Fostering diffusion of Heating & Cooling technologies using the seawater pump in the Adriatic-Ionian Region

Case study report – Albania

University Building Durres

Fostering diffusion of Heating & Cooling technologies using the seawater pump in the Adriatic-Ionian Region

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1 Contents

Purpose of this document

This document is a pre-feasibility study for University of Durres and is one of altogether 6 pre-feasibility studies that will be done in the scope of the SEADRION project.

2 Introduction

The subject of this document is sea water heat pump utilization case study on an existing public building, i.e. the "Aleksander Moisiu" University, Durres.

The "Aleksander Moisiu" University building was built in 2006 according to all the regulations, knowledge and materials available, and has been intensively used and maintained since then. Minor adaptations and changes have been made on the building since then. Today, the total available building area of about 11276 m^2 is used for the needs of the students.

3 Characterization of the site

3.1 Location

University of Durres “Aleksander Moisiu” (UAMD) is the newest public academic institution of the Republic of Albania. The University is located in the ancient city of Durres. Its address is: Rruga "Currila", Durrës, Albania. It was inaugurated in 2006.

Figure 1 shows situtation of the building on on the satellite mapThe building is about 60 m away from the sea making the building ideal for the utilization of the seawater heat pump system.

Location (available from Google Map) with Latitude 41.313528''N and Longitude 19.434138"E.

Figure 1 Situtation of the building on the satellite map

3.2 Building

3.2.1 The existing state of the building

The subject of the case study is the application of the seawater heat pump in the "Aleksander Moisiu" University, Durres. The building was built in 2006 and is designed and constructed as a non-residential, free-standing building, 50-60 meters from the sea. Figure 2 shows facades, windows and the shape of the building.

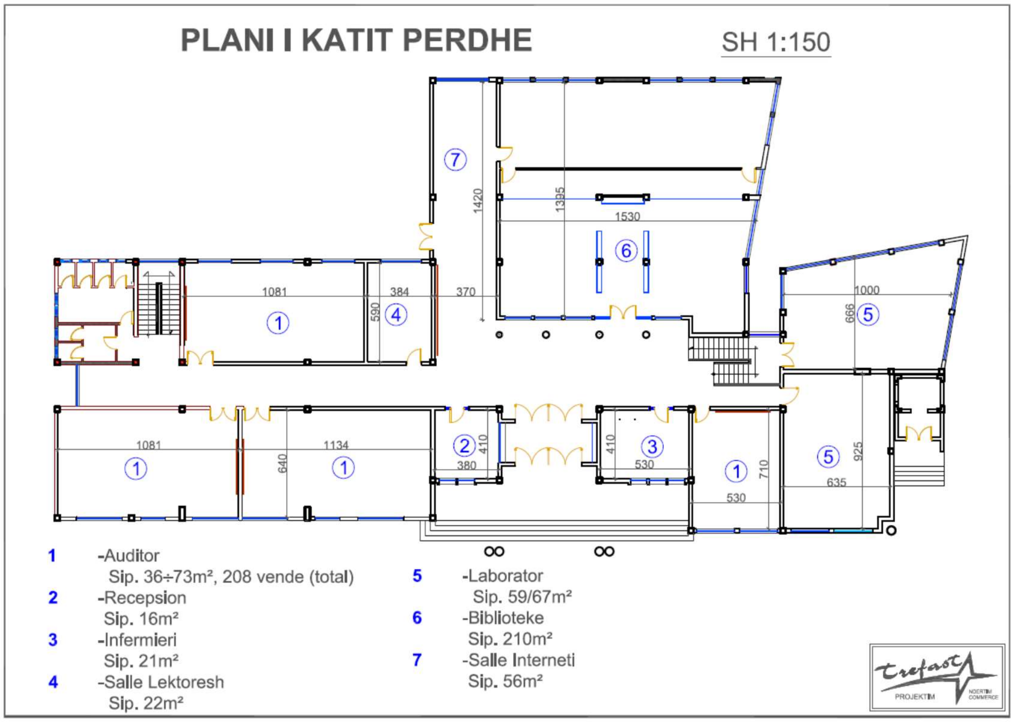
Figure 2 Existing state of the the "Aleksander Moisiu" University building in Durres

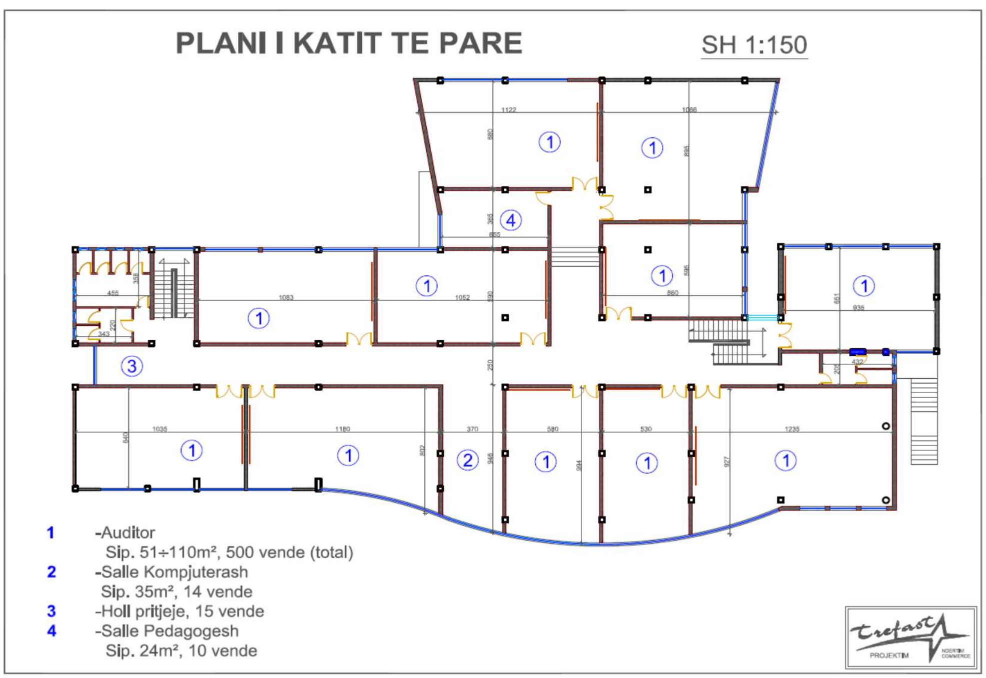
This building has four floors: ground floor and 3 floors with reinforced-concrete external and internal walls as well as reinforced-concrete slabs. The walls are with 25cm red brick and the foundations are reinforced concrete. The walls are with outdoor plaster. The slabs are concrete. Building has a flat roof, concrete slab. The windows are double glazed, standard insulation, air gap, with duralumin frame.

This building has a large surface of windows. It has about 872m^2 windows surface that are cover with curtains to protect the internal air from radiation of the sun.

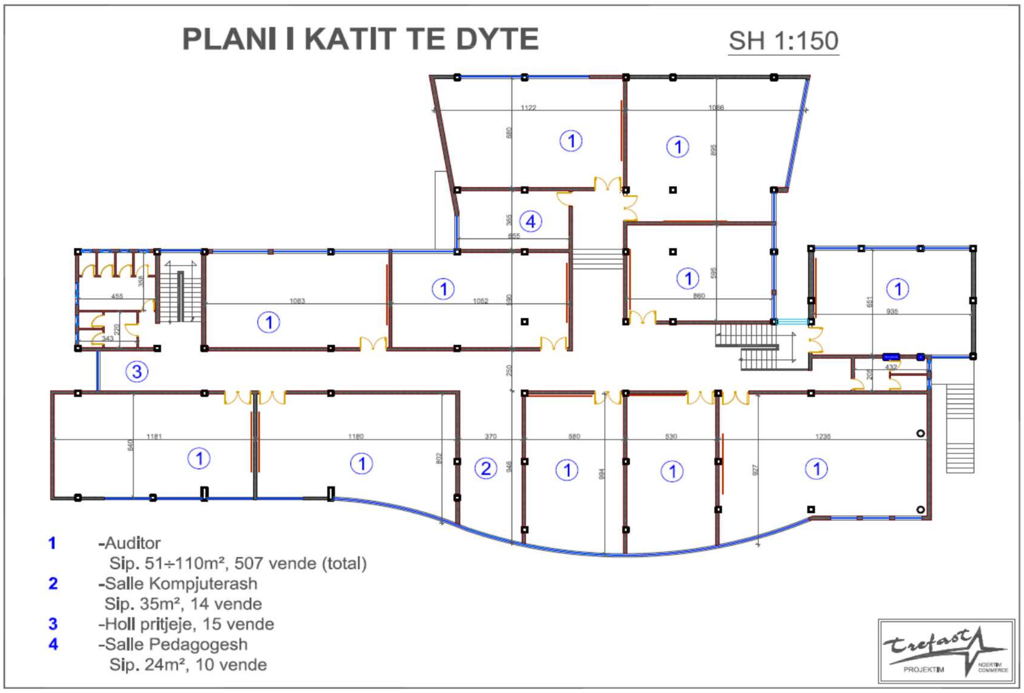
Plan of ground floor

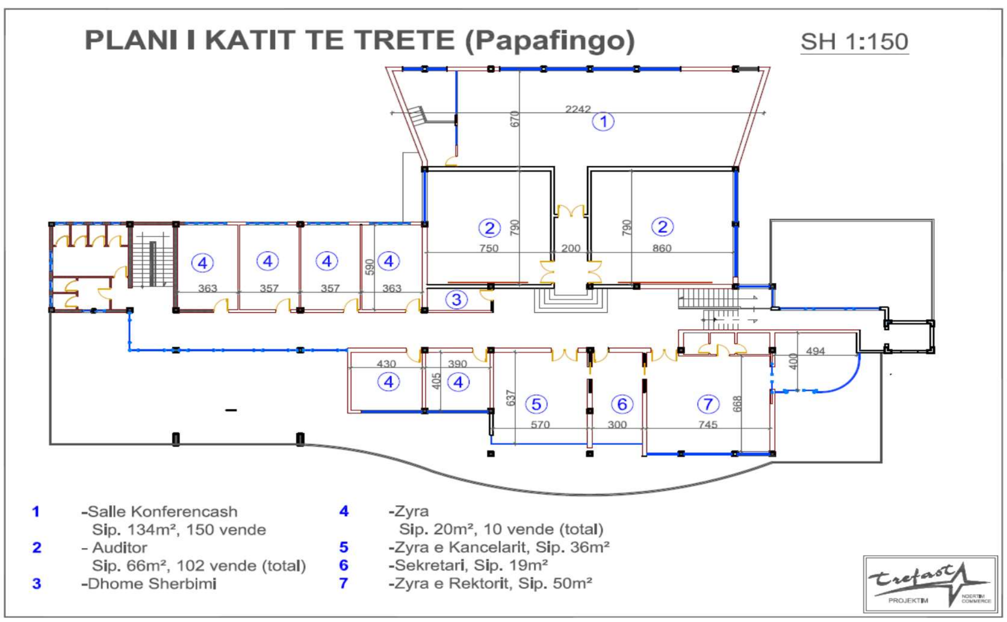
Total net floor area= 1075m^2
Heated area= 687m^2





Plan of first floor
Total net floor area= 1120 m^2
Heated area= 845 m^2
Plan of second floor
Total net floor area= 1120 m^2
Heated area= 845 m^2





Plan of third floor
Total net floor area=880 m^2
Heated area= 442m^2

The number of the students in the building is 2590 In the heated part of the building aren’t all the rooms. Also the corridors aren’t heating. Building height is 13.5m.

The values of the outer shell and floor parameters of the building are given in tables 1 and 2.

Table 1 Parameter values of the outer shell of the building

Parameter	Value
Area of the heated part of the building, A_h [m^2]	2819
Useful area of the building, A_u[m^2]	4195
Volume of the heated part of the building, V_h [m^3]	9303
Total area of the facade, A_t [m^2]	4558
Total window area, A_w [m^2]	872
Share of window area in the total area of the façade %	19.3

Table 2 Data on the floors of the building

Floor	Floor area, [m^2]	Floor height, [m]	Floor volume, [m^3]
0-GROUND FLOOR	1075	3.3	3547.5
1-FIRST FLOOR	1120	3.3	3696
2-SECOND FLOOR	1120	3.3	3696
3-THIRD FLOOR	880	3.3	2904

3.2.2 Technical characteristics of the outer shell of the heated part of the building

Technical characteristics of the building parts and the external openings of the heated part of the building are given in tables 3 and 4:

Table 3 Technical characteristics of the building parts of the heated part of the building

Building part	A, [m^2]	U, [W/(m^{2}K)]
Walls, north (m^2)	288	1.428
Walls, east (m^2)	406	1.428
Walls, south (m^2)	240	1.428
Walls, west (m^2)	366	1.428
Roof (m^2)	1650	2.669
Floor (m^2)	2819	2.206

Table 4 Technical characteristics of the external openings of the heated part of the building

External opening	A_w, [m^2]	U_w, [W/(m^{2}K)]
Windows, doors etc., north (m^2)	72	2.8
Windows, doors etc., east (m^2)	320	2.8
Windows, doors etc., south (m^2)	120	2.8
Windows, doors etc., west (m^2)	360	2.8

3.3 The heating/ Cooling system

University of Durresi has installed (VRC system) the cooling/heating system with capacity 540 kW, heating start from November to April and cooling system begins in April and lasts until October. Heating and cooling system operates throughout the working hours of the University building (07:00 - 15:00 h).

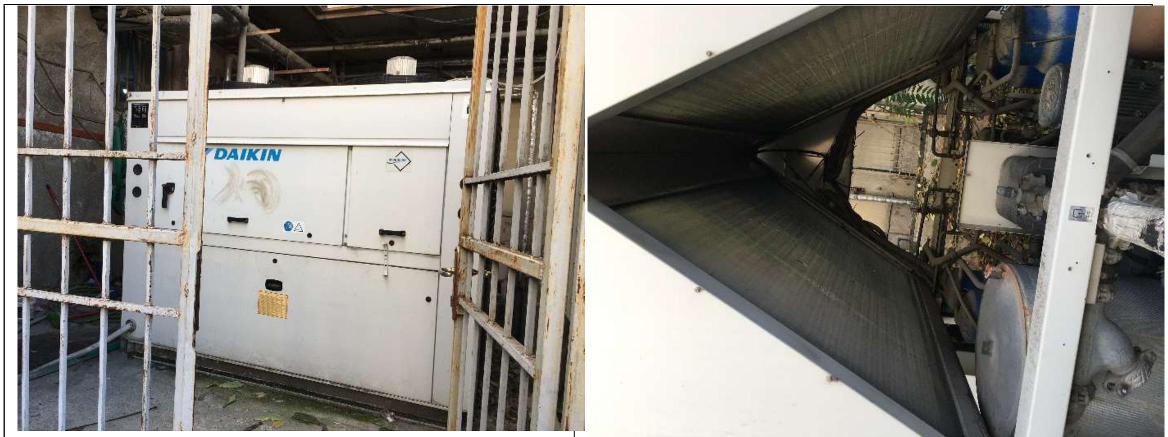


Figure 3 VRV cooling system Durres University

University Building use the Variable Refrigerant Flow (VRF) Systems. The characteristics of this system depended from the following criteria:

- Using flexibility all the time that means system capacity to provide variable performances during the day and in the various seasons;
- Using flexibility according to ambient destinations;
- To be enables to obtain conditions of advanced level to the norm well-being;
- Low cost of using and of maintenance
- Low initial cost, less noise and ease of installation;

Each system is totally independent and has its own control

- Variable Refrigerant Flow (VRF) Systems

  - General

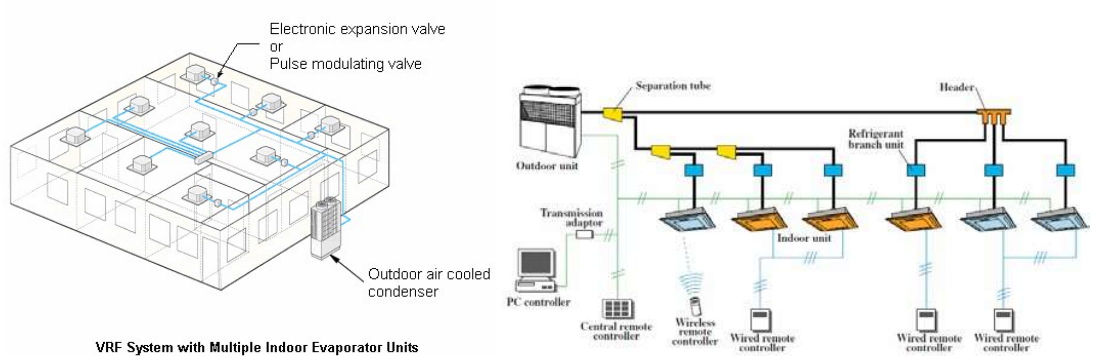
Variable refrigerant flow (VRF) is an air-condition system conFIGUREtion where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and conFIGUREtions connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones.

The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermistor sensors in each indoor unit. The indoor units are linked by a control wire to the outdoor unit which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements.

VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a somewhat higher cost.

Refrigerant piping runs of more than 60 mm are possible, and outdoor units are available in sizes up to 54 kW.

A schematic VRF arrangement is indicated below:



The modern VRF technology uses an inverter-driven scroll compressor and permits as many as

48 or more indoor units to operate from one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in the total cooling/heating load as determined by the suction gas pressure measured on

- Types of VRF

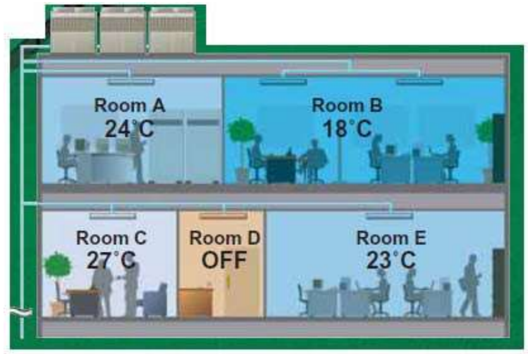
VRF heat pump system permit heating or cooling in all of the indoor units but NOT simultaneous heating and cooling. When the indoor units are in the cooling mode, they act as evaporators; when they are in the heating mode, they act as condensers. These are also known as two-pipe systems.

VRF heat pump systems are effectively applied in open plan areas, retail stores, cellular offices and any other area that require cooling or heating during the same operational periods.

- VRF Advantages

- Comfort

The main advantage of a variable refrigerant flow system is its ability to respond individually to fluctuations in space load conditions. The user can set the ambient temperature of each room as per his/her requirements and the system will automatically adjust the refrigerant flow to suit the requirement;



VRF systems enable wide capacity modulation and bring rooms to the desired temperature extremely quickly and keep temperature fluctuations to minimum. The technology offers excellent dehumidification performance for optimal room humidity regardless of outside conditions. Any area in the building will always be exactly at the right temperature and humidity, ensuring total comfort for their occupants;

VRF systems are capable of simultaneous cooling and heating. Each individual indoor unit can be controlled by a programmable thermostat. Most VRF manufacturers offer a centralized control option, which enables the user to monitor and control the entire system from a single location or via the internet;

VRF systems can generate separate billing that makes individualized billing easier;

VRF systems use variable speed compressors (inverter technology) with 10 to 100% capacity range that provides unmatched flexibility for zoning to save energy. Use of inverter technology can maintain precise temperature control, generally within ±1C°.

- Energy Efficiency

VRF systems benefits from the advantages of linear step control in conjunction with inverter and constant speed compressor combination, which allows more precise control of the necessary refrigerant circulation amount required according to the system load. The inverter technology reacts to indoor and outdoor temperature fluctuations by varying power consumption and adjusting compressor speed to its optimal energy usage. Inverter provides superior energy efficiency performance and also allows for a comfortable environment by use of smooth capacity control. Field testing has indicated that this technology can reduce the energy consumption by as much as 30 to 40% a year compared to traditional rotary or reciprocating type compressors.

VRF technology yields exceptional part-load efficiency. Since most HVAC systems spend most of their operating hours between 30-70% of their maximum capacity, where the

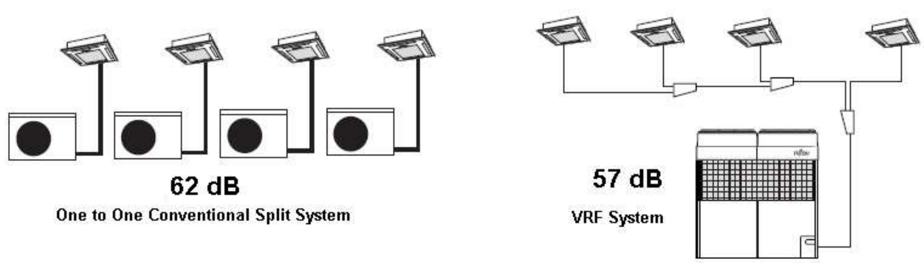
coefficient of performance (COP) of the VRF is very high, the seasonal energy efficiency of these systems is excellent.
A VRF system minimizes or eliminates ductwork completely. This reduces the duct losses often estimated to be 10% to 20% of the total airflow in a ducted system.

Inverter compressor technology is highly responsive and efficient. The modular arrangement permits staged operation, i.e. Indoor units can easily be turned off in locations requiring no cooling, while the system retains highly efficient operation.
It is possible to include cooling and heating in a single system which avoids duplicating systems (a reversible heat pump only costs 10% more than a cooling unit).
Energy sub-metering with VRF systems is relatively simple and inexpensive by placing an electric
meter on one or a few condensing units. This is a very important feature in the multi-tenant buildings if energy costs are charged explicitly to each tenant rather than being hidden in overall leasing costs.

- Reduced Noise Levels

Indoor and outdoor units are so quiet that they can be placed just about anywhere, providing more flexibility on how to use indoor and outdoor space. Indoor ductless operating sound levels are as low as 27dB (A) and ducted units sound levels are as low as 29dB(A)

Outdoor units can even be placed directly under a window and quiet indoor units are perfect in environments that require minimal disruption like schools, places of worship, libraries and more. When compared to the single split system, a VRF system reduces outside noise levels by almost 5 dB@1m.



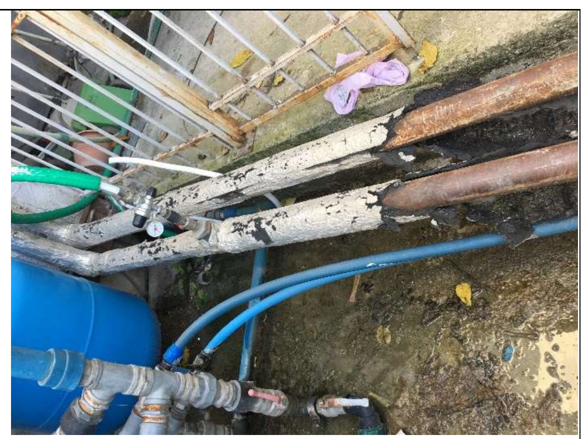
Maintenance and Commissioning

VRF systems with their standardized conFIGUREtions and sophisticated electronic controlsare aiming toward near plug-and-play commissioning. Normal maintenance for a VRF system is similar to that of any DX system and consists mainly of changing filters and cleaning coils. Because there are no water pumps to maintain or air ducts to be cleaned, less maintenance is required compared to other technologies.

Figure:4 Heating and cooling elements

Table 5 Type and performances of the outdoor units of the VRV heating/cooling system

Type	Amount	Cn [kW]	Cm, [kW]
EWYP220CAYNP-D	10	54	90
TOTAL:	10	540	900



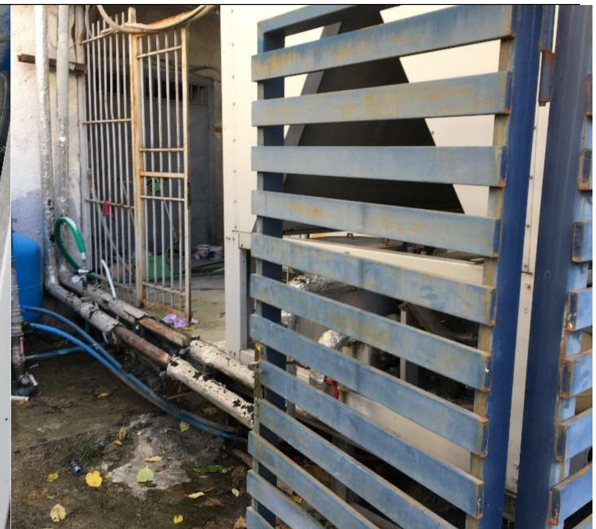
 

Figure:5 VRC in Durresi University

There are no radiators in the attic, instead, split-system air conditioners with outdoor and indoor units are used for heating (and cooling).

3.4 Domestic Hot Water system

The sanitary water supply is done from public network and does not meet any design requirements or criteria. The network outside building is done through plastic pipe, is in very poor condition and without thermal insulation. The building has not sanitary water tank or any pump station and in toiltes they used plastic container for water if network water is missing. In general all water supply system is old and need to be renewed.

In this building is not installing any system for hot water production. According to Europian Norms and Standarts shuld have a quantity of hot water 10 liter for each person. The absence os sanitary hot water is an indicator that was not met the comfort condition for Durres University Building.

3.5 Energy consumption

Estimating the energy demand for space heating for standard comfort level, the team calculated the thermal losses, the required heating components (boiler, burner, heating panel, etc.), the initial investments for the new space heating system, the energy costs and the other costs. The methodology for calculations include:

- Based on the existing general layout of the building, the thermal losses are calculated. The structures of the walls, ceilings, windows and doors are taken from the drawings of each floor. By using a method which calculates the thermal losses for each floor, it is calculated the overall coefficient of thermal volumetric losses (Gv), the energy needed in order to guarantee the space heating, and the annual thermal energy demand.
- Gv [W/m^3 °C] depends mainly on the numbers of floors, the volume of the building, the ratio of windows/walls area, the structural design of the building. This coefficient is based on the ratio of outside walls of the building/total building's volume as well as other secondary factors.
- **From the geometry and thermal characteristic of the building, the coefficient Gv for** the existing building is determined. Based on this coefficient and on the building volume the annual thermal energy demand is calculated.
- The Albanian Energy Building Code for Private and Public Buildings given the number of degree-days for the Durres, where 'university' is allocated. The calculation of the additional thermal losses depends on the space heating system function, the average heat transfer coefficient from the building, and the building orientation. From the studies carried out such additional thermal losses are determined for types and activities in a building. Coefficient *r* =1–0.6, represents the coefficient which takes into consideration the space heating interruptions during the day and/or the weekends (for schools, institutions and etc). Coefficient "*r*" has high value for hospitals and re-creative centers (such as university Durres) and low value for schools and administrative buildings.

Taking into consideration the difficult economic situation now and in the next years we assume a "poor thermal comfort" for the heating load before the investment for the purpose of this feasibility study[1], that the heated space will be only the absolutely necessary and will be heated with interruptions when needed. Based on the above the following assumptions have been used to calculate space heating energy demand:

- Heating Degree Days (base 17,5 °C taking into account internal thermal gains) : 1320
- Number of Heating Days: 99
- Volumetric Heat Losses Coefficient: 1.55 W/m3 0C
- Electricity is used for cooling
- Electricity used for heating
- Average yearly energy consumption: **237,460** Kwh
- Average yearly energy costs: 21310 Euro (without VAT)

3.5.1 Thermal load of the University of Durres

Calculation of the thermal load of the city administration building of the University of Durres was conducted according to Albania Energy Code. Internal and external design temperature of the thermal load calculation for the location of Municipality of Durres are given in Table 7.

Table 6 Design temperatures for thermal load calculation

Description	Symbol	Value	Unit
External design temperature for Durres University	Tja	7	[°C]
Internal design temperature	Tbr	22	[°C]

Table 8 shows the values of transmission, ventilation and total thermal losses of the university of Durres. The values are shown for each floor of the building, and are the largest for the basement of the building since the floor and wall of the cellar to the ground are not thermally insulated which is why the transmission heat losses are large. The total thermal load of the university of Durres building is $Htok = 96.39$ [kW]. This data will be used for selecting heat pumps in economic analysis.

Table 7 Thermal load calculation results

Floor	H_T,	H_V,	Hto,	Htok,	Hsp,
	[W]	[W]	[W]	[kW]	[W/m^2]
Ground floor	14784.34	9313.97	24098.31	24.10	8.55
1st floor	14784.34	9313.97	24098.31	24.10	8.55

[1] Note that the heating system has been dimensioned to cover the full load for heating and hot water

2nd floor	14784.34	9313.97	24098.31	24.10	8.55
3rd floor	14784.34	9313.97	24098.31	24.10	8.55
Total	59137.35	37255.88	96393.23	96.39	34.19

Figure 6 graphically illustrates the thermal losses of the University.

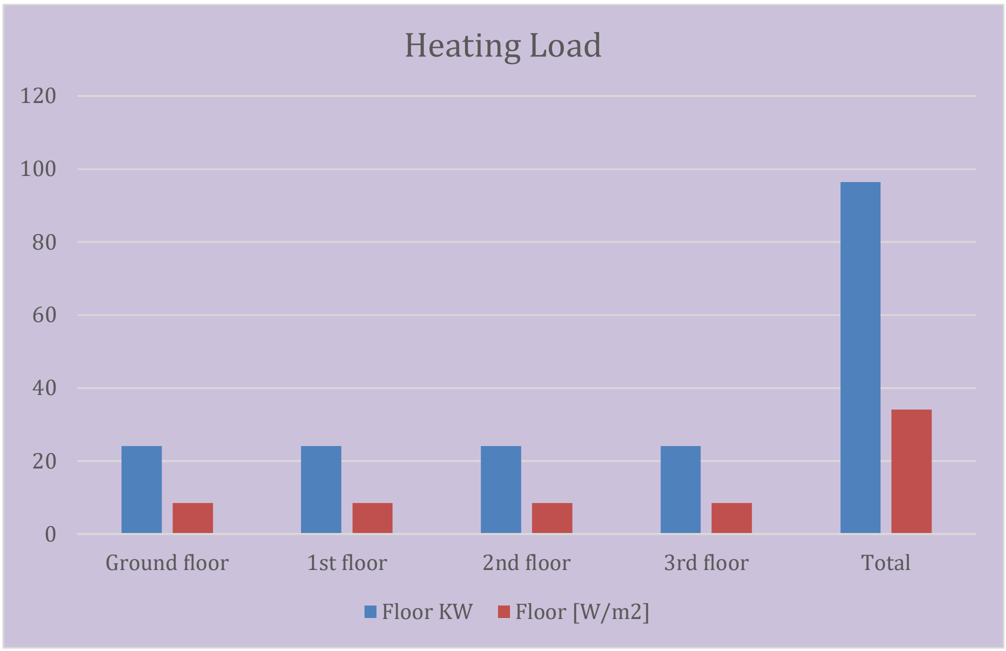


Figure 6 Graphical illustration of thermal loses in the Durres City

3.5.2 Cooling load of the University of Durres

Calculation of the cooling load of the Durres University is calculated based on Albania Energy Code. Internal and external design temperature of the cooling load calculation for the location of Durres are given in Table 9.

Table 8 Design temperatures for cooling load calculation

Description	Symbol	Value	Unit
External design temperature for Durres	Tj	34	[°C]
Internal design temperature	Tb	24	[°C]

Table 10 presents the values of the internal, external and total thermal gains of the Durres University. The values are shown for each floor of the building and are the largest for the basement of the building where the conference halls are located. It is assumed that the accumulation of the people on these premises is greatest so therefore the internal heat gains are high. Floors on which the offices are located also have high heat gains since on these floors the accumulation of people and appliances is large and there are a large number of transparent elements facing south. The total cooling load of the city administration building of the University is $Htokf = 165.75\ [\mathrm{kW}]$. This data will be used for selecting heat pumps in economic analysis.

Table 9 Cooling load calculation results

Floor	H_T, [W]	H_V, [W]	Hto, [W]	Htokf, [kW]	Hsp, [W/m^2]
Ground floor	12807.19	28630.17	41437.37	41.44	14.70
1st floor	12807.19	28630.17	41437.37	41.44	14.70
2nd floor	12807.19	28630.17	41437.37	41.44	14.70
3rd floor	12807.19	28630.17	41437.37	41.44	14.70
Total	51228.77	114520.70	165749.47	165.75	58.80

Figure 7 graphically illustrates the thermal gains of the Durres University.

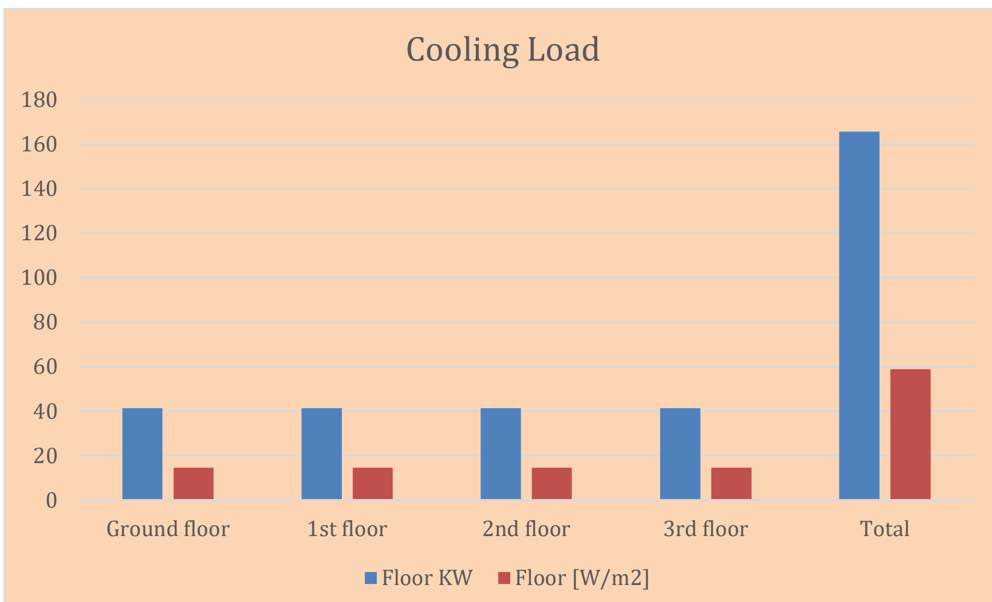


Figure 7 Graphical illustration of thermal loses in the Durres City

3.5.3 Calculation of the annual heat energy required for heating and cooling

The annual heat energy required for heating and cooling, $Htok$ and $Htokf$ is the calculated amount of heating/cooling energy that a heating/cooling system needs during a year to be brought into a building to maintain its internal design temperature during the building heating/cooling period and is calculated according to Albania Energy Code.

Input climatic and building calculation data are given in Table 11 and 12.

Table 10 Input building calculation data

Parameter	Value	Unit
Area of the heated part of the building, A_h [m^2]	2819	[m^2]
Useful area of the building, A_u[m^2]	4195	[m^2]
Volume of the heated part of the building, V_h [m^3]	9303	[m^3]
Total area of the facade, A_t [m^2]	4558	[m^2]
Total window area, A_w [m^2]	872	[m^2]
Share of window area in the total area of the façade %	19.3	%
Roof area to the ground	1650	[m^2]
Floor area to the ground	2819	[m^2]

Table 11 Input climatic calculation data

Description	Symbol	Heating	Cooling	Unit
Average annual outdoor temperature	Tj	7	35	[°C]
Internal calculation temperature	Tb	23	24	[°C]

The results of the annual heat energy calculation required for heating and cooling are shown in Table 13. The total annual heat demand for the cooling period is Hc =*87222.92* [kWh/a] and for the heating period Hh =*150237.08* [kWh/a].

Table 12 Required annual heating/cooling energy in the city administration building in Kaštel Sućurac

Description	Symbol	Heating	Cooling	Unit
Annual heating/cooling demand	$Q_{H/C,nd}$	150237.08	87222.92	[kWh]
Annual heating/cooling demand	$Q_{H/C,nd}/A_k$	53.29	30.94	[kWh/m^2]

Figure 8 shows the monthly distribution of the required heat energy for heating and cooling the Durres University. The greatest need for heat energy for heating is in January and February while the needs in October and April are almost negligible. On the other side, the greatest need for heat energy for cooling is in June, July and August.

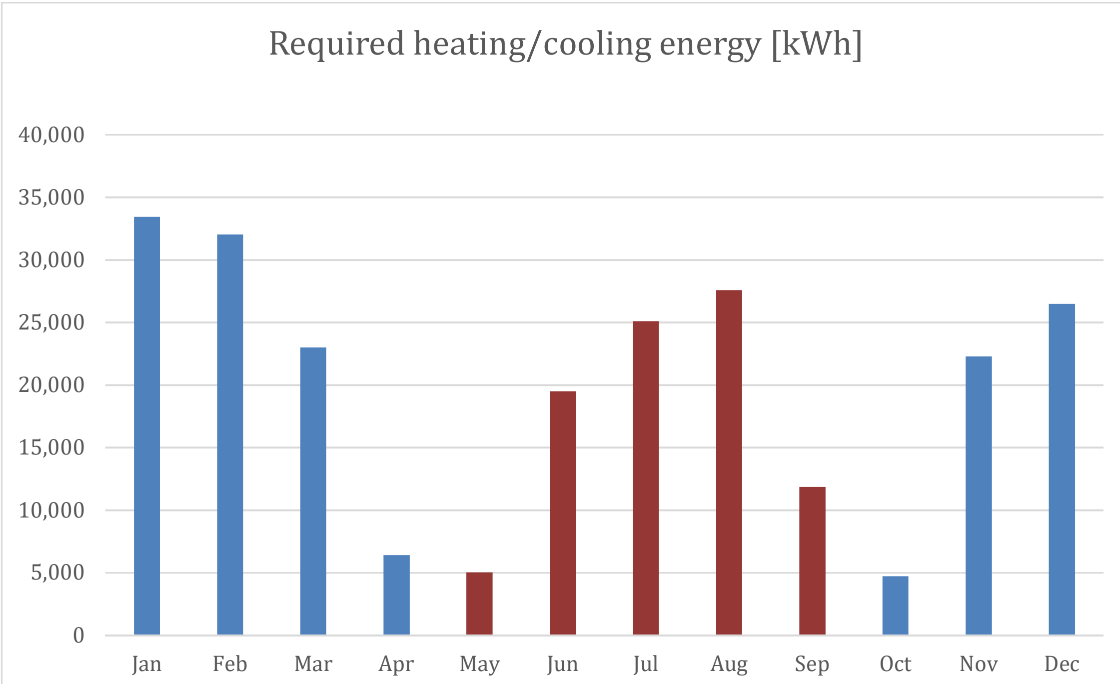


Figure 8 Monthly distribution of the required heat energy for heating and cooling Durres University

Calculated data will be used in the following section to carry out a techno-economic analysis.

4 Techno-economic analysis of sea water heat pump utilization for heating and cooling of the Durres University

3.1. Measurement of energy and water consumed

Data for electricity and water are taken for three

years. The available data include:

- Electricity bills taken from personel of University;
- Water bills taken from Personel of University;
- Expenses in Lekë for electricity and water taken from personel of

University. Energy Audit team did not find data for for maintenance costs.

3.2. Water Consumption

Water consumption data in m^3/month for Durres University Building are given in the table below.

TABLE 14: Monthly data based on information given from personel of University

Monthly water consumption based on data given from University (m^3/month)														
Building	**Year**	January	February	March	April	May	June	July	August	September	October	November	December	**Total (m^3/year)**
Durres University	**2012**	510	515	540	570	620	650	670	615	595	578	571	542	**6,976.00**
	2013	510	518	540	565	618	643	665	615	595	578	571	542	**6,960.00**
	2014	505	508	533	566	618	643	665	615	595	578	571	542	**6,939.00**
	Average Consumption for 3 years												**6,958.3**	**m^3/year**
	Daily average												**19.1**	**m^3/d**
Source: Durres University Personel														

From the analysis of sanitary water bills we concluded that is an approximately constant consumption during years. During inspections in Municipality Building, we discuss with the staff and found that they were were satisfied with water supply due the old installations.

In accordance with the norms for sanitary water supply, for each person needed 30 liter/day and quantity of water consumed should be 5850*10=58500 litra/day or approximately 588 m^3/year. Refer to the table above with have consumption much higher then needs.

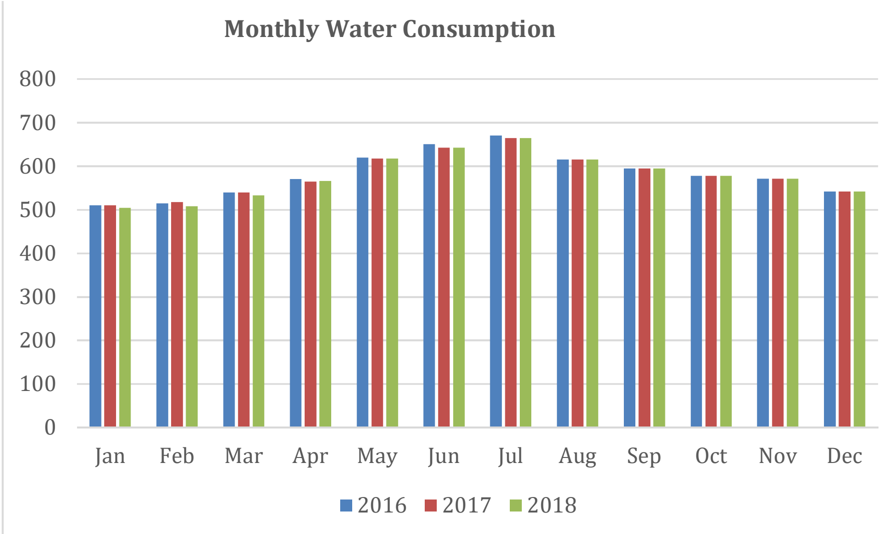


Figure 9 **Monthly Water Consumption**

3.3. Electricity Consumption

In the table below are given the data for electricity consumption for three years taken from Gjirokastra Municipality. The date is taken for annual electricity consumption, not for each month. So we can analyse the consumption for different periods of the year.

Table 15 **Electricity Consumption**

Electricity Consumption		
Durres University	Year	Electricity Consumption (kWh/year)
	2016	238400
	2017	237200
	2014	236780
Source: Durres University		

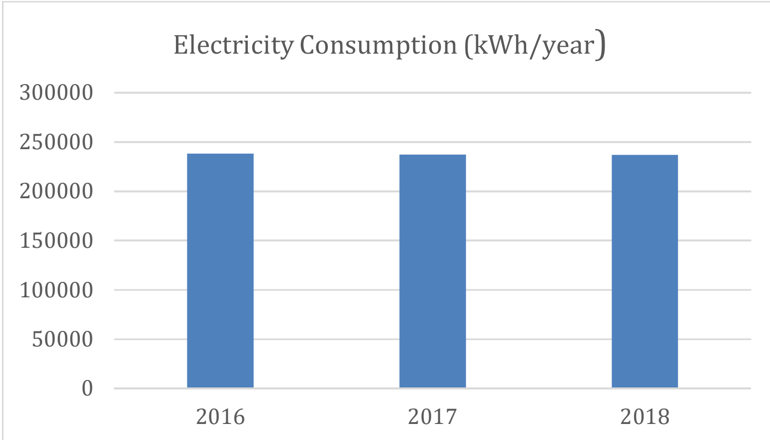


Figure 10 **Electricity Consumption (kWh/year)**

The table below shows the rezults of specific consumption.

TABLE 16: Specific electricity Consumption

Year	Consumption (kWh/Year)	Surface (m^2)	Specific Consumption (kWh/m^2year)
2016	238,400	2,819.0	84.57
2017	237,200	2,819.0	84.14
2018	236,780	2,819.0	83.99
Average	**237,460**	2,819.0	84.24

Average specific consumption is 84.24 kWh/m^{2}year, which is not a real consumption because the consumption value is very lower (note that the building has electrical heater and wall split conditioner for heating). Since we have not the real bills of electricity consumption we cannot make a partition of electricity consumption for each system that operate in the building.

3.5. Economic feasibility analysis

Economic feasibility analysis of different heating and cooling source implementation was carried out in the University of Durres. The University of Durres, with a building area of 2819 m^2, the thermal load of 96.39 [kW] and cooling load of 165.75 [kW], is located in Durres, a coastal part of Durres city of Albania . The specific annual heat energy required for heating divided to the useful surface of the building values 53.29 [kWh/m^{2}a)] while the total annual heat energy required for heating of the building values 150237.08 [kWh/a]. On the other hand, the annual cooling demand of the building values 87222.92 [kWh/a], while the amount of specific annual cooling energy divided to the useful surface area of the building values 30.94 [kWh/(m^{2}a)].

The reference scenario of the building consists of two systems: an oil boiler connected to the radiator distribution system as a heating system and a newly installed VRV cooling system. In this chapter, two scenarios will be analysed:

1. VRC replacement by the seawater heat pump for the purpose of heating the University of Durres, $Ch = 100\ \ [\mathrm{kW}]$
2. VRV system replacement by the seawater heat pump for the purpose of cooling the University of Durres, $Cc = 165\ \ [\mathrm{kW}]$

3.6. Reference scenario - analysis of current consumption

Heating system

The heating system of the University of Durres consists of an VRC with the power of 540 [kW] and and for heating needs of 96-100 [kW]. Annual required heating energy of the city administration building values $Ch = 150237.08\ [\mathrm{kWh/a}]$. The consumption was not modelled on the reference data since the aim of the calculation was not to determine the energy class of the building but to actual needs in order to gain the value to be used in the techno-economic analysis of seawater heat pump utilization. Actual consumtion for heat is 238400 $[\mathrm{kWh/a}]$, and in the economic analysis of the utilization of the two above-mentioned scenarios, the amount of modelled annual heat energy consumption for heating at the input of the generation subsystem will be used $Ch = 150237.08\ \ [\mathrm{kWh}]$.

Cooling system

The cooling system of the university building consists of a VRV system which consists of 10 outdoor units with the power of 540 kw and for cooling needs of 165 [kW].. The VRV cooling system was installed at the end of July 2006. There is no central regulation of the cooling system, but it is possible on every single indoor unit.

Annual cooling demand of the city administration building values $Cc = 87222.92[\mathrm{kWh/a}]$. In conversation with building janitor, information was obtained that the cooling season begins in April and lasts until October. The energy needed to operate the cooling system is electricity.

In the economic analysis of the utilization of the two above-mentioned scenarios, the amount of modelled annual energy consumption for cooling at the input of the generation subsystem that will be used is $Cu = 87222.92\ \ [\mathrm{kWh}]$.

3.7. Seawater heat pump implementation

Prior to carrying out the economic analysis of the two scenarios mentioned in the introduction of this chapter, it is necessary to define the investment costs of the seawater heat pump implementation. The economic analysis of the investment and operating costs of heating and cooling systems of the city administration building is based on the following assumptions:

- Building a heating and cooling systems are independent of the source of the heating and cooling efficiency, ie. it is assumed that all devices shown in this analysis are able to deliver the heating or cooling medium in the required temperature regime.
- A seawater heat pump works in monovalent mode, ie. it can deliver the heat energy that covers the heating and cooling load of the building.

The above assumptions allow to easily determine the investment and operating costs of different thermotechnical systems and assume that there is no need to install additional auxiliary devices besides implemented thermal devices.

Investment costs for the implementation of the seawater heat pump system are:

- the costs of a seawater heat exchange system
- the cost of seawater heat pump unit
- the costs of heat energy distribution
- other costs (installation, maintenance)
- Location of the building is suitable for installation of SWHP
- Distance to the shore is 65 m.
- VRC can be replaced with SWHP
- heating power 96 kW
- cooling power 165 kW
- SCOP (seasonal coefficient of performance): 4,40
- SEER (seasonal energy efficiency ratio): 4,71
- SWHP will be used in boreholes
- We avoid problems with biofuling of the system (intake, discharge, heat exchangers)
- Heat exchanger under SWHP with boreholes
- PE pipes length: 3543 m

Boreholes

For the both scenario we will use two borehole of seawater. Around 15-metre deep suction and absorbing wells would be drilled in the middle green area (there are three in total) in front of the University building.

The required groundwater flow rate would have to be pre-established through test boreholes and it would need to be at least 9.5 l/s (at the source $\Delta\theta$ = 7 °C) considering the required power of the heat pump. To ensure safe operation of the heat pump, an indirect plate heat exchanger would also be installed on the primary side before the entrance to the evaporator.

Scenarios

The two scenarios listed at the beginning of the chapter will be analysed. The first scenario is to replace an existing VRC -Heating with a seawater heat pump for building heating while retaining the existing VRV cooling system. The heat pump system would be connected to the existing heating elements (radiators) with the change of the heating temperature regime from 90/70 [°C] to 55/45 [°C]. The power of installed radiators in the 55/45 [°C] temperature regime values. 96.39 [kW] so there would be need to install additional articles on the radiators as the thermal load of the building value Htok= 96.39 [kW]. In scenario 1, the implementation of a 102 [kW] heat pump with all the accompanying equipment is planned which would be used for heating the university building.

The second scenario is the replacement of the existing VRV cooling system with a seawater heat pump with the cooling effect of 165.75 [kW] whose purpose would be heating and cooling of the university building. With the implementation of the heat pump, 135 new heating elements, fan coils, and all the accompanying equipment would be installed. Scenario 2 is much more demanding than scenario 1. Table 17 lists the prices of total investment cost for each scenario.

Table 17 The prices of total investment cost for each scenario

	Scenario 1	Scenario 2
Description	Seawater heat pump for building heating	Seawater heat pump for building heating and cooling
The wells + immersed pump	14,190.00 €	16,892.00 €
The pipeline to the heat exchanger	2,028.00 €	2,028.00 €
A plate titanium heat exchanger	2,298.00 €	2,298.00 €
A heat pump unit	16,892.00 €	23,650.00 €
A storage tank, 3000 l	6,082.00 €	6,082.00 €
An electric cabinet and the wiring	12,162.00 €	12,162.00 €
The fan coils	0.00 €	42,568.00 €
The pipelines and isolation	0.00 €	4,730.00 €
Installation works	13,514.00 €	30,406.00 €
Total	68,514.00 €	142,163.00 €

3.8. Economic analysis

Prior to carrying out an economic analysis, it is necessary to determine the cost of energy sources required for the operation of the system. The electricity price is determined according to the received electricity bills. The tariff model of the city administration building is HEP PRO and the electricity price values 0.9 [€/kWh]. For the price of extra light fuel oil 0.95 [€/kWh] is taken. The money needed to implement the heat pump system will be calculated, in both scenarios, by means of loans for entrepreneurs whose interest rate is 5% .

A reversible water-to-water heat pump with two scroll compressors and R-410A refrigerant would be installed to produce hot and cold water. The maximum heating temperature would be 60 °C. The main criterion for heat pump selection is the required heating power.
Technical characteristics:
− heating power (40 / 45 °C – 10 / 7 °C): 100 kW
− COP (40 / 45 °C – 10 / 7 °C EN14511:2013): 4.15
− SCOP 4.40
− cooling power (12 / 7 °C – 30 / 35 °C): 165 kW
− EER (EN14511:2013): 4.38
− SEER 4.71
The heat pump would be installed in ground floor.
Heat storage tanks would be included in the heating and cooling system. The heat pump works in a way that it primarily ensures the desired temperature of hot water in both heat storage tanks, while discharging excess heat at the source (seawater).

Table 18 total investment cost for each scenario

	VRF heating/ cooling system	VRF replacement by seawater heat pump for the purpose of heating, K=100 KW	Replacement of VRF system with seawater heat pump for the purpose of heating and cooling, K=165 KW
Total estimated investment		70,587.12 €	143,555.06 €
Annual cost of heating and cooling	21371Euro	7512Euro	5200 Euro

Return period of investment		12 year	29 year
With 40% subsidies		8 year	15 year

Sources of financing

The sources of financing for the case where the University of Durres applies for co-financing with the IPA programme Cross Border are presented hereafter. The IPA programme Cross Border co-finances 85% of eligible costs. VAT is deemed to be a non-eligible cost. The sources co-financed by the IPA programme Cross Border are only shown for two variants.

3.9. Environmental impact

The return period of the investment has a significant impact on the decision to utilize seawater heat pumps, however, one of the most important factors is the environmental impact. By comparing the CO_2 emissions in each scenario, it is estimated that these emissions are 80% less in scenario 1 and 2 than in the reference scenario. This is a result of lower primary energy consumption in scenario 1 and 2 than in the reference scenario, which is used for generating the same amount of heating and cooling energy. Table 17 shows the values of primary energy consumption and CO_2 emissions for each scenario as well as its reductions.

Table 13 Primary energy consumption and CO_2 emissions for each scenario

	Reference scenario	**Scenario 1**	**Scenario 2**
Primary energy consumption, [kWh/a]	237460	85,000.00	76,000.00
Reduction of Primary energy consumption, [%]	0%	64.2%	68%
CO_2 emissions, [kg CO_2/a]	58627.53	12366.16	11056.77
Reduction of CO_2 emissions, [%]	0%	79%	81%

4. Conclusion

The University Durres is located about 100 meters from the sea, whose winter temperature, at depths up to twenty meters does not fall below 13 [°C]. This area is good opportunity for investment sea woter pump.

Heat pump systems are systems with high investment costs and it is still easier and cheaper to implement conventional heating and cooling systems, however, attention should not be put on the cost and complexity of the system's performance. The ultimate goal in the current period of climate change and the struggle for fossil fuel reserves should be to reduce CO_2 emissions and increase the use of renewable energy sources, and in particular to achieve energy independence, as systems such as seawater heat pumps and heat pumps in general provide.

Table 18. Sumary of SWHP of Durresi University

Location	University of Durres
Building	2006
Last adaptations	2006
Situation	No thermal insulation
Flor area (m2)	2819
Sea distance (m)	60
Average yearly energy consumption kwh	237,460
Average yearly energy costs (euro)	21371.4
system heating and cooling	VRC
SWHP	boreholes
Heat exchanger	boreholes
pipes length (m)	3543
Investment costs	
VRF replacement by seawater heat pump for the purpose of heating, K=100 KW	70,587.12 €
Replacement of VRF system with seawater heat pump for the purpose of heating and cooling, K=165 KW	143,555.06 €
water flow (l/s)	9,5
payback period cooling (Year)	15
payback period heating (Year)	8
Heat needed for heating (MW)	100
Cooling energy needed for cooling (MW)	165
CO2 [kg CO2/a]	12366.16

5. References

1. Albania building Code 2003
2. Energy Balance of Albania, 2018
3. Energy data base University of Durres 2018
4. EU Directive for Energy Efficiency
5. Albania Machanical University Enerfy efficncy Manual 2014