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GEOTHERMAL ENERGY IN BULGARIA - PROSPECTS FOR GEOTHERMAL DEVELOPMENT IN INDUSTRY AND BUILDINGS

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Introduction

Scope of the presentation

I	Approach to GHP analysis
II	Overview of the GHP technologies
III	Geothermal for industry
IV	Geothermal for households
V	Support schemes
VI	Summary and recommendations

Ancient and modern thermal facilities in BG

Source: WB

- Bulgaria has a long tradition in the use of geothermal waters, mostly for thermal bathing facilities that often date back to Roman times.
- Historical thermal baths exist in many cities, including Sofia, and are often still in operation.
- Modern spa resorts for leisure and balneotherapy have been developed in several areas of central and southern Bulgaria and along the northern Black Sea coast.

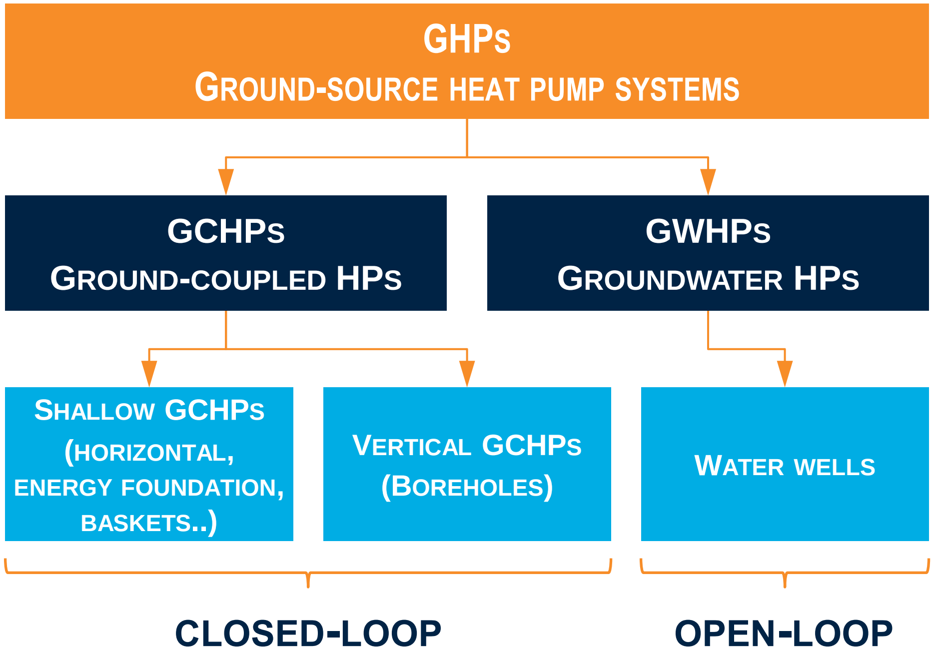
Ground-source heat pumps offer many layout alternatives, each with its own pros and cons. Both the technical feasibility and economic advantages are case-specific

II Overview of the GHP technologies

Heat pump technologies

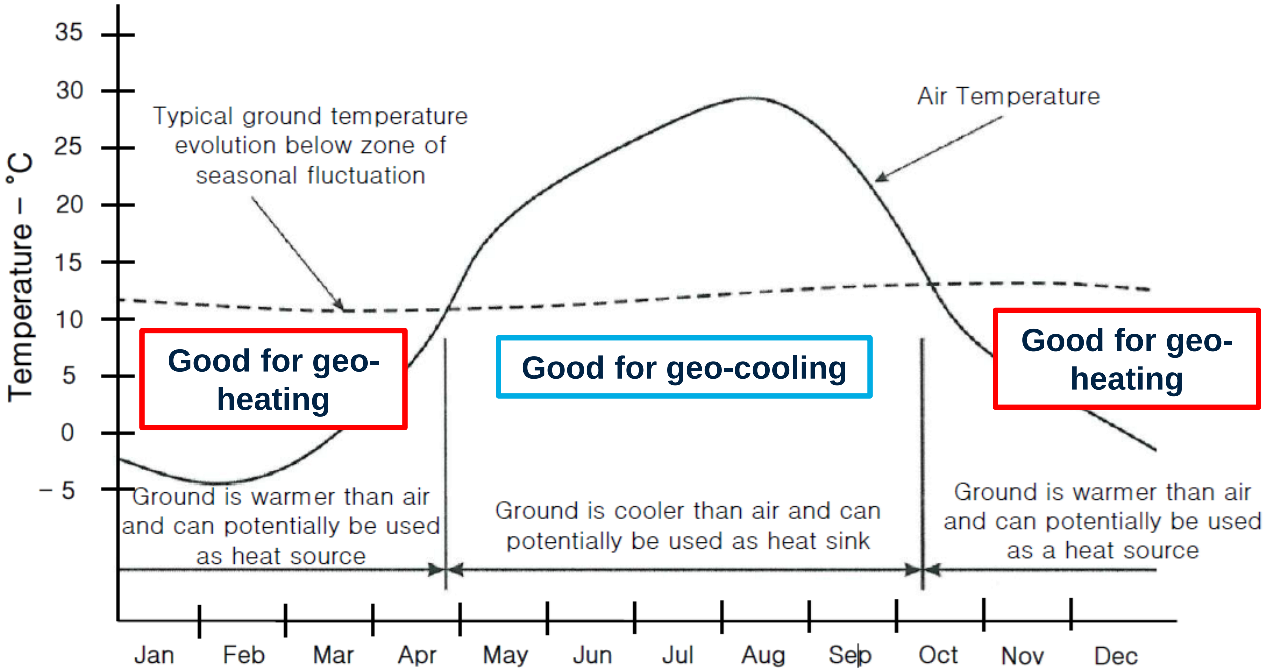
Technology	Pros	Cons
Air-source HPs	▪ Low CAPEX per kW	▪ Lower energy performances related to outdoor temperature
GWHPs	▪ Energy performances ▪ Low CAPEX per kW	▪ Clean groundwater availability ▪ Environmental concerns
V-GCHPs (boreholes)	▪ Energy performances ▪ Low environmental concerns	▪ High CAPEX per kW
H-GCHPs (horizontal)	▪ Good energy performances ▪ Low CAPEX	▪ Land requirements ▪ Not-suitable for large-capacity systems

Types of ground-source heat pump systems



Ground source can be advantageous than air source, depending on time-varying operative conditions

OPERATION PRINCIPLES AND COEFFICIENT OF PERFORMANCES



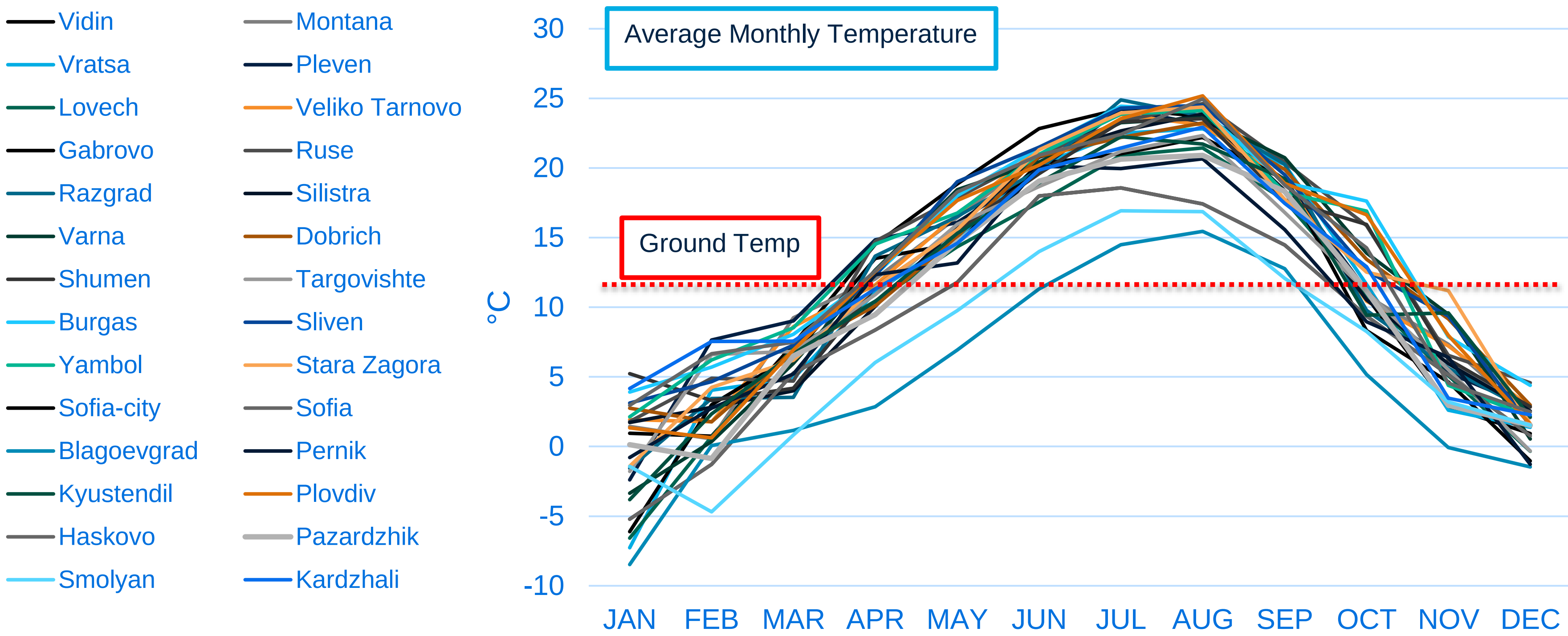
- Increasing COP increases the energy exchange with the ground
- The heat exchange modifies the natural temperature of the subsoil
- Need for a proper design and management strategy of heat extraction.

Ground sources can be utilized for heat production mostly in the winter season, with performance limitations during the mild or hot months

II OVERVIEW OF THE GHP TECHNOLOGIES

BG CLIMATE: TMY – TYPICAL METEOROLOGICAL YEAR

Source: PVGIS-SARAH 2005-2020

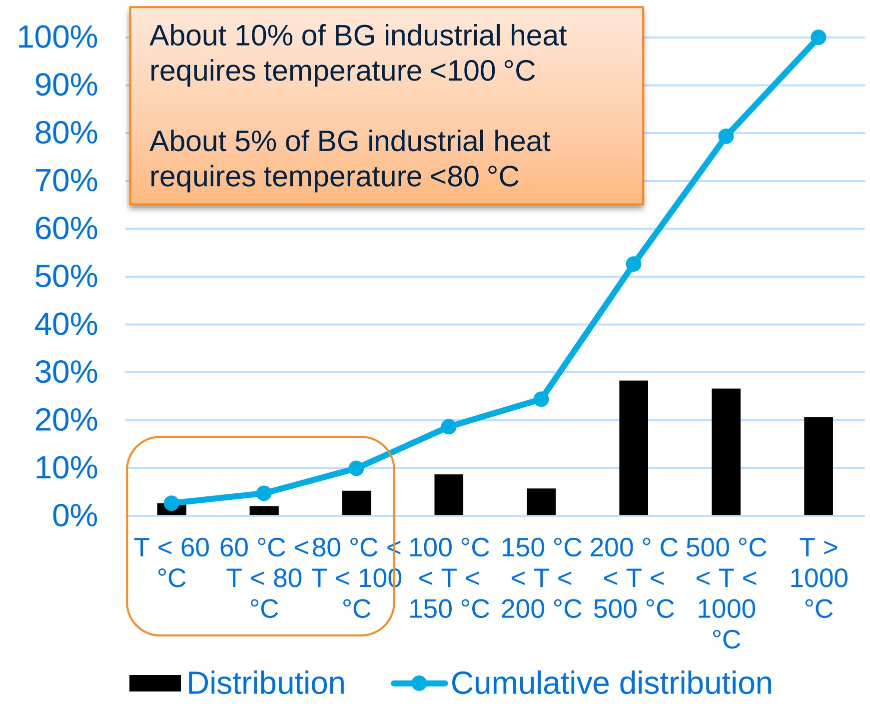


About 10% of BG industrial heat requires temperature <100 ° C, with chemical products and non-metallic mineral products showing the largest demand potential

III GEOTHERMAL FOR INDUSTRY

HEAT DEMAND IN BG INDUSTRIAL SECTORS

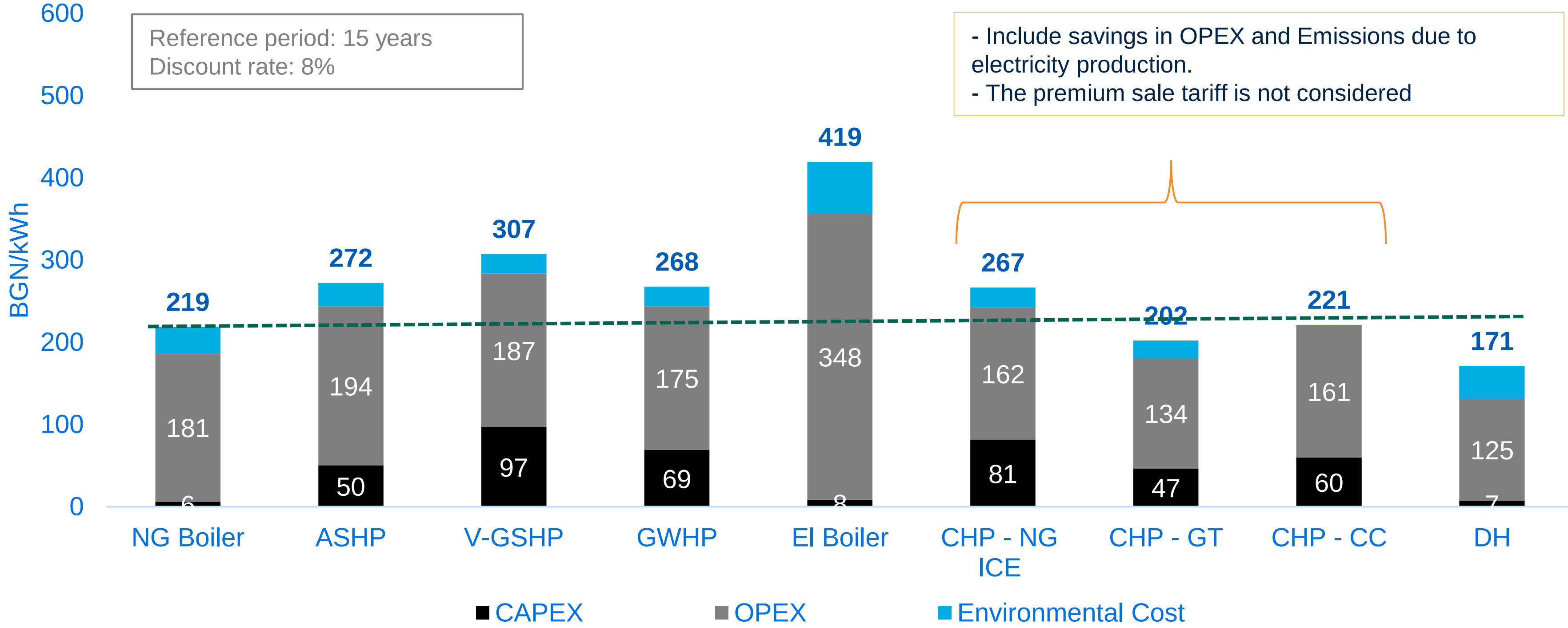
NO	SECTOR	% BG IND HEAT DEMAND	% HEAT DEMAND T≤80°C	% HEAT DEMAND T≤100°C
1	Food & Beverage	2%	<1 %	1 %
2	Wood & Wood products	2%	<1 %	1 %
3	Refined petroleum products	14%	<1 %	<1 %
4	Paper, pulp & print	7%	<1 %	2 %
5	Textile & Leather	<1%	<1 %	<1 %
6	**Chemical Products**	**40%**	**3 %**	**5 %**
7	Iron & Steel	3%	<1 %	<1 %
8	Pharmaceutical Products	< 1%	<1 %	<1 %
9	Non-ferrous	6%	<1 %	<1 %
10	Transport infrastructure	<1%	<1 %	<1 %
11	Plastic Products	<1%	<1 %	<1 %
12	**Non-metallic mineral products**	**24%**	**<1 %**	**<1 %**
13	Other chemical products	2%	<1 %	<1 %
	TOTAL:	**16.35 TWh / 59.5 PJ / 1.4 MTEP**		



Due to the expected efficiency in high-temperature industrial applications, GHPs have similar OPEX of NG boilers but are limited by higher CAPEX. GHP technology requires support mechanisms that could lower the CAPEX in the mid-term

III **GEOTHERMAL FOR INDUSTRY**

AVERAGE VALUES OF LCOH – BGN / MWH



The LCOH options can vary considerably with changes in assumptions about demand, fuel costs, and CAPEX costs

Supporting GHPs, especially GWHPs, results in higher environmental benefits and increased cost-effectiveness

III **Geothermal for Industry**

All BG Industrial sectors: incremental effect of CAPEX financial support on HP technologies

- **132 Production sites**
- 16,525,122 MWh/yr total heat demand* (~5% deliverable with GHPs)
- **~ 52.3 ktonCO2/yr possible savings** with GHP technologies
- CAPEX subsides required to make LCOH of GHP (HP + ground apparatus) equal to the LCOH of NG boilers
- On average, for each production site, the required support to make V-GHPs economically viable corresponds to about **66% of the initial CAPEX**.
- On average, for each production site, the required support to make GWHPs economically viable corresponds to about **21% of the initial CAPEX**.
- **A total of ~ 328 M BGN** is needed for **closed-loop systems** to support all the current 132 production sites and achieve the total technical potential
- **A total of ~ 62 M BGN** is needed for **open-loop systems** to support all the current 132 production sites and achieve the total technical potential

2 sectors with highest ind. demand

Chemical products

- 40% of industrial heat demand
- 11 production sites
- CAPEX subsidies required to make LCOH of GHP (HP + ground apparatus) equal to the LCOH of NG boilers
  - ~ 178 M BGN for closed-loop systems
  - ~ 6 M BGN for open-loop systems
  - **The CAPEX support correspond to 56%**

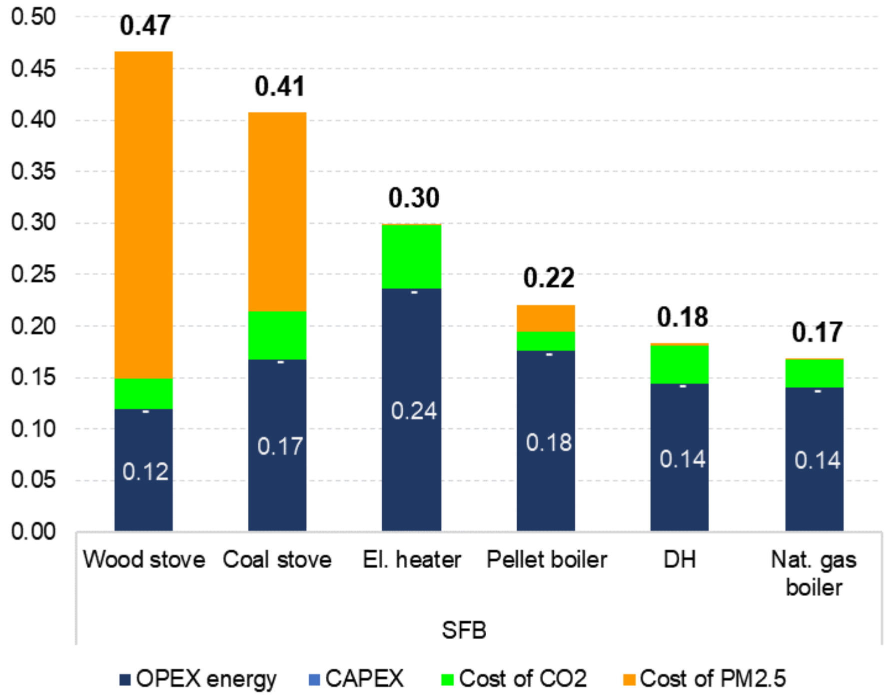
Non-metallic mineral products

- 24% of industrial heat demand
- 22 production sites
- CAPEX subsides required to make LCOH of GHP (HP + ground apparatus) equal to the LCOH of NG boilers
  - ~ 17 M BGN for closed-loop systems
  - ~ 3 M BGN for open-loop systems
  - **The CAPEX support correspond to 53% the total CAPEX required to install V-GHP and GWHP, respectively**

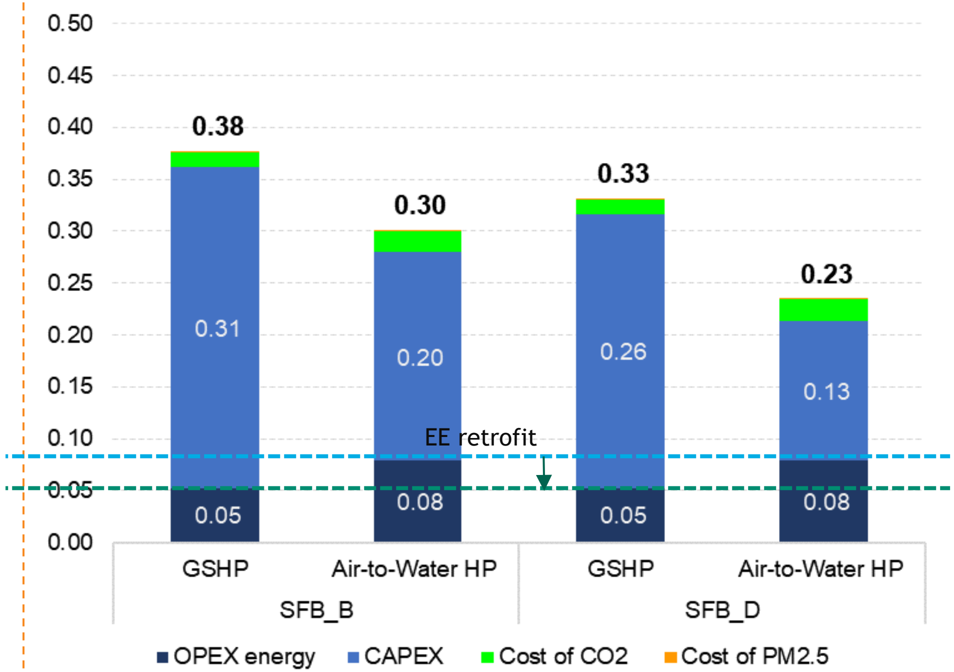
GSH demonstrate lower energy costs of produced heat energy per kWh in single-family buildings. High initial investment costs of GHP are due to the high upfront drilling costs which can be reduced with increased demand

IV GEOTHERMAL FOR HOUSEHOLDS IN SINGLE-FAMILY BUILDING (SFB)

LCOH OF EXISTING HEAT SOURCE BGN/KWH



LCOH OF REPLACED HEAT SOURCE BGN/KWH



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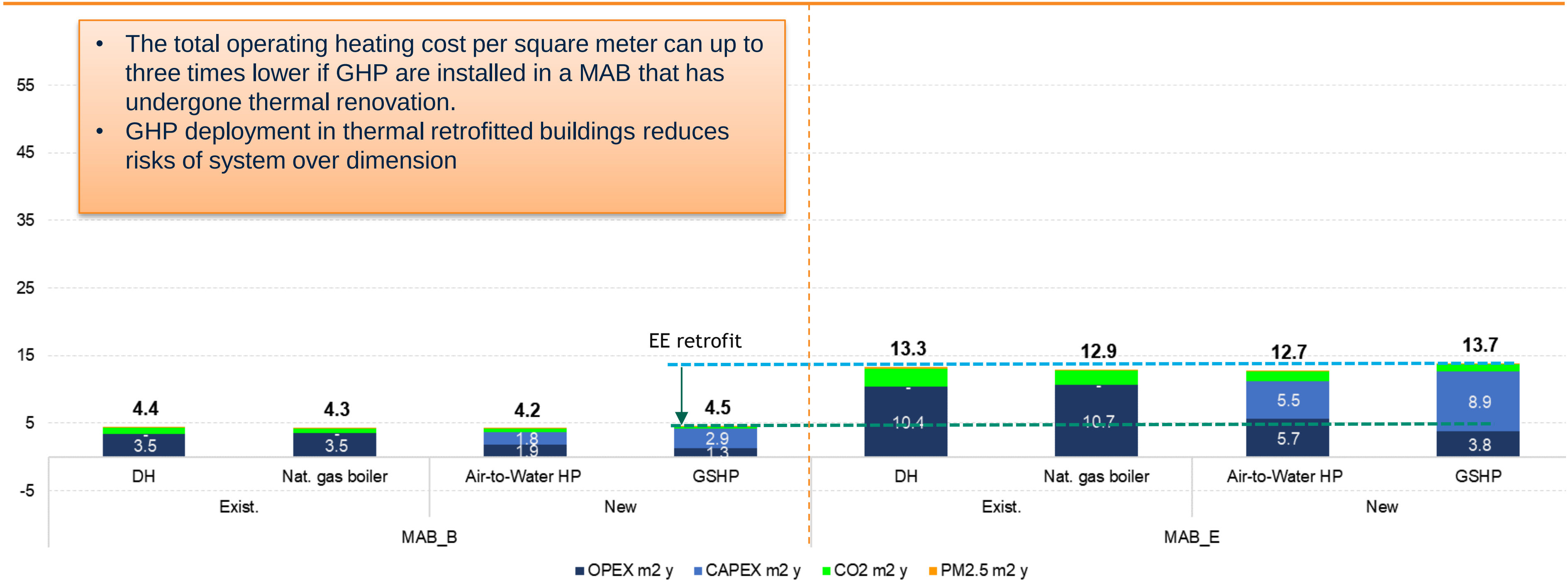
While the installation of GSP in non-renovated MAB reduces both operational costs and emissions, the total annual heating costs per square meter remains significantly higher compared to renovated MAB-scale-up should be accompanied with investments in energy efficiency

IV GEOTHERMAL FOR HOUSEHOLDS IN MULTI-APARTMENT BUILDING (MAB)

COST BGN/M2 OF HEATED AREA

- The total operating heating cost per square meter can up to three times lower if GHP are installed in a MAB that has undergone thermal renovation.
- GHP deployment in thermal retrofitted buildings reduces risks of system over dimension



Number of buildings that can be targeted for the potential program of GHP installation

IV GEOTHERMAL IN BUILDINGS

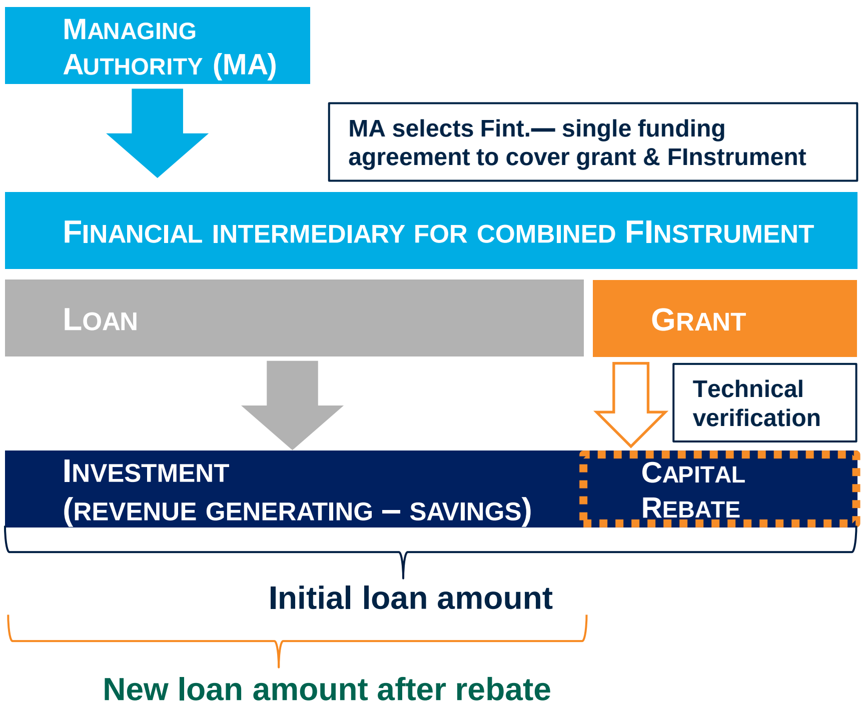
Existing fuel type by building	Targeted buildings area, mil. m2	Share of total heated area2	Investments in GHP, mil. BGN	Energy savings, GWh	Savings of CO2, ton CO2e	Savings of PM2.5, ton
Single family building	**54.9**	**20.6%**	**13,769**	**3,977**	**930,683**	**10,260**
Coal	0.0	0.0%	3	1	314	2
Delivered Heat	1.2	0.5%	311	50	14,279	1
Electricity	8.4	3.1%	2,096	411	199,973	4
Natural Gas	4.0	1.5%	995	170	31,040	0
Pellet	8.3	3.1%	2,073	459	35,829	134
Wood	33.0	12.4%	8,292	2,886	649,248	10,118
Multi-apartment building	**20.1**	**7.5%**	**2,688**	**935**	**253,581**	**23**
Delivered Heat	17.3	6.5%	2,317	799	228,721	22
Natural Gas	2.8	1.0%	371	136	24,860	0
Public building	**7.4**	**2.8%**	**2,076**	**531**	**142,510**	**13**
Delivered Heat	6.2	2.3%	1,741	440	126,067	12
Natural Gas	1.2	0.4%	334	90	16,443	0
Grand Total	**82.4**	**30.9%**	**18,532**	**5,443**	**1,326,774**	**10,296**

Support Mechanisms

Capital rebate combined with Financial Instrument for residential and industry

V ILLUSTRATIVE SCHEME

CAPITAL REBATE MODEL



DESIGN

The mechanism utilizes the capital rebate model for FInstrument design based on the best practices from EU and includes:

- **Grants** for a share of investment costs
- **Loans provided up front** and reduced after the grant share is received
- **Guarantees** to provide risk-sharing support to loan providers
- Additional grants for **technical assistance**
- Grants to **reduce interest rates** on loans
- Special grants to **support vulnerable households** ("energy poor" or "vulnerable households") to repay loans.
- **Revolving funds** that can potentially be utilized to recycle funds and provide low-cost financing.

Support Mechanisms

Establishing well-designed programs with the right criteria

V PROGRAM DESIGN CRITERIA

DESIGNS AND CRITERIA NEED TO BE TAILORED TO LOCAL CONTEXT

DH INFRASTRUCTURE

- Focus initial marketing of GHPs where DH is not available or unoperational, or to mitigate environmental impacts from heating

HIGHER UPFRONT COSTS, ENERGY BILLS

- Introduce simple financing schemes (e.g., utility on-bill financing, supplier leasing) with incentives/discounts, market aggregation, etc. to lower costs
- Focus on households that use expensive fuels or lack heating options
- Focus on simple, basic GHP models

UNDERDEVELOPED MARKET

- Use existing institutions (e.g., electric utilities, municipalities) to help market in initial stages
- Provide training to local technicians

INEFFICIENT BUILDINGS

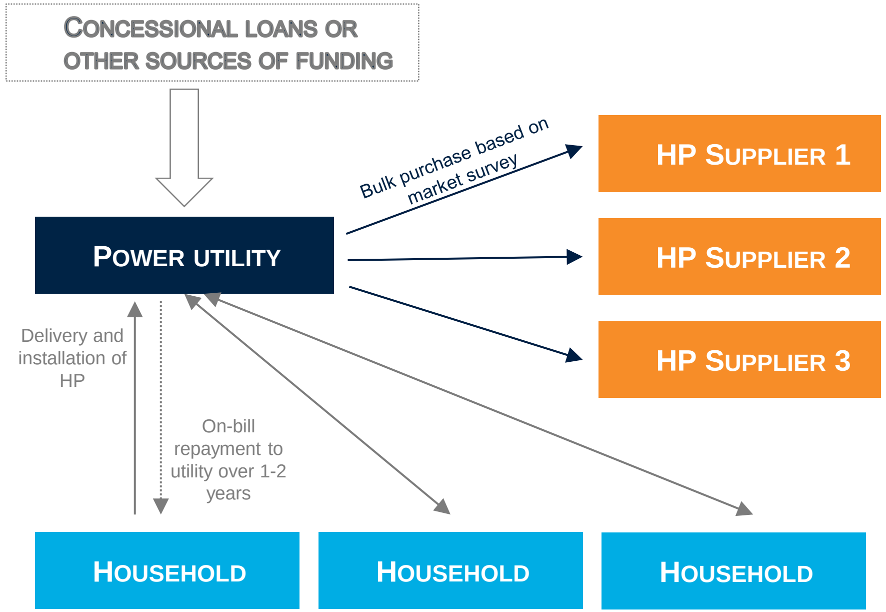
- Focus on newer or renovated buildings, or combine GHP deployment with EE renovation programs

Support Mechanisms

Residential — option of electric utility bulk purchase with on-bill financing for single-family homes in initial development stages

V POTENTIAL BENEFITS

ON-BILL FINANCING MODEL



PROPOSED STEPS

- Include utilities in target regions
- Work with utilities to conduct a rapid market assessment conducted to determine configuration of households, heat demand, level of insulation, ability to pay, impact on energy bills, confirm ability to repay
- Program partners/utilities develop tender to aggregate likely demand in target area, perhaps with framework contract and minimum quantities
- Utilities work with one or more installation contractors to install GSH
- Households repay cost of GSH over several years on electricity bills

Support Mechanisms

Overview for households in Europe

V LEVEL OF SUBSIDIES FOR HEAT PUMPS, INCLUDING GHP

COUNTRY	BUILDING TYPE	SUBSIDIES LEVELS AND CONDITIONS	ADDITIONAL INFO OR REQUIREMENTS
LITHUANIA	New build	▪ **All types incl. GSHP** Max Maximum of €14,500	▪ Subsidy level dependent on the HP GWP
	Renovation	▪ **All types incl. GSHP** Max Maximum of €14,500	
GERMANY	Renovation	▪ **GSHP** €18,000	▪ Up to 25% for heat pump. 5% bonus for GHSP. 10% for replacement of fossil fuel boiler. In some parts, dependent on income categories ▪ Energy efficiency subsidy scheme ▪ Carbon price, existing ban on fossil fuel heating
FINLAND	Renovation	▪ **All types incl. GSHP** up to €4,000	▪ In 2022, tax deduction for oil burner replacement up to 60% and max €2,400. ▪ 45 to 60% of renovations and heat pump installations are also tax deductible.

GWP-global warming potential

Summary and high level recommendations

VI SUMMARY AND KEY RECOMMENDATIONS- INDUSTRY

GSP technical feasibility in the industrial sector depends on specific in-situ heat and temperature requirements, as well as the **availability of ground and groundwater resources**.

The potential for environmental savings is proportional to the **renewable share of electricity** and will increase together with the RES penetration

Energy carrier prices- the economic viability, especially for industry, depends strongly on the ratio of electricity to gas prices. Existing charges and levies create a perverse incentive that needs to be gradually removed

Implement a targeted support program for CAPEX expenditure and make GHP competitive compared to NG-burning technologies

Promote integrated energy-efficiency solutions, hybrid systems and cascade thermal uses in industry. GHP and HP in general could benefit from a combined uses with other energy technologies and energy-efficiency actions to reduce heat demand, GHP capacity and installation costs

Summary and high level recommendations

VI SUMMARY AND KEY RECOMMENDATIONS- RESIDENTIAL

Develop a targeted grant program that covers e.g. up to 50% of capital expenditures (CAPEX) to reduce the initial financial barrier for heat pump installations. Program design should incentive optimal system capacities and efficiency

Establish revolving funds to provide low-interest loans and grants for heat pump installation, ensuring sustainable financial support for the program.

Consider to introduce fiscal incentives such as reduced VAT for both residential and commercial properties that adopt heat pump technologies and replace polluting heat sources.

Implement additional supports for vulnerable groups by offering special grants and subsidies to ensure that low-income households can also benefit from the technology.

Explore options to couple **HP deployment with EE renovation through graded subsidy model**. To achieve faster uptake, in initial stages HP deployment may be decoupled form EE renovations, depending on the implementation pace.

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