LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

GEOTHERMAL ENERGY: Status and Future in the Peri-Adriatic Area
XIV International Conference on Science, Arts and Culture
Veli Lošinj, Croatia, 25-27 August 2014

LEGEND project

Mobilizing ground-source heat pumps investments in Adriatic area

Dalibor Jovanović
IRENA – Istrian Regional Energy Agency Ltd.

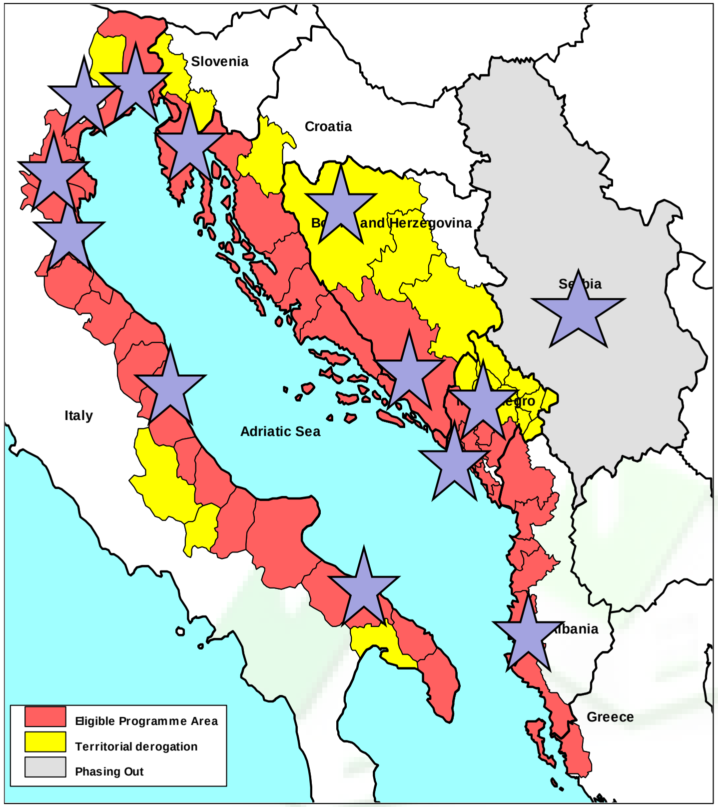
IRENA
Istarska Regionalna ENergetska Agencija
Istrian Regional ENergy Agency

LEGEND project

General information

- **LEGEND** - *Low Enthalpy Geothermal ENergy Demonstration cases for Energy Efficient buildings in Adriatic Area*
- *IPA ADRIATIC cross border cooperation programme 2007-2013.*
- *13 partners*
- *10 pilot investments*

PARTNERSHIP



PROJECT BUDGET: 3.085.540,00 €

PROJECT DURATION:10/2012 - 12/2014
27 MONTHS

LEAD BENEFICIARY: Province of Ferrara -ITALY

B2: Geological Survey of Slovenia - SLOVENIA

B3: Istria Region - CROATIA

B4: «Local Development Initiative»,Banja Luka – BOSNIA HERTZEGOVINA

B5: Emilia Romagna Region - ITALY

B6: Veneto Region - ITALY

B7: Municipality of Scutari - ALBANIA

B8: Province of Teramo – ITALY

B9: Regional Economic Development Agency for Sumadija and Pomoravlje – SERBIA

B10: Municipality of Kotor – MONTENEGRO

B11: Dubrovnik-Neretva Region - CROATIA

B12: Puglia Region - ITALY

B13: Montenegro Green Building Council - MONTENEGRO

ASSOCIATE PARTNER: EUROPEAN GEOTHERMAL ENERGY COUNCIL - EGEC

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014
Veli Lošinj, Croatia

ECSAC
EUROPEAN CENTRE FOR SCIENCE ARTS AND CULTURE

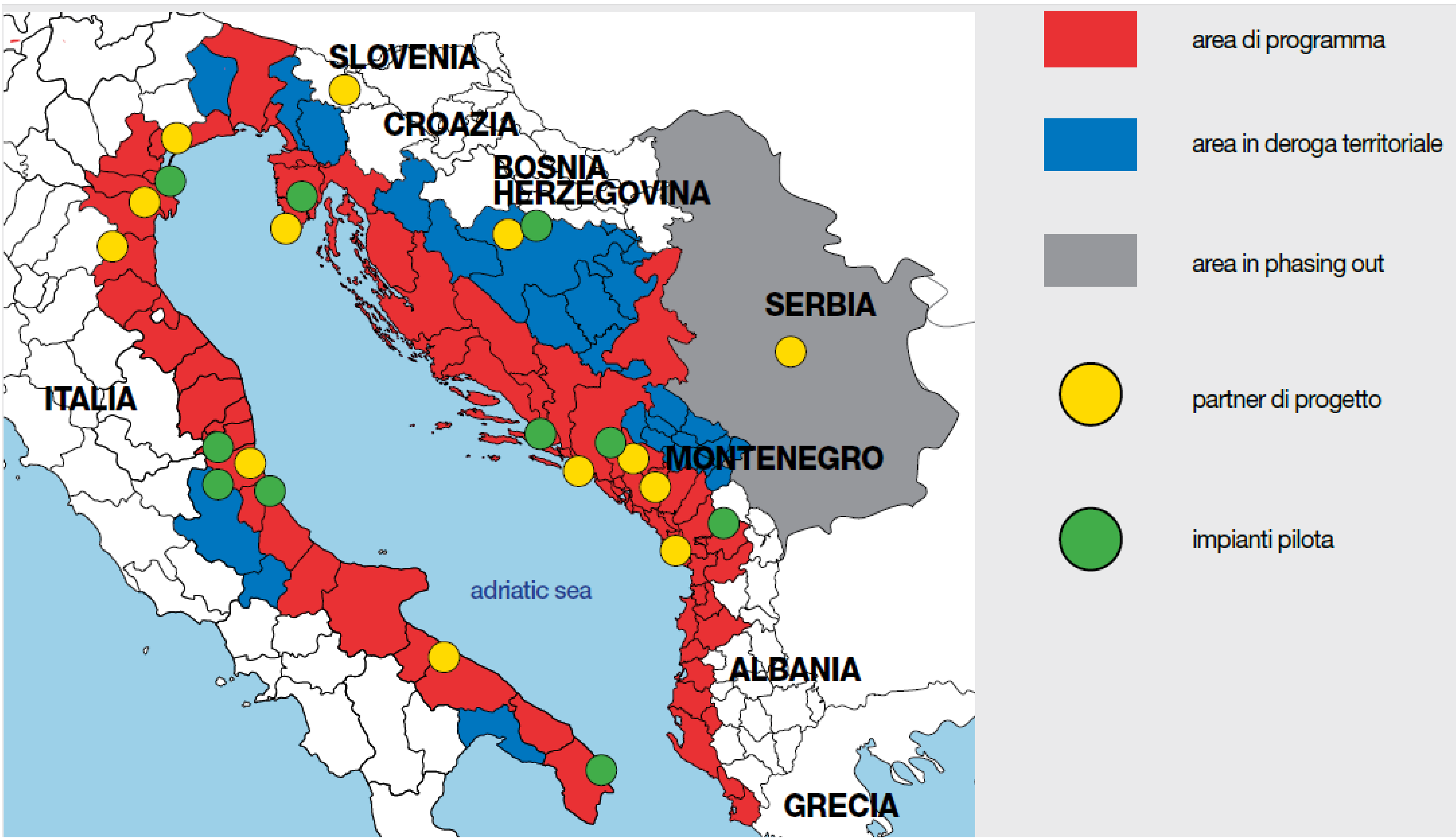
The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together
Adriatic IPA
Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

General information



from earth to people

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC
European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together
Adriatic IPA
Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

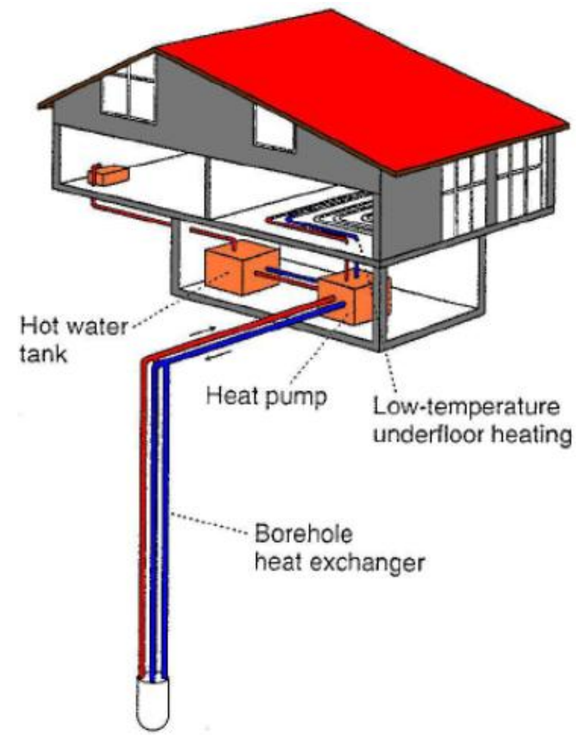
General information

MAIN GOAL

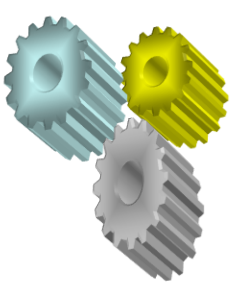
Promotion **of geothermal energy benefits in the Adriatic area**

Promotion tools

- **development of 10 demonstration cases in public buildings** utilizing GCHP (Ground Coupled Heat Pumps)
- **development of cost/benefit monitoring analysis and policy & financial supporting schemes** to overcome market barriers
- knowledge fertilization through **training and workshops for energy managers and technicians** to get familiar with GCHP potentialities



CAPITALIZATION



LEGEND capitalizes the results of EU funded projects such as ***GEO.POWER***, ***VIGOR*** & ***SEAR*** in order to address practical application with high transferability potential in 7 countries & 11 regions of the IPA Adriatic area

from earth to people

LEGEND project

Basic asumptions

PROJECT BACKGROUND

The Adriatic Area has adeaquate climatic and geological conditions to fully exploit the potentialities of low enthalpy Geothermal Energy (Ground Coupled Heat Pumps - GCHP) due to the presence of medium temperature basin across the Western Adriatic shore and the shallow geothermal conditions that characterizes the entire Eastern Adriatic Countries.

Severe **technology gaps and market barriers are present**:

- **Lack/poor harmonized regulations** at national / regional level regarding heating and cooling permissions .
- Existence of **knowledge barriers** among policy and decision makers, stakeholders and citizenship such as: insufficient information on applicability prerequisites; cost-benefit calculation; lack of demonstrative successful examples and reliable statistics on the RES H/C applications. **They are *key obstacles* that slow INVESTMENTS in such type of RES.**

LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Basic asumptions

NEEDS

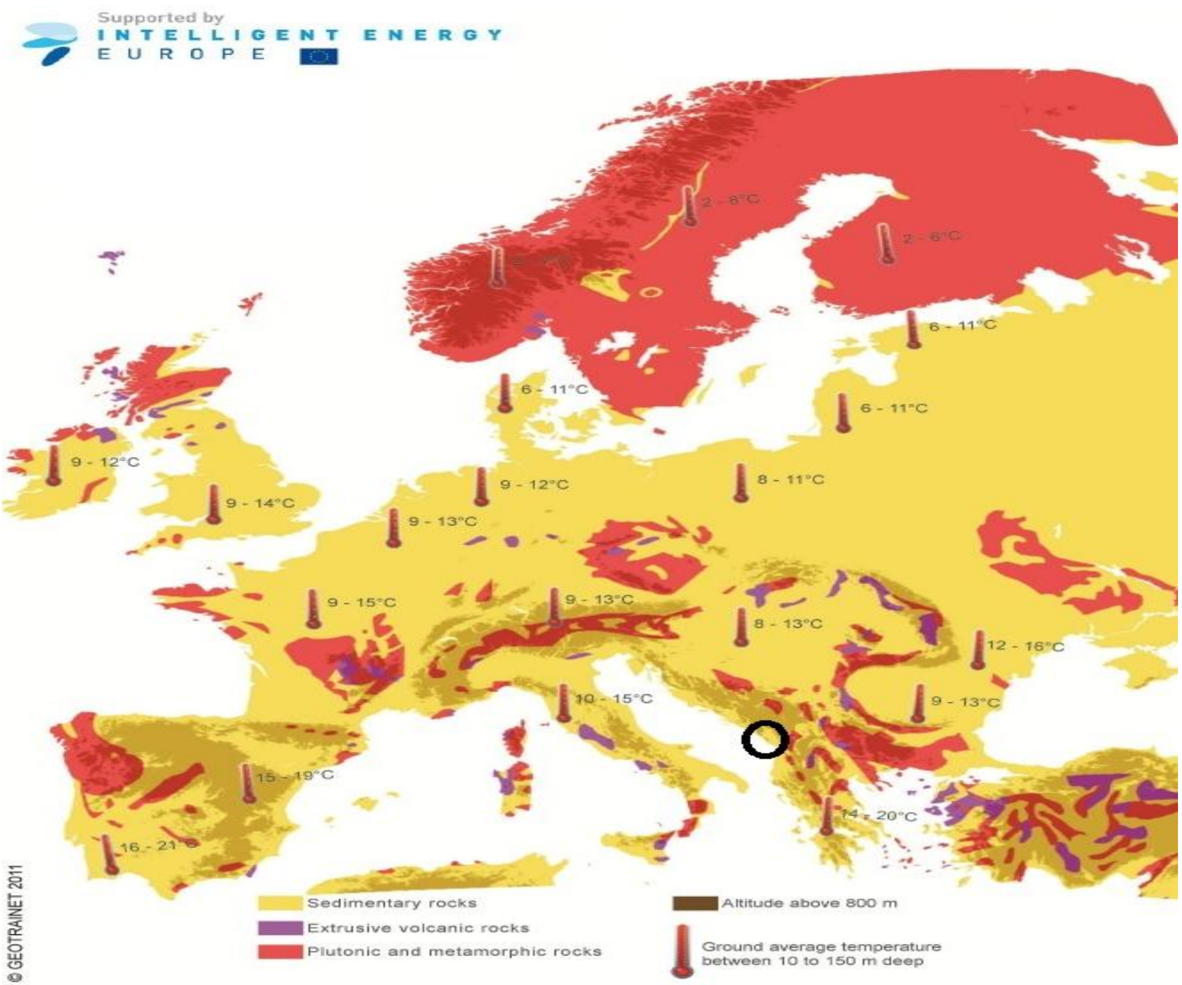
- **Need of promoting the GCHP concept as integral part of the RES options**
- **Need of demonstrative investments to catalyze the interest of the local administrators**
- **Need of a better normative setting to facilitate investments**

Results

1. ***GCHP energy requalification (demo-cases) on 10 public buildings***
2. ***295 tons of CO2 per year not released in the atmosphere***
3. ***144 toe/year renewable energy production triggered***
4. ***132 toe/year primary energy saved***

LEGEND project

Basic asumptions – energy potential



LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

LEGEND project

Heat pump pilot investments

Basic concepts

1. ***Peak power generation (IRENA, LIR, DUNEA (up to 95%))***
2. ***Partial load (Ferrara, Skhodra, Teramo, Danilovgrad, Puglia***

Ground heat exchanger types

1. ***Closed loop - vertical (IRENA, LIR)***
2. ***Closed loop – energy baskets (DUNEA)***
3. ***Open loop (Ferrara, Teramo, Puglia, Danilovgrad, Skhodra)***

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014
Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

IRENA – Pjerina Verbanac nursery

Start of activities: July, 2013.

End of activities: March, 2013.

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014
Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

Drilling and TRT: July, 2013.

3 boreholes of 100 m depth

Lithological profile: 3 m clay
97 m limestone

Duration : 24 days

Total cost: 17.000 €

TRT results:

- Static temperature along the borehole – 14,7 °C
- Total thermal energy stored in the rock mass during TRT – 127,8 kWh
- Temperature of the working fluid in PE pipes reached at the end of TRT – Tin/Tout – 29,6/27,3°C
- Thermal conductivity 1,92 W/m°C
- Thermal energy per meter gained – 54 W

from earth to people

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

LEGEND LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

IRENA – Pjerina Verbanac nursery

Main system characteristics

- INSTALLATION PERIOD: DECEMBER 2013. – MARCH 2014.

- INTERVENTIONS REALIZED:

1. Low radiant heating/cooling systems – floor, wall, ceiling heating/cooling
2. Fan coils used as backup cooling solutions (for high humidity periods)
3. Ventilation with integrated heat recuperation unit– air coming into recuperation unit preheated/precooled with geothermal heat pump
4. 22 kW geothermal heat pump with active cooling solution (peak heating/cooling 18,9/19,8)
5. **Investment: 73.000 €**

LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

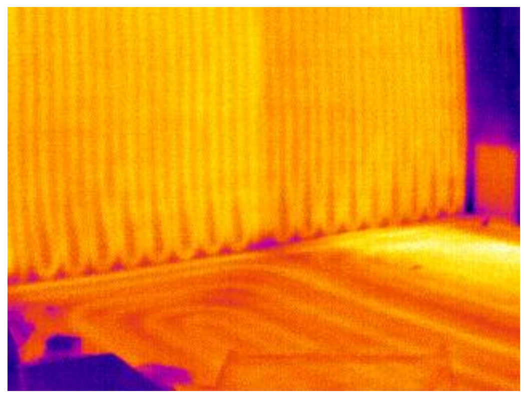
LEGEND project

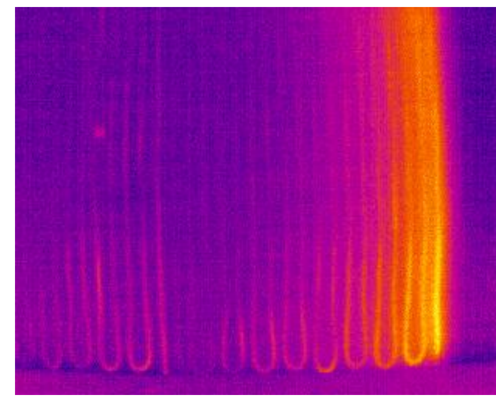
Heat pump pilot investments

IRENA – Pjerina Verbanac nursery

Engine room

System in operation





25 days 24h/day testing period under full load – minimum borehole temperature -2 °C

LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

IRENA – Pjerina Verbanac nursery

System drawbacks and potential improvements

1. Slow reaction of both ground heat exchanger and inner low radiant systems – improvements needed regarding grouting materials, borehole pipe material. Larger buffer units provide partial solution.

2. Outside temperature sensors issues with high daily(hourly) temperature amplitudes

3. Peak power design – only 30% of borehole potential used. Transfer of heat to adjacent building is planned – this building consumes 110.000 kWh/year for heating (72 kW electric heater). This should significantly reduce the investment payback period (currently 14 years).

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014 Veli Lošinj, Croatia

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

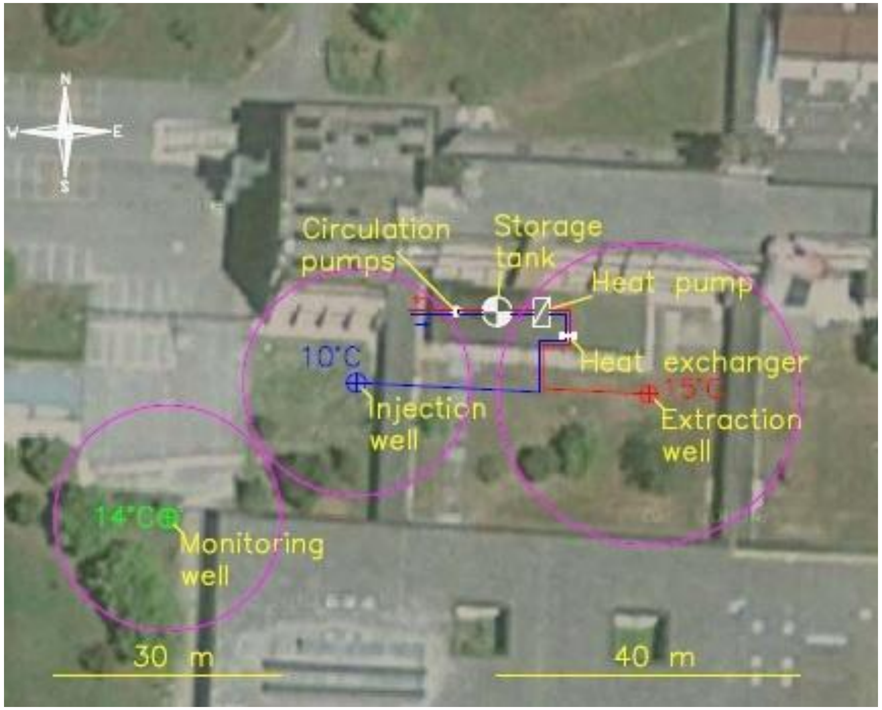
Heat pump pilot investments

Province of Ferrara – IIS CIVITA – MONACO DI POMPOSA

Environmental monitoring →

Control of aquifer situation:

- **TEMPERATURE**
- **CHEMICAL DATA**
- **WATER TABLE LEVEL**



LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC EUROPEAN CENTRE FOR SCIENCE ARTS AND CULTURE

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

Province of Ferrara – IIS CIVITA – MONACO DI POMPOSA

Main system characteristics:

Open loop system

Heating only solution

Extraction well:

- 50 m depth, d=140 mm
- Submersible pump at 24 m (2,2 kW)
- Filter from 40 to 50 m

Injection well:

- 56 m depth, d=140 mm
- Filter from 28,5 to 56 m

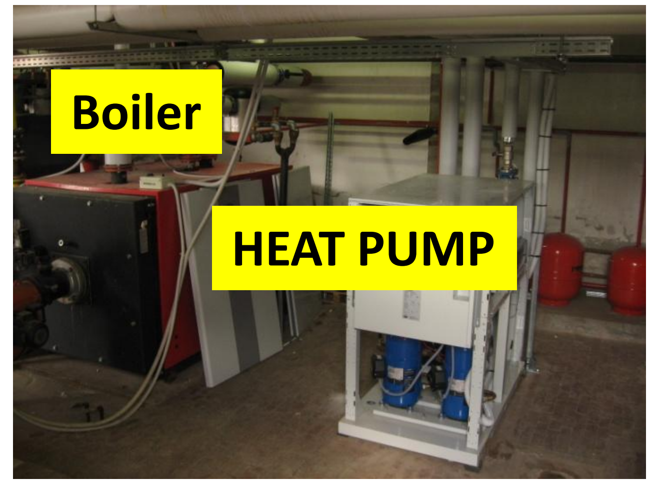
- Flow rate: 12.000 l/h

Building net floor heated area (high temperature radiators) 10.365 m^2

Heat pump: 106 kW

Estimated yearly energy production: 360.000 kW/h

Investment: 120.000 €



XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014
Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together
Adriatic IPA
Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

Province of Ferrara – IIS CIVITA – MONACO DI POMPOSA – MONITORING SYSTEM

Energy monitoring →

- **Check of energy savings**
- **Check of CO_2 reduction**
- **Check of renewable energy production**
- **Check of economic profit of the investment**

from earth t

Technical High School - Codigoro (FE)

OPEN LOOP GROUND COUPLED HEAT PUMP SYSTEM

Working hours	3	h		
Thermal energy production	418,60	kWh_t		
	Heat pump		Extraction pump	
Electric consumption	70	kWh_e	20	kWh_e
Seasonal Performance Factor	4,65			
Natural gas savings	59,52	m^3		
Energy savings	327,60	kWh_t		
CO2 reduction	22,70	t		
Renewable energy production	328,60	kWh_t	Pay-Back time	
Economic profit	37,36	€	-4,7	y
	To radiators		From radiators	
Fluid temperature internal loop	75	°C	65	°C
Fluid flow internal loop	12.000	l/h		
	To heat pump		From heat pump	
Fluid temperature geothermal loop	14		4	°C
Fluid flow geothermal loop	12.000	l/h		
Temperature extraction well	15	°C		
Temperature reinjection well	3	°C		
Temperature monitoring well	15	°C		

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

LEGEND project

WWW.LEGEND-GEOTHERMALENERGY.EU

Heat pump pilot investments

DUNEA – Elementary school Opuzen

Main system characteristics:

Closed loop system – geothermal baskets

- 13 baskets
- 250 m coil lenghth
- Bottom depth – 4,5 m
- Top depth – 1,8 m
- Power output per basket – 2 kW
- Heating only solution
- Heat distribution system – high temperature radiators (to be replaced with low temperature radiators)
- Building net floor heated area (high temperature radiators) 1.500 m^2

Heat pump: 35 kW
Estimated yearly energy production: 53.000 kW/h
Investment: 70.000 €

from earth to people

LEGEND project

Heat pump pilot investments

IRENA – Labin capacity building seminar

MAIN PROBLEM FOR WIDER ACCEPTANCE OF GCHP INSTALLATIONS:

Extreme discrepancy between average salary/investment ratio

Albania – 329/80.000 €
Italy – 1604/80.000 €

LEGEND
LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture
WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area
25 - 27 August 2014
Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

LEGEND project

Heat pump pilot investments

IRENA – Labin capacity building seminar

Main goals:

- To introduce high school students to basic concepts of geothermal energy exploatations
- To design and constructs 15 cost effective ground heat exchangers and significantly reduce salary/investment ratio for ground heat exchanger
- To design and construct heat exchanger field based on 15 different materials/structures commonly found in Istrian county
- To perform 15 TRT tests
- To construct heat pump out of basic elements and use it to heat/cool high school physics cabinet
- To lay foundations to future projects within the school and especially the one in which cost effective heat pump will be designed and constructed - this should significantly reduce salary/investment ratio for inner installations

LEGEND project

IRENA – Labin capacity building seminar

Materials/structures tested:

1. Silica sand
2. Bentonite clay
3. Concrete MB 30, vibrated
4. Red soil, dry
5. Red soil, wet
6. Loam
7. Humus
8. Limestone flour
9. Limestone gravel (fraction 0-4 mm)
10. Limestone gravel (fraction 40-80 mm)
11. Dolomite flour
12. River sand
13. Thermo active cement
14. Static water tank
15. Circulating water tank

Location of LEGEND geothermal park – High school Mate Blažine, Labin

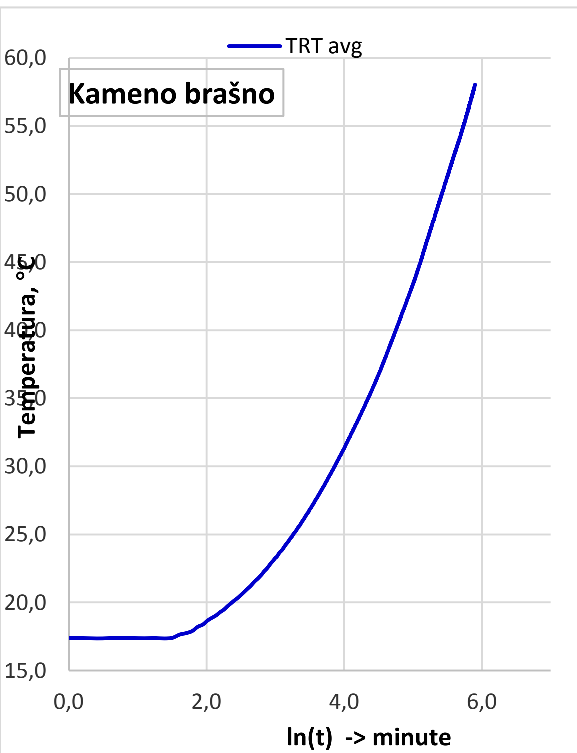
TRT results:

Basket number	Basket name	Q_{8h} (l/h)	P_{8h} (kW)	Q_{10h} (l/h)	$P_{10\,h}$ (kW)	P_{Qfix} (kW)
1	Limestone gravel (0-4 mm)	1.100,96	1,05	1.016,36	0,97	0,95
2	Dolomite flour (0-35 µm)	814,19	0,75	747,05	0,69	0,92
3	Limestone flour (0-35 µm)	574,09	0,51	527,54	0,47	0,90
4	River sand	947,92	1,03	872,74	0,95	1,08
5	Silica sand	594,85	0,51	548,43	0,47	0,85
6	Red soil - wet	1.160,36	1,19	1.070,24	1,10	1,03
7	Red soil - dry	703,41	0,66	651,53	0,61	0,93
8	Limestone gravel (40-80 mm)	1.201,92	1,24	1.094,78	1,13	1,03
9	Loam	1.065,41	0,97	999,05	0,91	0,91
10	Humus	909,28	1,00	828,88	0,91	1,10
11	Static water tank	4.455,35	4,10	3.891,79	3,58	0,92
12	Bentonite clay	640,28	0,53	590,38	0,49	0,82
13	Circulating water tank	15.859,64	18,60	15.859,64	18,60	1,17
14	Thermo active cement	1.289,42	1,30	1.189,06	1,20	1,01
15	Concrete MB 30	n/a	n/a	n/a	n/a	n/a
TOTAL			33,45		32,08	
Q_{fix} (l/h)						
1000,00						

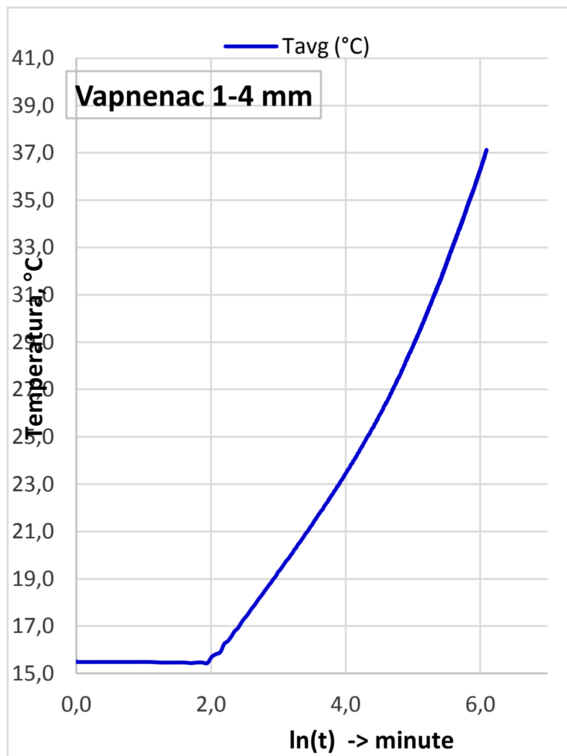
IRENA – Labin capacity building seminar

Limestone – different fractions comparison

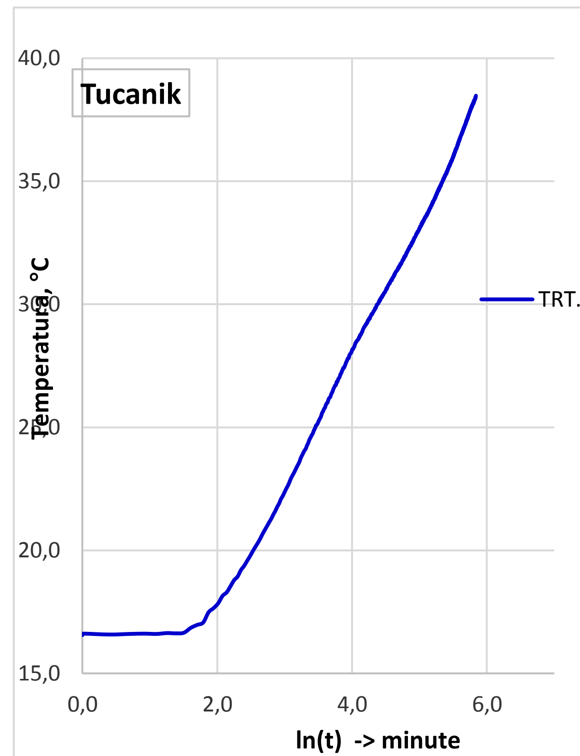
(0-35 µm)



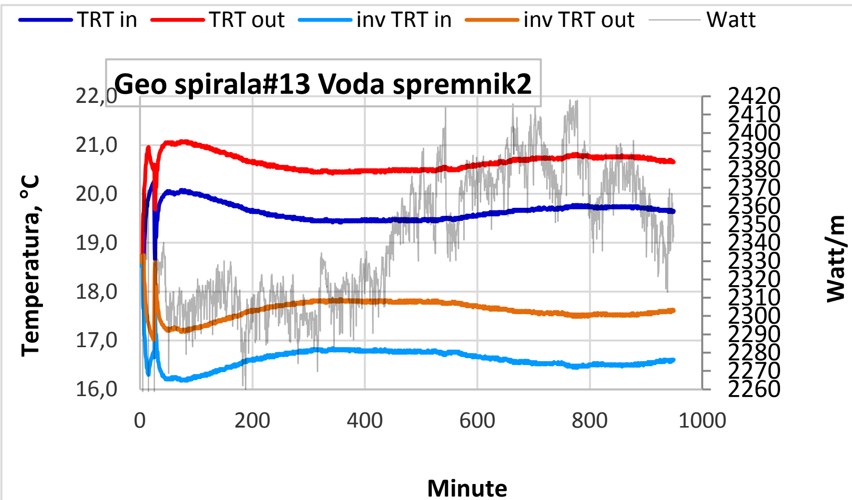
(0-4 mm)

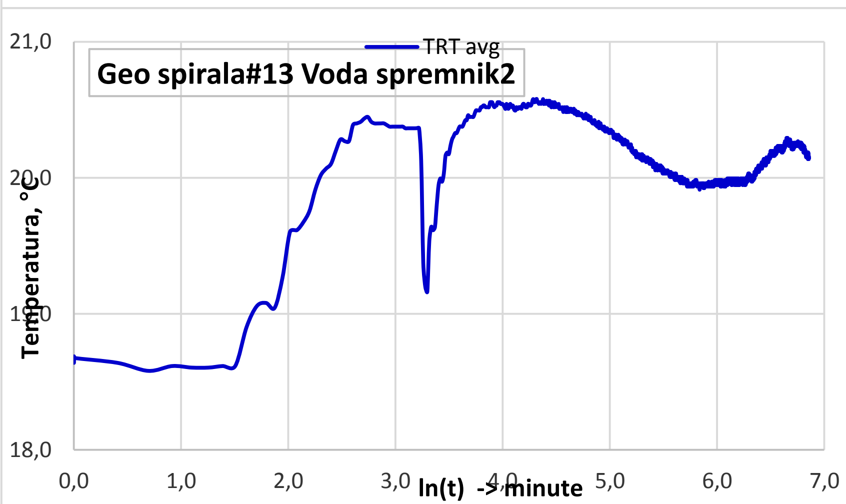


(40-80 mm)



Circulating water tank





General data:
Construction material: reinforced concrete
Volume: 4,5 m^3
Tank water flow: 0,2 l/s
Tap water usage (8 hours): 5,76 m^3
Spiral lenght: 80 m
Investment cost: 450 €
Total output (extrapolated): 18,6 kW

Labin boreholes investment cost: 17.000 €
Total output: 16,2 kW

Labin geothermal park

General data:

Total investment cost: 10.000 €
Total output: 33,45 kW
Investment/kW: 298,95€
Optimal solution investment/kW (excluding water tank): 194,73 €
Labin borehole investment/kw: 1049,38 €

LEGEND

LOW ENTHALPY GEOTHERMAL ENERGY DEMONSTRATION

XIV International Conference on Science Arts and Culture

WORKSHOP on GEOTHERMAL ENERGY Status and future in the Peri - Adriatic Area

25 - 27 August 2014 Veli Lošinj, Croatia

ECSAC European Centre for Science Arts and Culture

The Project is co-funded by the European Union Instrument for Pre-Accession Assistance

Let's grow up together Adriatic IPA Cross Border Cooperation 2007-2013

WWW.LEGEND-GEOTHERMALENERGY.EU

GEOTHERMAL ENERGY: Status and Future in the Peri-Adriatic Area
XIV International Conference on Science, Arts and Culture
Veli Lošinj, Croatia, 25-27 August 2014

THANK YOU FOR YOUR ATTENTION

Dalibor Jovanović

IRENA – Istrian Regional Energy Agency Ltd.
Dalibor.Jovanovic@irena-istra.hr

IRENA
Istarska Regionalna ENergetska Agencija
Istrian Regional ENergy Agency