurements Laboratory	25	34,57	138,28
TOTAL			197	**536,74**	**2146,96**

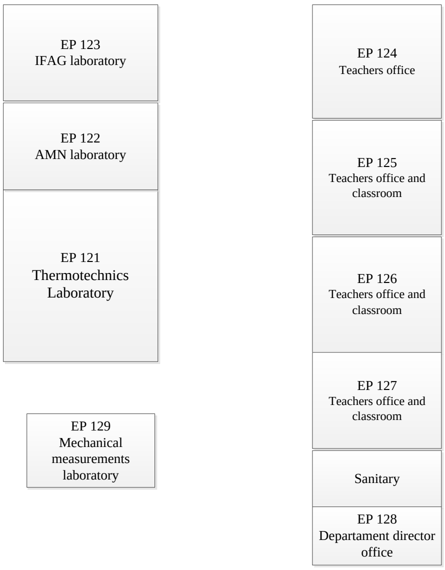

Figure 2 Layout of the 1st floor

2. MATHEMATICAL MODELS USED TO CALCULATE HEAT DEMAND OF THE BUILDING

For a more accurate determination of the heat demand of the building we chose to conduct a thorough analysis, using for this purpose four calculation models found in the literature.

2.1 Method I

A simple method for determining the heat necessary is based on the following formula:

$$N_t = S \cdot h \cdot (32 \dots 48)[W]$$

where:

- S is the surface of required space to be heated, m^2;
- h is the high of the analyzed area, m;
- range 32…48 is the coefficient of thermal discharge of the building.

This will select 32 as the value of the coefficient of thermal discharge if the building has a very good thermal insulation (double glazing, thick brick walls, and so on). Coefficient of 48 will choose simple glass buildings with normal glass, concrete walls, or if it communicate directly with the exterior walls.

In our case, considering building framing analysis, we adopt a value of the coefficient of thermal discharge of 35.

We have to specify that the height of the rooms on the ground floor is h = 3.5 m and height for 1st floor rooms will be h = 4 m. Also, to simplify the calculation we use direct volume separately determined for each space according to data presented in tables 1 and 2, as the product of area and height.

Table 3 Heat required for ground floor

No.	Room code	Destination	Volume (m^3)	Adopted coefficient	Heat required [W]	Heat required [kW]
5.	EP 24	Engine room simulator	173,57	35	6074,95	6,074
6.	EP 25	Tank simulator	173,57	35	6074,95	6,074
7.	EP 26	Engine laboratory	921,69	35	32259,15	32,269
8.	EP 27	Hydraulics laboratory	454,86	35	15920,1	15,920
TOTAL			**1723,69**		**60329,15**	**60,33**

Table 4 Heat required for 1st floor

No.	Room code	Destination	Volume (m^3)	Adopted coefficient	Heat required [W]	Heat required [kW]
1.	EP 121	Thermotechnics Laboratory	533,52	35	18673,2	18,68
2.	EP 122	A.M.N. Laboratory	264,4	35	9254	9,25
3.	EP 123	I.F.A.G. Laboratory	264,4	35	9254	9,25
4.	EP 124	Teachers office	214,32	35	7501,2	7,50
5.	EP 125	Teachers office and classroom	214,32	35	7501,2	7,50
6.	EP 126	Teachers office and classroom	214,32	35	7501,2	7,50
7.	EP 127	Teachers office and classroom	214,32	35	7501,2	7,50
8.	EP 128	Department director office	89,08	35	3117,8	3,12
9.	EP 129	Mechanical Measurements Laboratory	138,28	35	4839,8	4,84
TOTAL			**2146,96**		**75143,6**	**75,15**

By summing the two values corresponding to ground floor and 1st floor will result specific heat demand of the building:

$$N_t = N_{tp} + N_{te}[W]$$

$$N_t = 60329{,}15 + 75143{,}6 \ [W] = 135472{,}75 \ [W] \approx 136 \ [kW]$$

We conclude that in this way we obtained a value of heat demand of 136 kW.

2.2 Method II

A more rapid method of determining the thermal requirements found in the literature is based on standard values used in the practice of specific heat requirement expressed in W/m^2. These are:

- For low-energy building - 40 $[W/m^2]$
- For new building with good insulation - 50 $[W/m^2]$
- For normal building insulation - 80 $[W/m^2]$
- For older buildings without special insulation - 120 $[W/m^2]$

Department building fall into the latter category, specifying that were made in recent years some insulation works that allow us to adopt in this case a value of specific heat requirement of 100 W/m^2.

Using known values of analyzed surfaces we get:

$$S_t = S_p + S_e[m^2] = 492{,}48 + 536{,}74$$

$$S_t = 1029{,}02 \ [m^2]$$

$$N_t = S_t \cdot 100 \ \ [W] = 102902 \ [W] \approx 103 \ [kW]$$

Calculus leads to a value of 103 kW thermal requirements. We are not yet fully satisfied with this result because the specific heat requirement values listed above are usually used for spaces with a height no more than 3 meters.

2.3 Method III

Another method of calculation is one in which we take into account the necessary volume to be heated and not the surface as the previous method.

In this case we use a coefficient from practice which represents thermal power needed for heating 1 cubic meter. It ranges from 30 W/m^3 for a very well insulated building and 70 W/m^3 for a poorly insulated building.

In general the thermal demand calculation is made using factor 50 W/m^3 (value that we also adopt in this case), for a building with an average degree of isolation. This property is multiplied by the volume (V = area x height) and thermal requirements is obtained in *W*. Obtained thermal power released by this radiators placed in rooms should exceed the required heat output by about 10%.

Already knowing the total areas analyzed (according to tables 1 and 2) we obtain the following values:

Table 5 Thermal need calculation

Floor	Volume $[m^3]$	Thermal power required for heating 1 m³ $\left([W]/m^3\right]$	Thermal need $[W]$
Ground floor	1723,69	50	86184,5
1st floor	2146,96	50	107348
TOTAL	**3870,65**	**50**	**193532,5**

In conclusion, we obtain a value of the heat demand of 194 kW by using this method.

2.4 METHOD IV

This method is more laborious but more accurate. In calculations performed by this method we take into account primarily the layout of climatic and wind of the zone (figures 3 and 4). Thus, Constanta is in climate zone I and wind zone II of Romania. The department building is inside town and we can adopt a wind speed of 5 m / s and a depth of groundwater of 7 m. [7]

Table 6 General settings for all areas

General settings				Wind zone		II
ºC IN	75	Climate zone	I	Inside town		5.0
ºC OUT	65		-12	7	1.00	

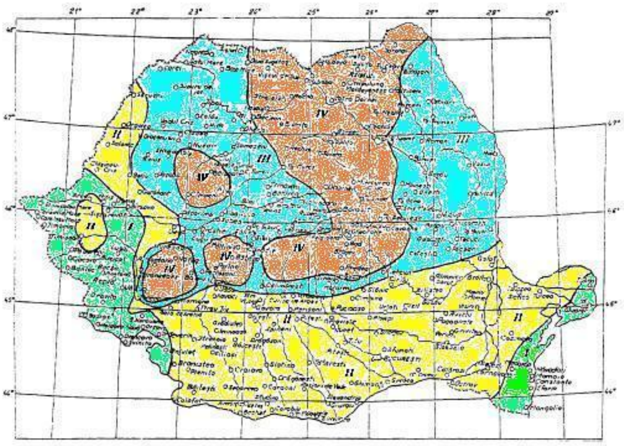

Figure 3 Climate zones in Romania

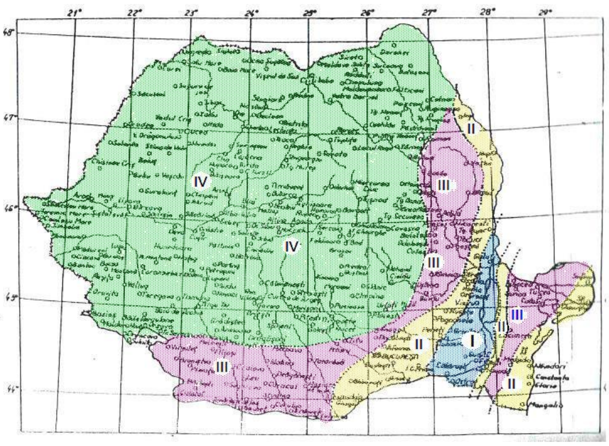

Figure 4 Wind zones in Romania

Spreadsheets of specific thermal requirements of each area are shown below.

Table 7 Spreadsheet of heat necessary for EP 24

	L	l	h	S	V; N_t			Tilting
EP 24	6.00	8.30	3.50	49.80	**174.30**	**FS**	**20**	**S - E**
glazing	6.00		6.00		**34.07**	T. Good	***23***	T. Good
exterior walls	1.00		28.6%	21.00	**5938**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 8 Spreadsheet of heat necessary for EP 25

	L	l	h	S	V; N_t			Tilting
EP 25	6.00	8.30	3.50	49.80	**174.30**	**FS**	**20**	**S - E**
glazing	6.00		6.00		**34.07**	T. Good	***23***	T. Good
exterior walls	1.00		28.6%	21.00	**5938**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 9 Spreadsheet of heat necessary for EP 26

	L	l	h	S	V; N_t			Tilting
EP 26	12.00	22.00	3.50	264.0	**924.00**	**FS**	**20**	**S - E**
glazing	12.00		12.00		**24.56**	T. Good	***23***	T. Good
exterior walls	1.00		28.6%	42.00	**22693**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 10 Spreadsheet of heat necessary for EP 27

	L	l	h	S	V; N_t			Tilting
EP 27	8.00	16.00	3.50	128.0	**448.00**	**FS**	**20**	**S - V**
glazing	9.00		9.00		**26.70**	T. Good	***23***	T. Good
exterior walls	1.00		32.1%	28.00	**11959**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 11 Spreadsheet of heat necessary for EP 121

	L	l	h	S	V; N_t			Tilting
EP 121	8.00	16.60	4.00	132.8	**531.20**	**FS**	**20**	**S - V**
glazing	20.00		20.00		**24.23**	T. Good	***23***	T. Good
exterior walls	1.00		62.5%	32.00	**12873**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 3.12 Spreadsheet of heat necessary for EP 122

	L	l	h	S	V; N_t			Tilting
EP 122	8.00	8.25	4.00	66.00	**264.00**	**FS**	**20**	**S - V**
glazing	15.00		15.00		**31.36**	T. Good	***23***	T. Good
exterior walls	1.00		46.9%	32.00	**8278**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 13 Spreadsheet of heat necessary for EP 123

	L	l	h	S	V; N_t			Tilting
EP 123	8.00	8.25	4.00	66.00	**264.00**	**FS**	**20**	**S - V**
glazing	15.00		15.00		**31.36**	T. Good	***23***	T. Good
exterior walls	1.00		46.9%	32.00	**8278**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 14 Spreadsheet of heat necessary for EP 124

	L	l	h	S	V; N_t			Tilting
EP 124	6.00	9.00	4.00	54.00	**216.00**	**FS**	**20**	**S - E**
glazing	20.00		20.00		**27.44**	T. Good	***23***	T. Good
exterior walls	1.00		83.3%	24.00	**5927**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 15 Spreadsheet of heat necessary for EP 125

	L	l	h	S	V; N_t			Tilting
EP 125	6.00	9.00	4.00	54.00	**216.00**	**FS**	**20**	**S - E**
glazing	20.00		20.00		**27.44**	T. Good	***23***	T. Good
exterior walls	1.00		83.3%	24.00	**5927**	**-12**	**P1**	**-12**
interior walls	1.00	2.00				**20**	**20**	**20**

Table 16 Spreadsheet of heat necessary for EP 126

	L	l	h	S	V; N_t			Tilting
EP 126	6.00	9.00	4.00	54.00	216.00	FS	20	S - E
glazing	20.00		20.00		27.44	T. Good	23	T. Good
exterior walls	1.00		83.3%	24.00	5927	-12	P1	-12
interior walls	1.00	2.00				20	20	20

Table 17 Spreadsheet of heat necessary for EP 127

	L	l	h	S	V; N_t			Tilting
EP 127	6.00	9.00	4.00	54.00	216.00	FS	20	S - E
glazing	20.00		20.00		27.44	T. Good	23	T. Good
exterior walls	1.00		83.3%	24.00	5927	-12	P1	-12
interior walls	1.00	2.00				20	20	20

Table 18 Spreadsheet of heat necessary for EP 128

	L	l	h	S	V; N_t			Tilting
EP 128	4.00	5.60	4.00	22.40	89.60	FS	20	S - E
glazing	6.00		6.00		74.49	T. Good	23	T. Good
exterior walls	1.00	1.00	15.6%	38.40	6674	-12	P1	-12
interior walls	1.00	1.00				20	20	20

Table 19 Spreadsheet of heat necessary for EP 129

	L	l	h	S	V; N_t			Tilting
EP 129	5.00	6.90	4.00	34.50	138.00	FS	20	S - V
glazing	10.00		10.00		62.15	T. Good	23	T. Good
exterior walls	1.00	1.00	21.0%	47.60	8577	-12	P1	-12
interior walls	1.00	1.00				20	20	20

Summing the values required for heating each space results a total of 114,916 watts, which represent 114,916 kW. However, according to the literature, this result will be adding a margin of 15% for identification of the final heat demand, value that can be used as the proper sizing of heating installations.
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In conclusion, we obtain a value of 133kW thermal need using this method.

4. CONCLUSIONS

After calculations, we obtained the following values

Table 20 Thermal need comparison

Method	Thermal need [kW]
I	136
II	103
III	194
IV	133

We notice at first glance that the values obtained by methods II and III are extreme opposite values. On the other hand, the values obtained by methods I and IV are very close. Therefore, we adopt a value of 140 kW for further calculations (the choice and sizing of renewable and alternative energy installations use).

For the next stage we want to use the results for developing technical solutions to ensure comfort parameters in Naval Machinery and Equipment Department through the use of renewable energy and present management and administrative solutions to be known and implemented in this context.

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