Interreg Europe

European Union | European Regional Development Fund

Cost-optimal energy performance benchmarks for buildings in Malta

Final Conference ZeroCO2 – Shaping the Buildings Low Carbon Future
19th September 2019
Marseille, France

Arch. Carmelo Barbara B.E.&A.(Hons.), MSc(Lond.), D.I.C.

carmelo.barbara@gov.mt

Building Regulation Office, Malta,
and University of Malta

INTERREG EUROPE Programme
Sharing solutions for better regional policies
Programme part financed by the European Union
European Regional Development Fund (ERDF)
Co-financing rate: 85%/75% EU Funds; 15%/25% National Funds
Investing in your future

Introduction

This presentation gives an overview of the cost-optimality studies carried out in Malta and how the results emanating from these studies were used to establish the cost-optimal and NZEB performance levels for different categories of buildings (both new and renovated).

Cost Optimal Studies

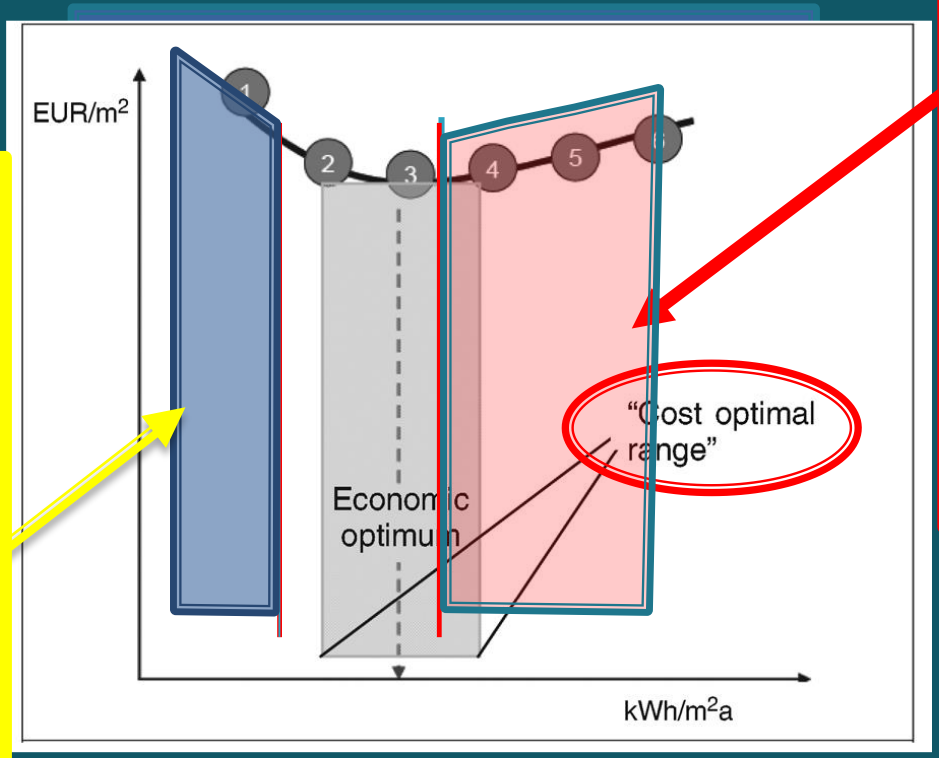
Cost-optimal studies have been carried out in 2018 for the following building categories:

- Hotels
- Restaurants
- Shops
- Homes for the Elderly
- Schools
- Sports Complexes
- Offices (New Only)

Studies have been carried out for both new buildings and buildings to undergo major renovation

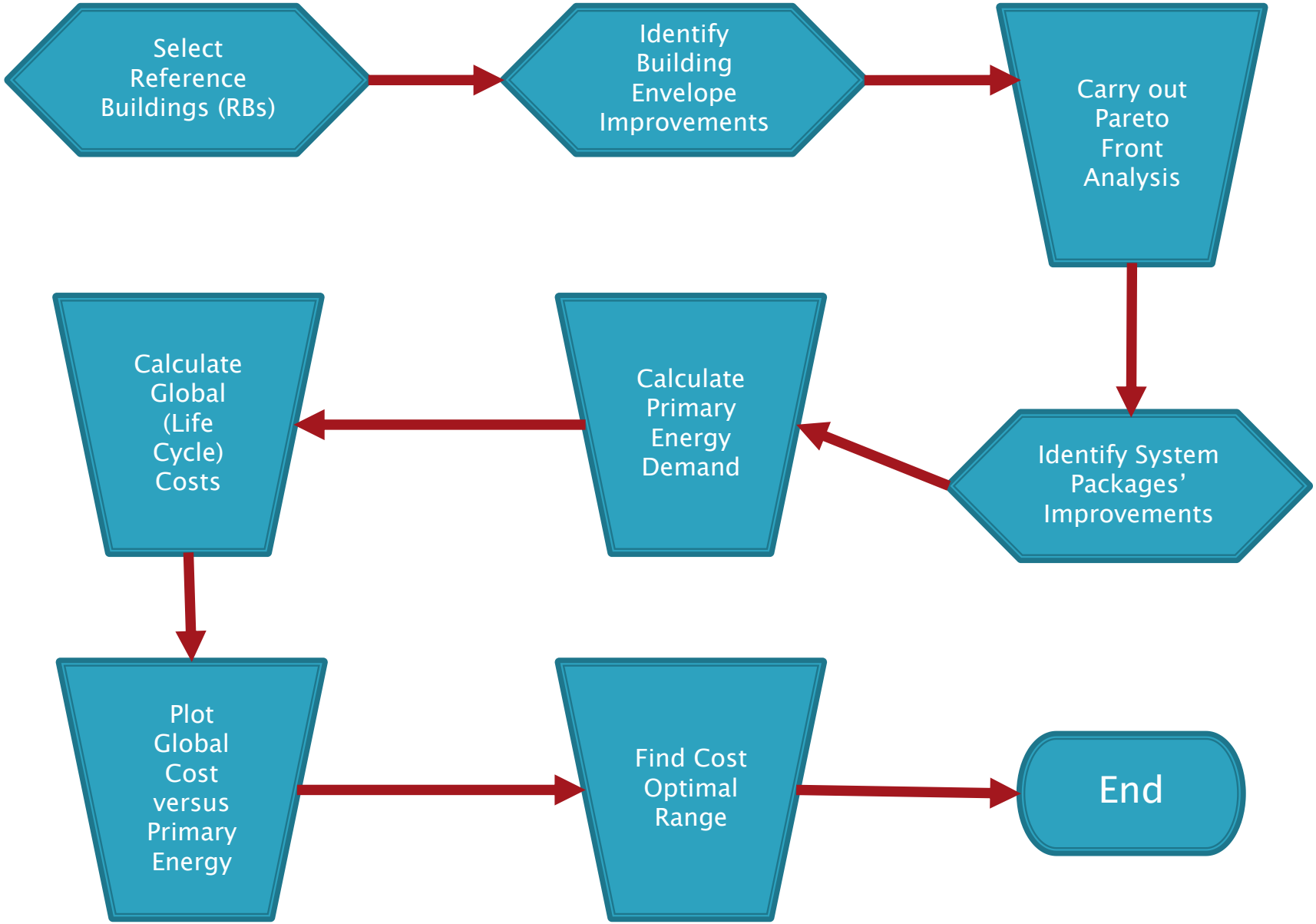
What is cost-optimality ? Cost-optimal range versus cost-optimal point

Non cost-optimal points (**higher LCC**, lower primary energy consumption, **better energy performance closer to nearly-zero energy status**) – Incentives could bridge the gap to make this region cost-optimal

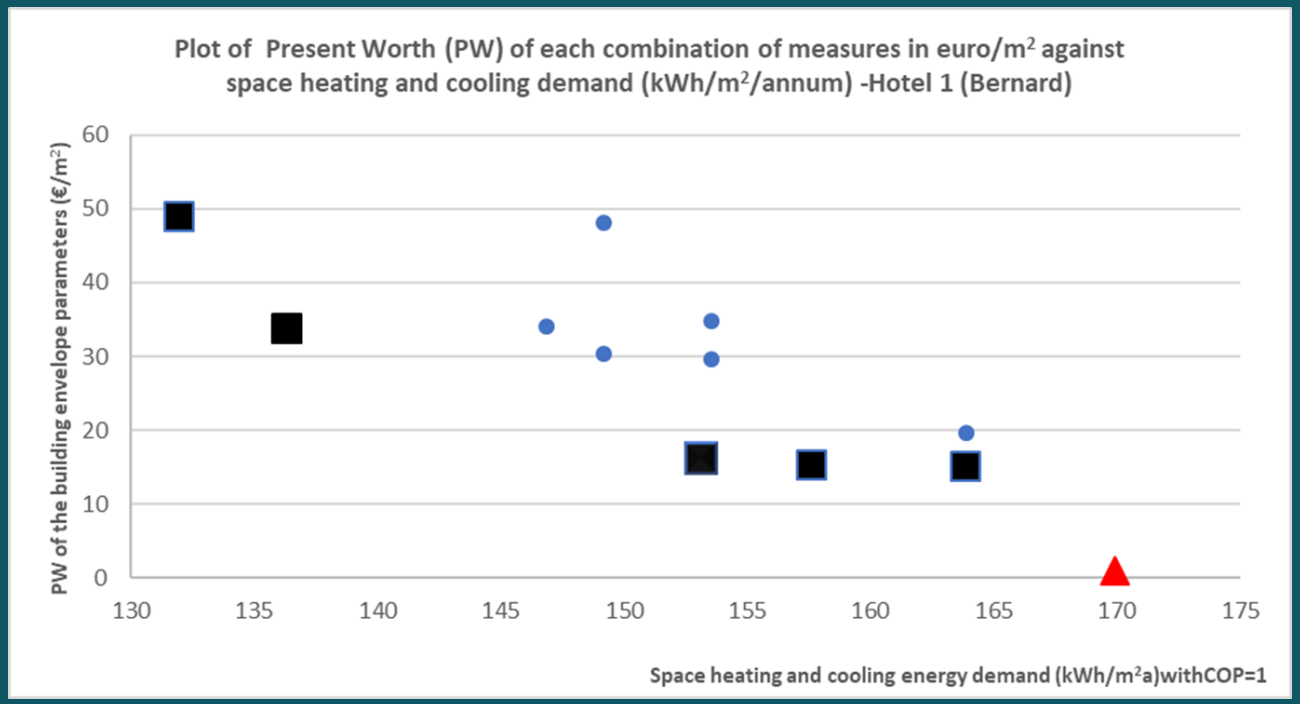


Non cost-optimal points (**higher LCC**, higher primary energy consumption, **lower energy performance**) NO-GO ZONE

Method adopted for cost-optimal studies



Pareto Front Analysis for Building Envelope



The chosen Pareto optimal envelope measures, which lie on the pareto front are depicted with black boxes. The y-axis is the present worth capital cost of different building envelope improvement options. Different HVAC equipment system improvements were afterwards applied to the chosen envelope options.

Package of Measures considered for active systems and RES

Example of active package of measures:

- Domestic Hot Water : Replacement of fuel boilers with Heat pump systems or heat pump/solar thermal system combination
- Space heating and cooling systems: Replacement of fuel boilers with Variable Refrigerant flow systems
- Renewables: Incorporation of PVs to occupy different percentage of roof area
- The packages are also tailor-made to the specific category of use of the building – sports complexes and hotels require considerable amounts of hot water.

Definition of measures and packages

Combination of resulting building envelope pareto measures with active + RES package of measures

	Building Envelope & Heat recovery					Systems		
Package of measures	Wall U-Value (W/m²K)	Window (incl. frame + glazing) U-Value (W/m²K)	Window glazing Tsol	Window glazing Light Transmittance Value	Shading factor	Space heating & cooling	DHW	Renewable energy (PVs) - kWp
Ref 1A	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Ref (oil boilers)	0
1B	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Ref (oil boilers)	27 kWp (hotel 1)
1C	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Air to water heat pump	0
1D	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Air to water heat pump	27 kWp (hotel 1)
1E	2	6	0.85	0.9	As designed	VRF + heat recovery	Air to water heat pump	0
1F	2	6	0.85	0.9	As designed	VRF + heat recovery	Air to water heat pump	27 kWp (hotel 1)
1G	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Ref (oil boilers + solar thermal)	0
1H	2	6	0.85	0.9	As designed	Ref (oil boilers) + chiller (no HR)	Ref (oil boilers + solar thermal)	27 kWp (hotel 1)
1I	2	6	0.85	0.9	As designed	VRF + heat recovery	Heat pump+ solar thermal	0
1J	2	6	0.85	0.9	As designed	VRF + heat recovery	Heat pump+ solar thermal	27 kWp (hotel 1)
COM1A	2	4	0.76	0.80	0.5	Ref (oil boilers)	Ref (oil	0

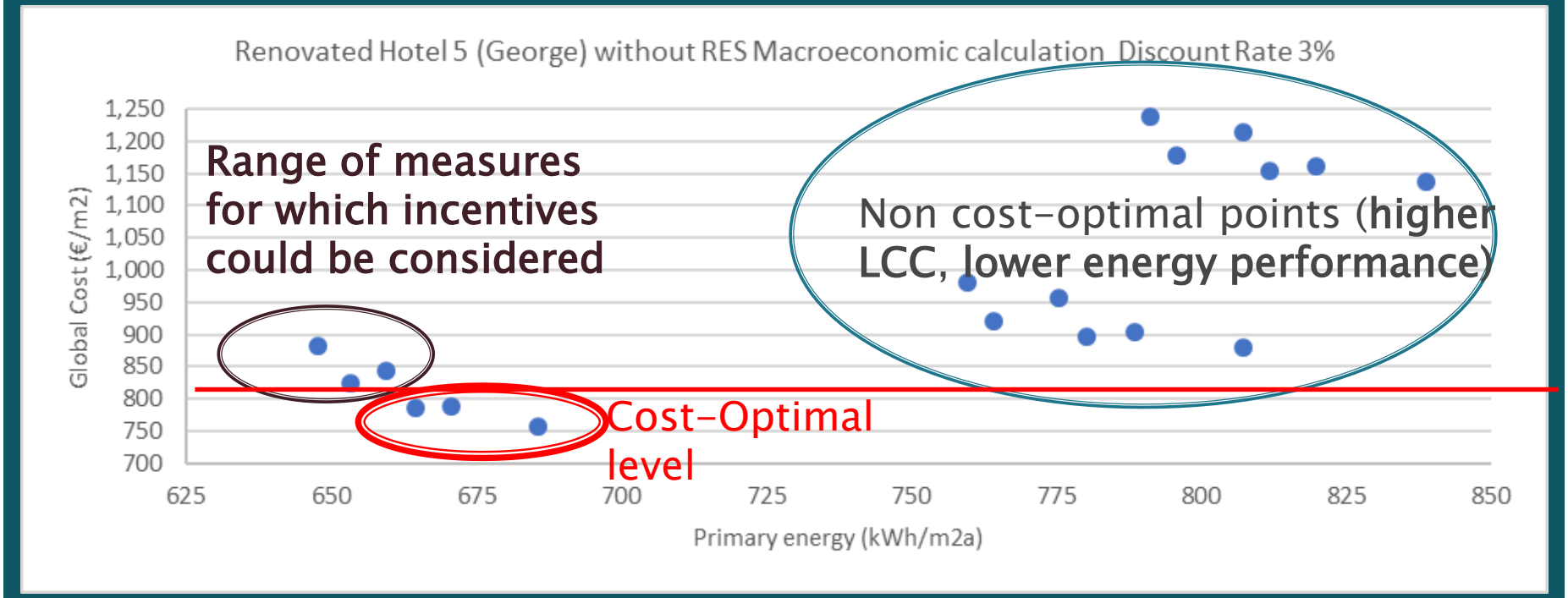
Tens to 100s of combinations were considered depending on the building category and reference building

Primary energy demand and global life cycle costings calculations

1. Calculation of **primary energy demand** for each combination of measures using the National Calculation Methodology – SBEM-mt
2. Calculation of **global (life-cycle) (LCC) costs for each combination of measure:**
3. **Data requirements for LCC analysis:**
   i. **Capital costs**
   ii. **Operating costs**
   iii. **Maintenance cost**
   iv. **Replacement/Re-investment costs**
   v. **Disposal costs**
   vi. **Discount rate**
   vii. **Price development for the calculation period (20 years)**
   viii. **Cost of carbon development (Macroeconomic analysis)**

Global life cycle cost versus primary energy graphs

Cost-optimal levels performed with DR3% Macro-economic Analysis with NO RES



Configurations and sensitivities considered for cost-optimal graphs

Global cost (€/m2) versus primary energy (kWh/m²/a) was plotted for each reference building (both for new and renovated) for the following configurations and sensitivities:

1. **For the financial calculation:**
   a. With RES - Discount rate (4.5 %), price development 1 for both electricity and heating oil
   b. With RES – Lower Discount rate (3 %), price development 1 for both electricity and heating oil
   c. With RES – Discount rate (4.5 %), price development 2 for both electricity and heating oil
   d. No RES - Discount rate (4.5 %), price development 1 for both electricity and heating oil
   e. No RES – Lower Discount rate (3 %), price development 1 for both electricity and heating oil
   f. No RES – Discount rate (4.5 %), price development 2 for both electricity and heating oil

2. **For the macroeconomic calculation:**
   a. With RES - Discount rate (3%), → **Scenario considered to determine near zero-energy levels**
   b. With RES – higher discount rate (5 %)
   c. No RES – Discount rate (3%), → **Scenario considered for cost-optimal energy performance levels**
   d. No RES – higher discount rate (5 %)

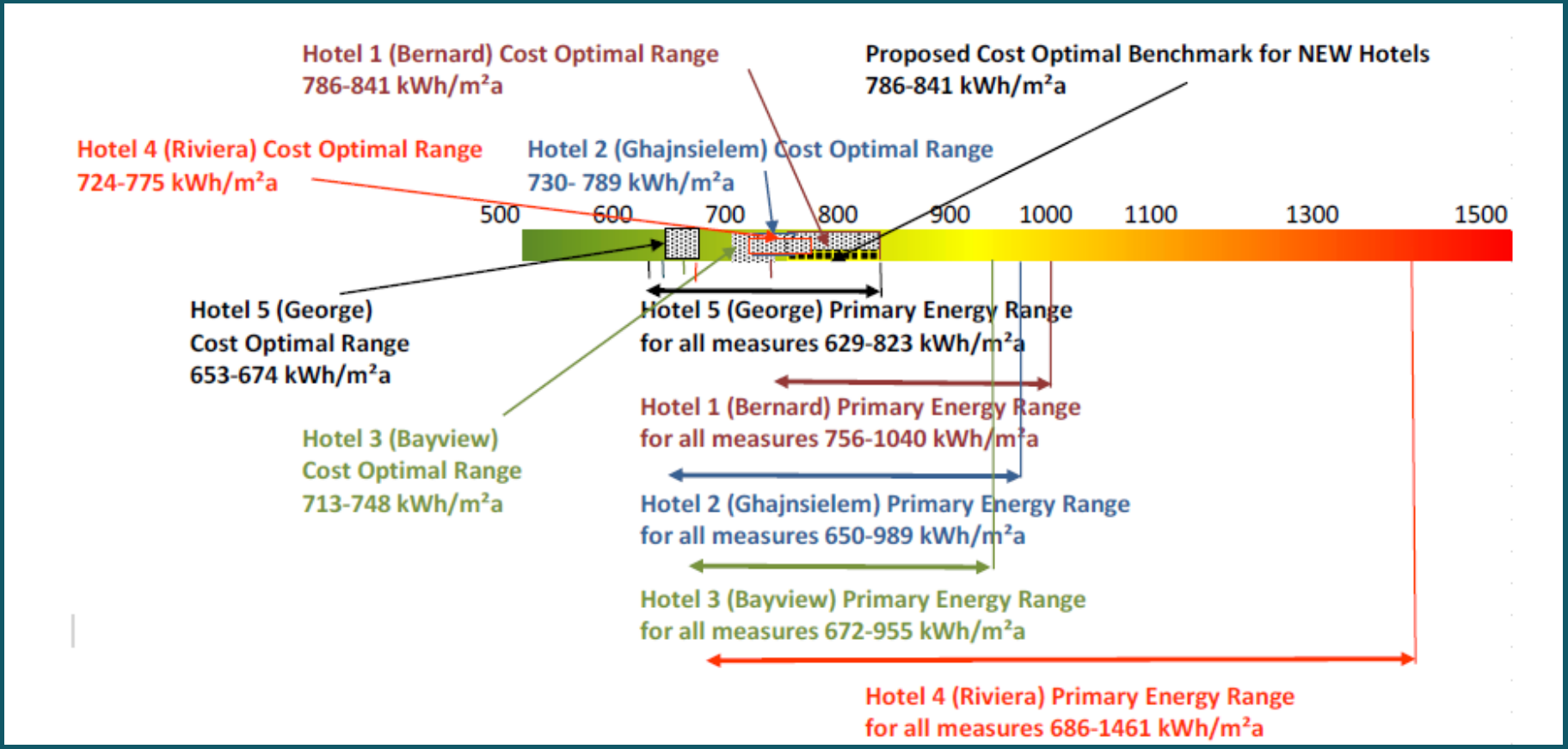
Analysis of results (i)- Summary of results

Critical difference between current and cost-optimal is 15 %, beyond which Minimum Energy Requirements need to be upgraded.

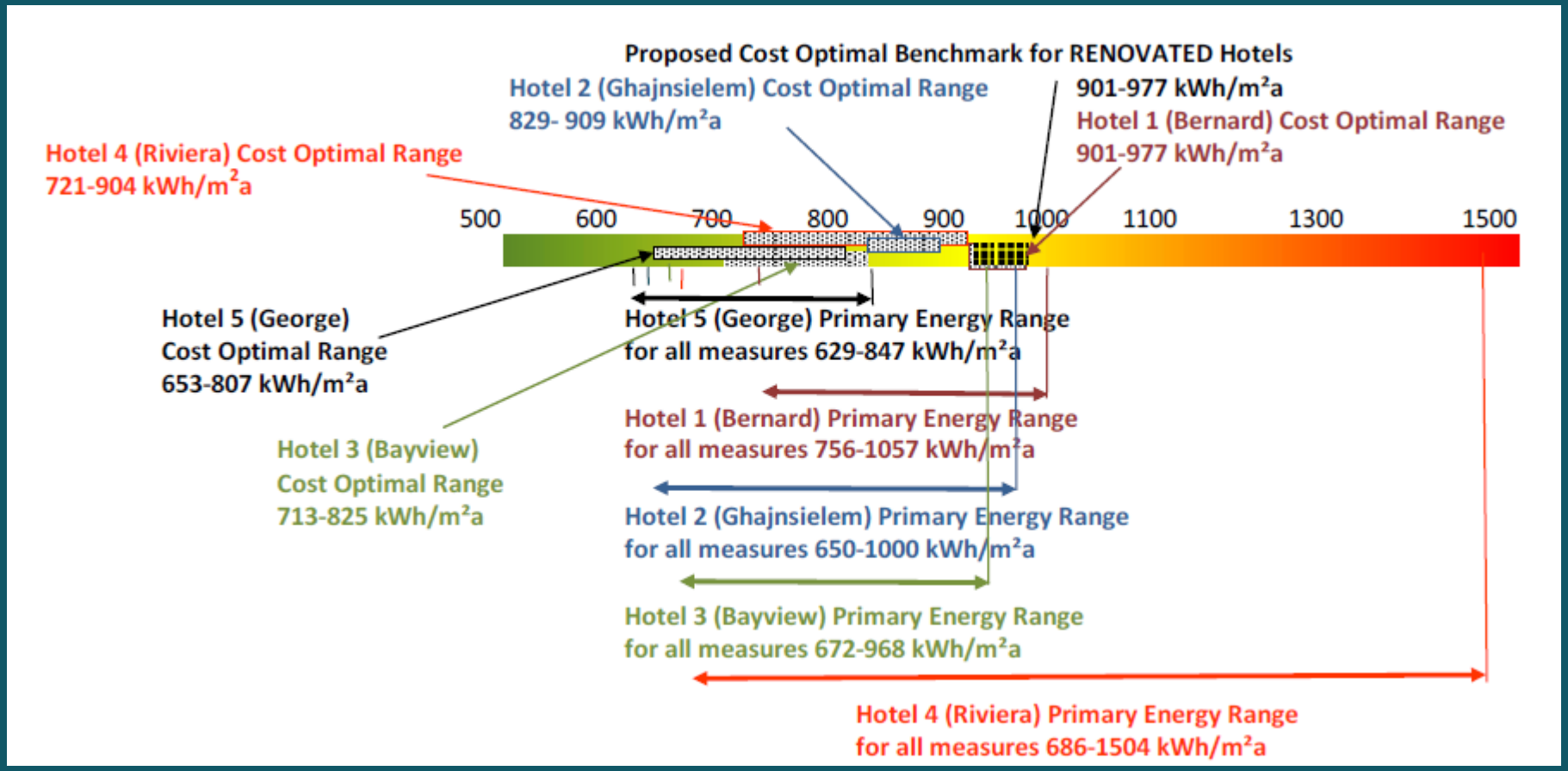
Analysis/Sensitivity	New hotel 1 (Bernard) cost optimal primary energy requirements range (kWh/m²/a)	Current² Minimum requirements – New hotel 1 (Bernard)	% Difference in primary energy btw median cost-optimal & current requirements New hotel 1 (Bernard)	New hotel 2 (Ghajnsielem) cost optimal primary energy requirements range (kWh/m²/a)	Current² Minimum requirements - New hotel 2 (Ghajnsielem)	% Difference in primary energy btw median cost-optimal & current requirements - New hotel 2 (Ghajnsielem)	New hotel 3 (Bayview) cost optimal primary energy requirements range (kWh/m²/a)	Current minimum requirements - New hotel 3 (Bayview)	% Difference in primary energy btw median cost-optimal & current requirements New hotel 3 (Bayview)	New hotel 4 (Riviera) cost optimal primary energy requirements range (kWh/m²/a)	Current² Minimum requirements – new hotel 4 (Riviera)	% Difference in primary energy btw median cost-optimal & current requirements new hotel 4 (Riviera)	New hotel 5 (George) cost optimal primary energy requirements range (kWh/m²/a)	Current² Minimum requirements – new hotel 5 (George)	% Difference in primary energy btw median cost-optimal & current requirements new hotel 5 (George)
Financial calculation with RES - DR (4.5 %), P. Dev. 1	757-841	1091.82	-36.65	651-789	1072.29	-48.93	672-748	1102.59	-55.29	687-775	1038.33	-42.04	630-674	922.66	-41.51
Financial calculation with RES - DR (3 %), P. Dev. 1	757-841	1091.82	-36.65	651-789	1072.29	-48.93	672-748	1102.59	-55.29	687-775	1038.33	-42.04	630-674	922.66	-41.51
Financial calculation with RES - DR (4.5 %), P. Dev. 2	757-841	1091.82	-36.65	651-789	1072.29	-48.93	672-748	1102.59	-55.29	687-775	1038.33	-42.04	630-674	922.66	-41.51
Financial calculation without RES - DR (4.5 %), P. Dev. 1	786-841	1091.82	-34.21	730-789	1072.29	-41.18	713-748	1102.59	-50.94	724-775	1038.33	-38.54	653-674	922.66	-39.06
Financial calculation without RES - DR (3 %), P. Dev. 1	786-841	1091.82	-34.21	730-789	1072.29	-41.18	713-748	1102.59	-50.94	724-775	1038.33	-38.54	653-674	922.66	-39.06
Financial calculation without RES - DR (4.5 %), P. Dev. 2	786-841	1091.82	-34.21	730-789	1072.29	-41.18	713-748	1102.59	-50.94	724-775	1038.33	-38.54	653-674	922.66	-39.06
Macroeconomic calculation with RES - DR (3 %)	757-841	1091.82	-36.65	651-789	1072.29	-48.93	672-748	1102.59	-55.29	687-775	1038.33	-42.04	630-674	922.66	-41.51
Macroeconomic calculation with RES - DR (5 %)	757-841	1091.82	-36.65	651-789	1072.29	-48.93	672-748	1102.59	-55.29	687-775	1038.33	-42.04	630-674	922.66	-41.51
Macroeconomic calculation without RES - DR (3 %)	786-841	1091.82	-34.21	730-789	1072.29	-41.18	713-748	1102.59	-50.94	724-775	1038.33	-38.54	653-674	922.66	-39.06
Macroeconomic calculation without RES - DR (5 %)	786-841	1091.82	-34.21	730-789	1072.29	-41.18	713-748	1102.59	-50.94	724-775	1038.33	-38.54	653-674	922.66	-39.06

For Malta, none of the measures yielded more than 15 % difference, mainly due to mild climate.

Analysis of results (ii)- Summary of results (New buildings)



Analysis of results (ii)- Summary of results (renovated buildings)



Analysis of results – identification of measures lying within the cost-optimal range (new and renovated)

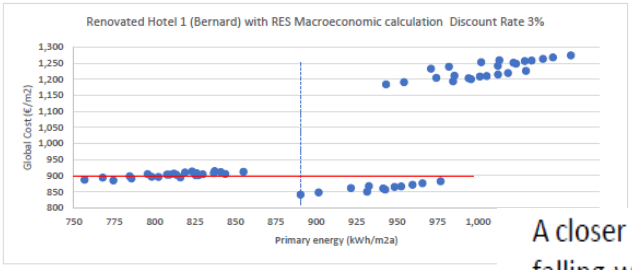


Figure 1-6: Global cost (€/m²) vs. Primary Energy (kWh/m²a) for renovated Hotel 1 (Bernard) with calculation Discount Rate 3 %

Table 1-8: Measures falling within the cost-optimal range (below red line) in figure 1-6

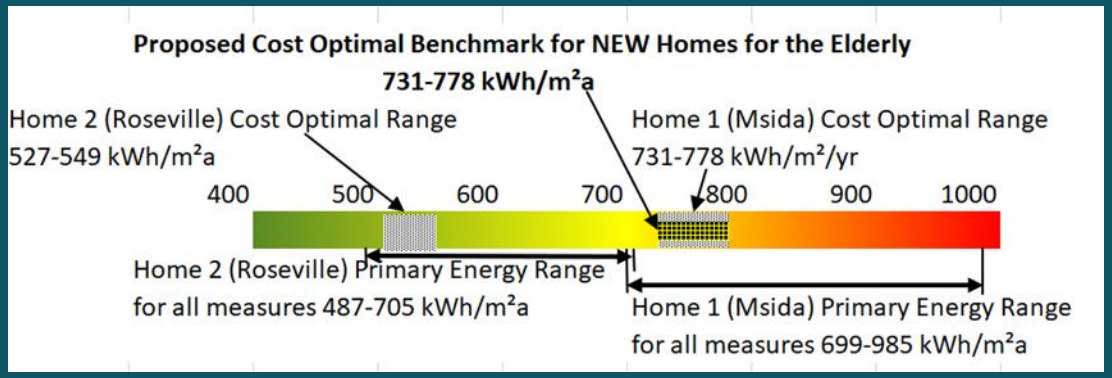
Package of measures	Wall U-Value (W/m²K)	Window U-Value (W/m²K)	Shading factor	Space heating & cooling	DHW	RES (PVs kW
[illegible]	2	6	1	Ref: oil boilers + chillers	Air to water heat pump	0
1D	2	6	1	Ref: oil boilers + chillers	Air to water heat pump	27 kW
COM1C	2	4	0.50	Ref: oil boilers + chillers	Air to water heat pump	
COM1D	2	4	0.50	Ref: oil boilers + chillers	Air to water heat pump	27 kW
COM2C	0.85	6	1	Ref: oil boilers + chillers	Air to water heat pump	0
COM2D	0.85	6	1	Ref: oil boilers + chillers	Air to water heat pump	27 kW
COM3C	1.20	6	1	Ref: oil boilers + chillers	Air to water heat pump	0
COM3D	1.20	6	1	Ref: oil boilers + chillers	Air to water heat pump	27 kW
COM4C	2.00	4.00	1	Ref: oil boilers + chillers	Air to water heat pump	
COM4D	2.00	4.00	1	Ref: oil boilers + chillers	Air to water heat pump	27 kW
[illegible]	0.85	4.00	0.50	Ref: oil boilers + chillers	Air to water heat pump	0
COM5D (Lowest g. cost)	[illegible]	4.00	0.50	Ref: oil boilers + chillers	Air to water heat pump	27 kW

A closer look at the macroeconomic analysis results for new hotels, revealed that the individual points falling within the cost optimal range for new hotel reference buildings include particular elemental features as shown below:

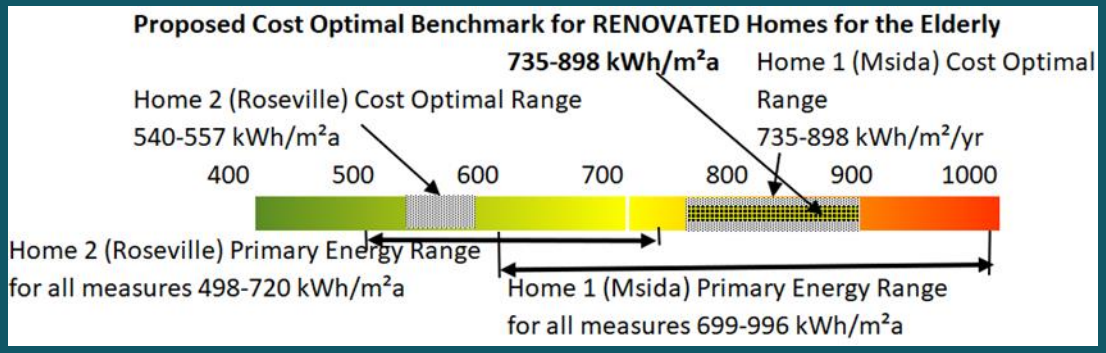
- Wall U-values in the cost optimal range consist of either 2 W/m²K (the reference) or the considered upgrades (1.2 or 0.85 W/m²K). Thus, the cost-optimal range is not sensitive to the wall U-value measure chosen for these buildings.
- The cost-optimal range for the different reference buildings contains either the shading factor of 1 (as designed) or the 0.5 shading factor upgrade. Thus, the cost-optimal range is not sensitive to the shading factor chosen for these buildings It must be however highlighted, that many individual glazed apertures within each simulation already had an initial over-shading factor between 0.7 and 0.3 in the as designed scenario.
- It is also noted for all new hotels that domestic hot water (DHW) heating oil boilers (the reference) do not feature in the cost optimal range. The DHW upgrades considered (i.e. heat pumps and the heat pump/ solar water heaters (SWH) combination) dominate the cost-optimal range.
- The reference scenario i.e. oil boilers for space heating combined with chillers for cooling do not feature in the cost-optimal range. High efficiency air-conditioners (VRF) are cost-optimal as they are the only space heating and cooling measure featuring within the cost-optimal range.
- For all hotels, both measures with and without photovoltaics can be found in the cost-optimal range. PVs are cost-optimal for all new hotels.

Cost Optimal: Homes for the Elderly

- New



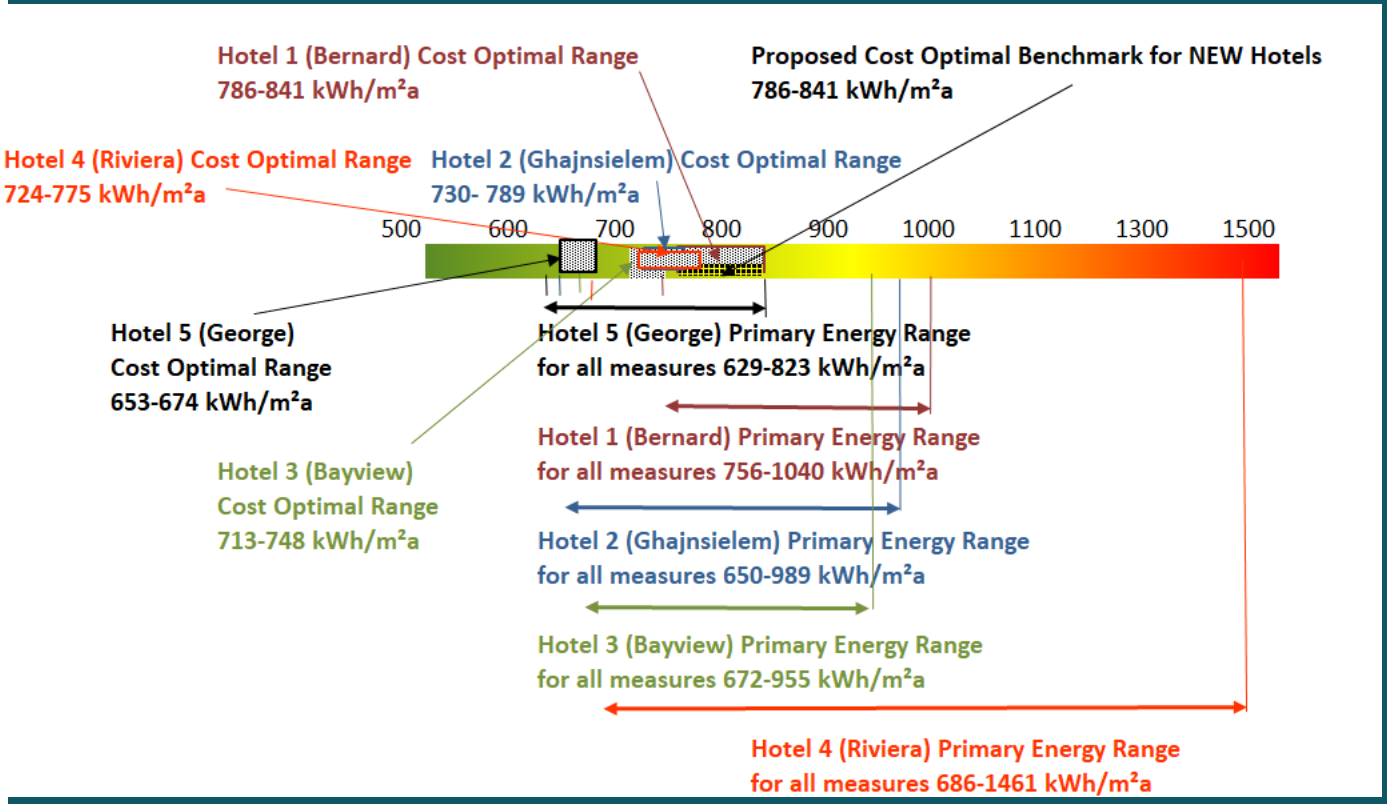
- Renovated



- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- *At least 5% of total hot water needs from solar heating or heat pump*
- *At least 5% renewable electricity*

Cost Optimal: Hotels

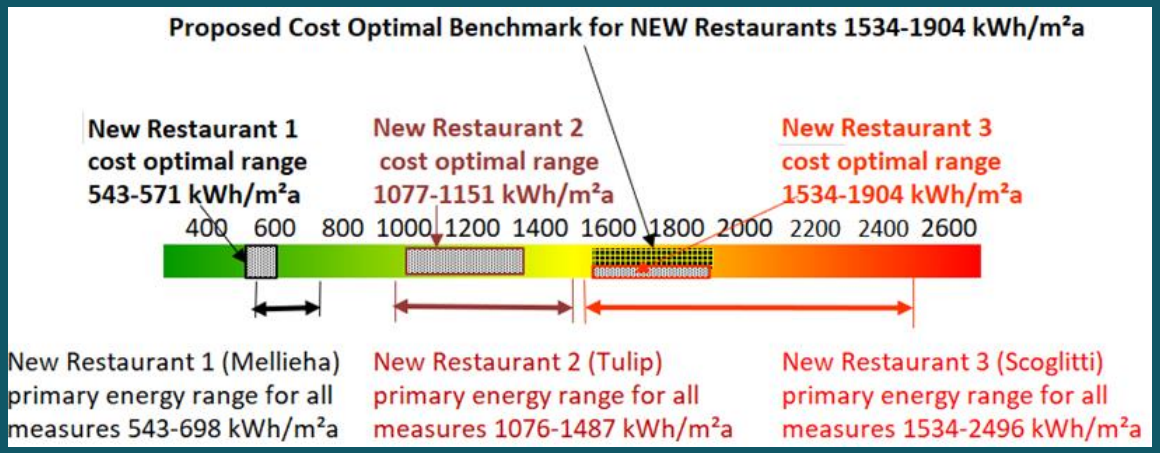
- New



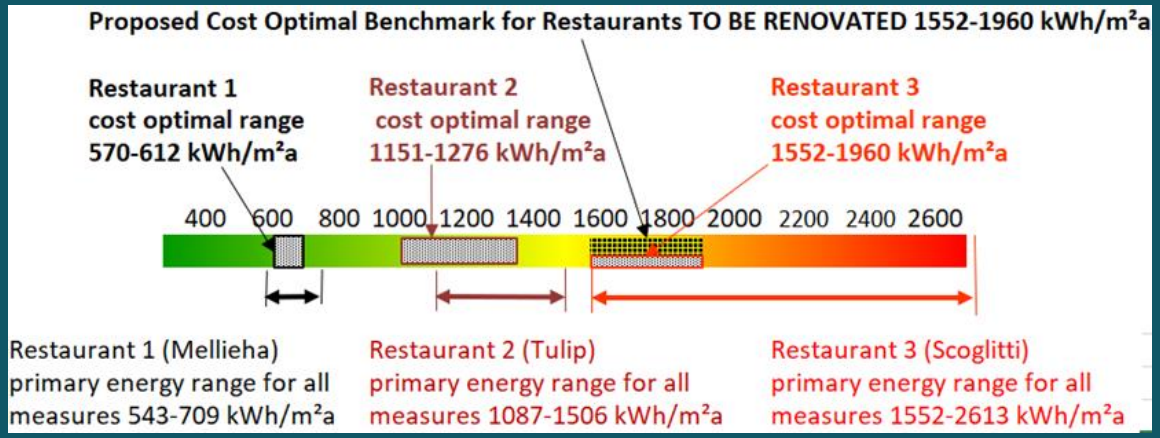
- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- *At least 5% of total hot water needs from solar heating or heat pump*
- *At least 5% renewable electricity*

Cost Optimal: Restaurants

New

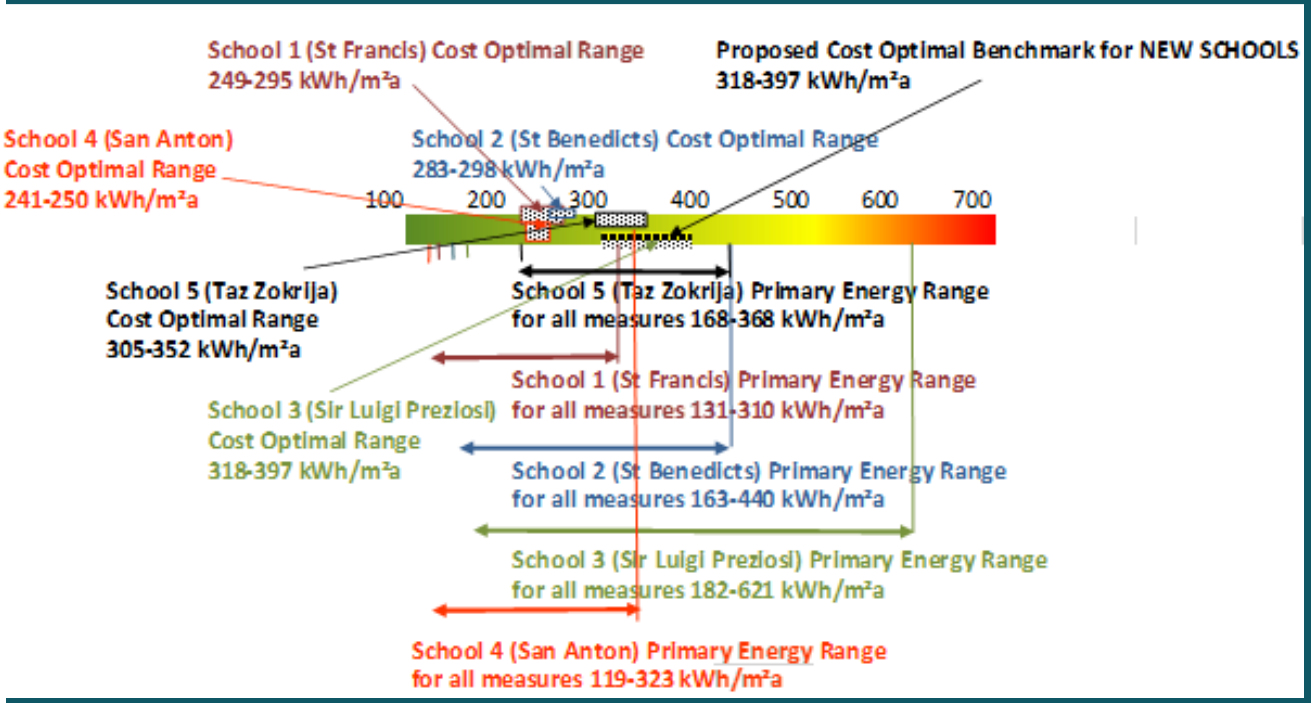


Renovated



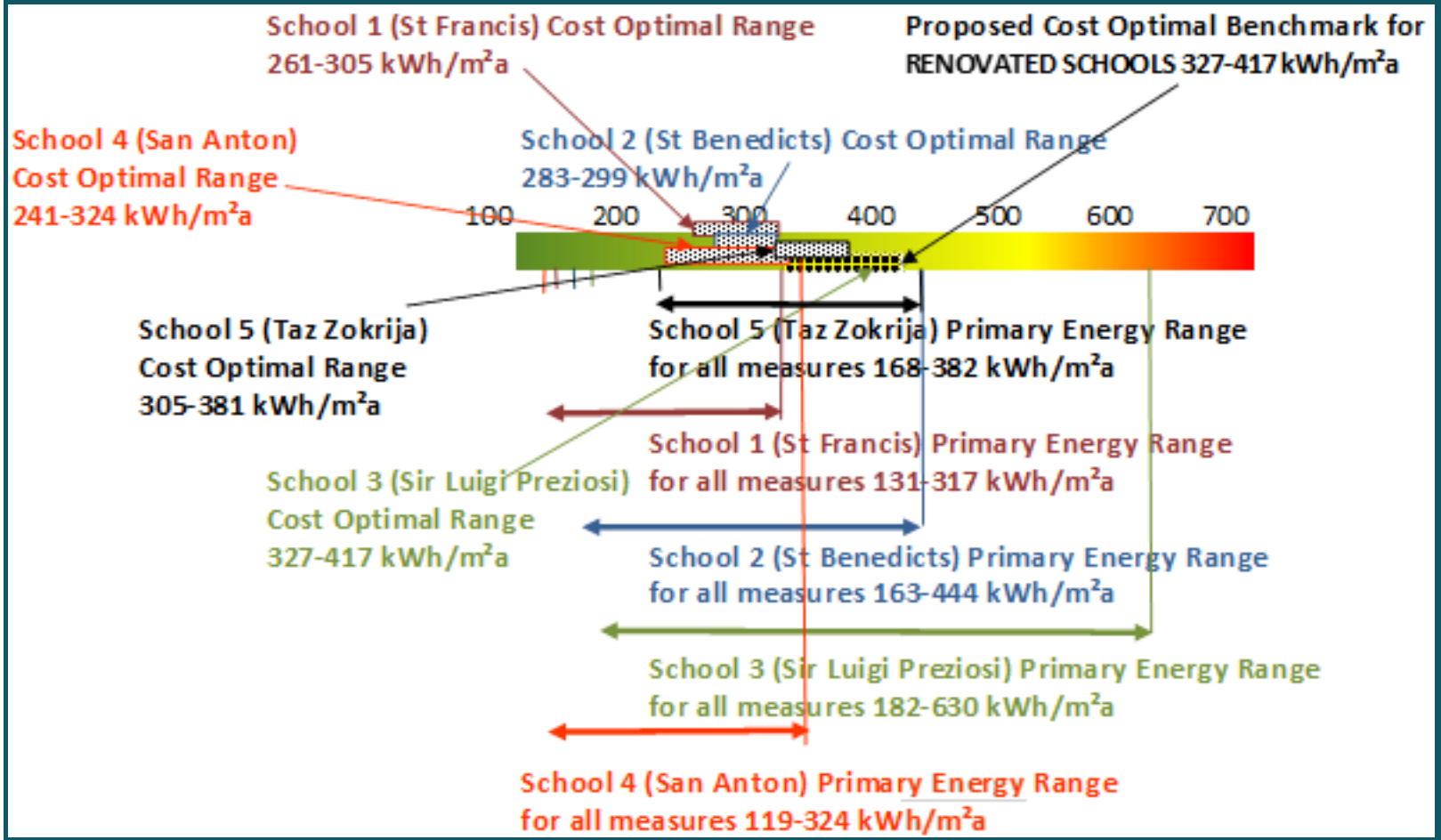
- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- *At least 5% of total hot water needs from solar heating or heat pump for total floor area of* ***150 m² or more***
- ***Allow large windows but shaded or use solar films***

Cost Optimal: New Schools

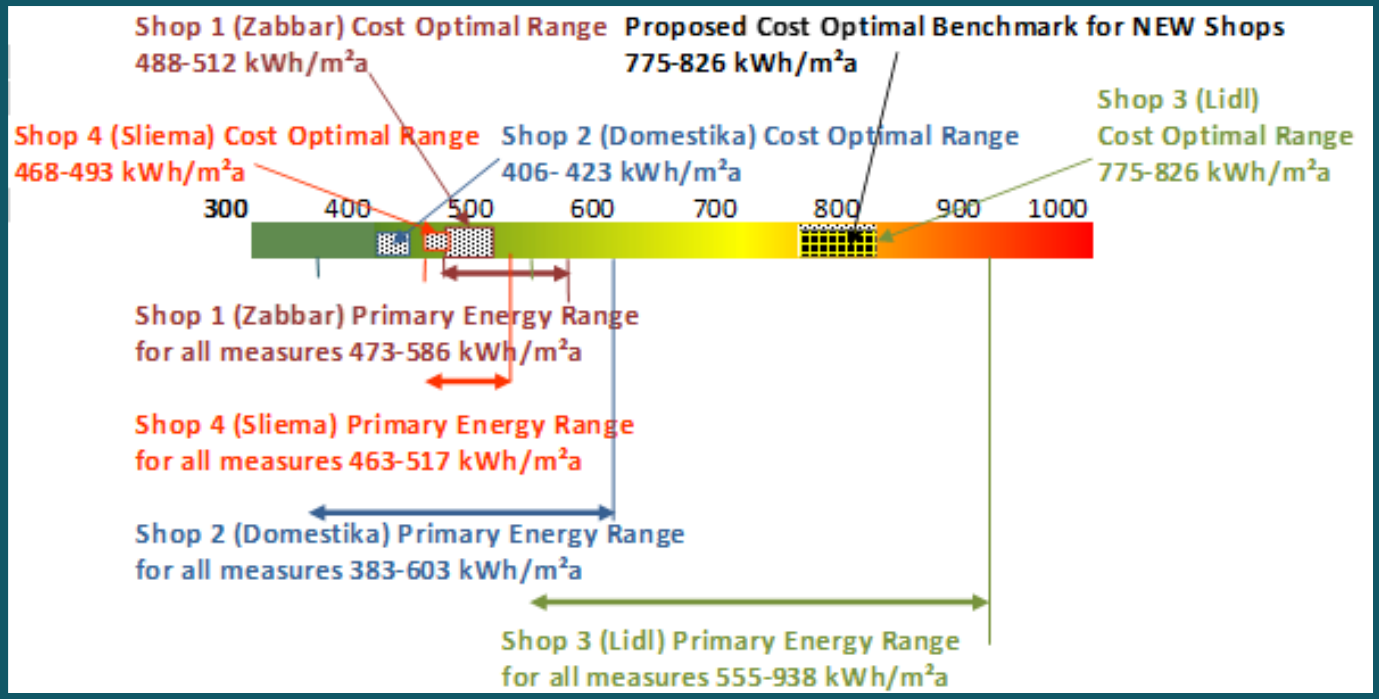


- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- *At least 5% of total hot water needs from solar heating or heat pump.*
- ***Renewable electricity of 15% minimum.***

Cost Optimal: renovated Schools

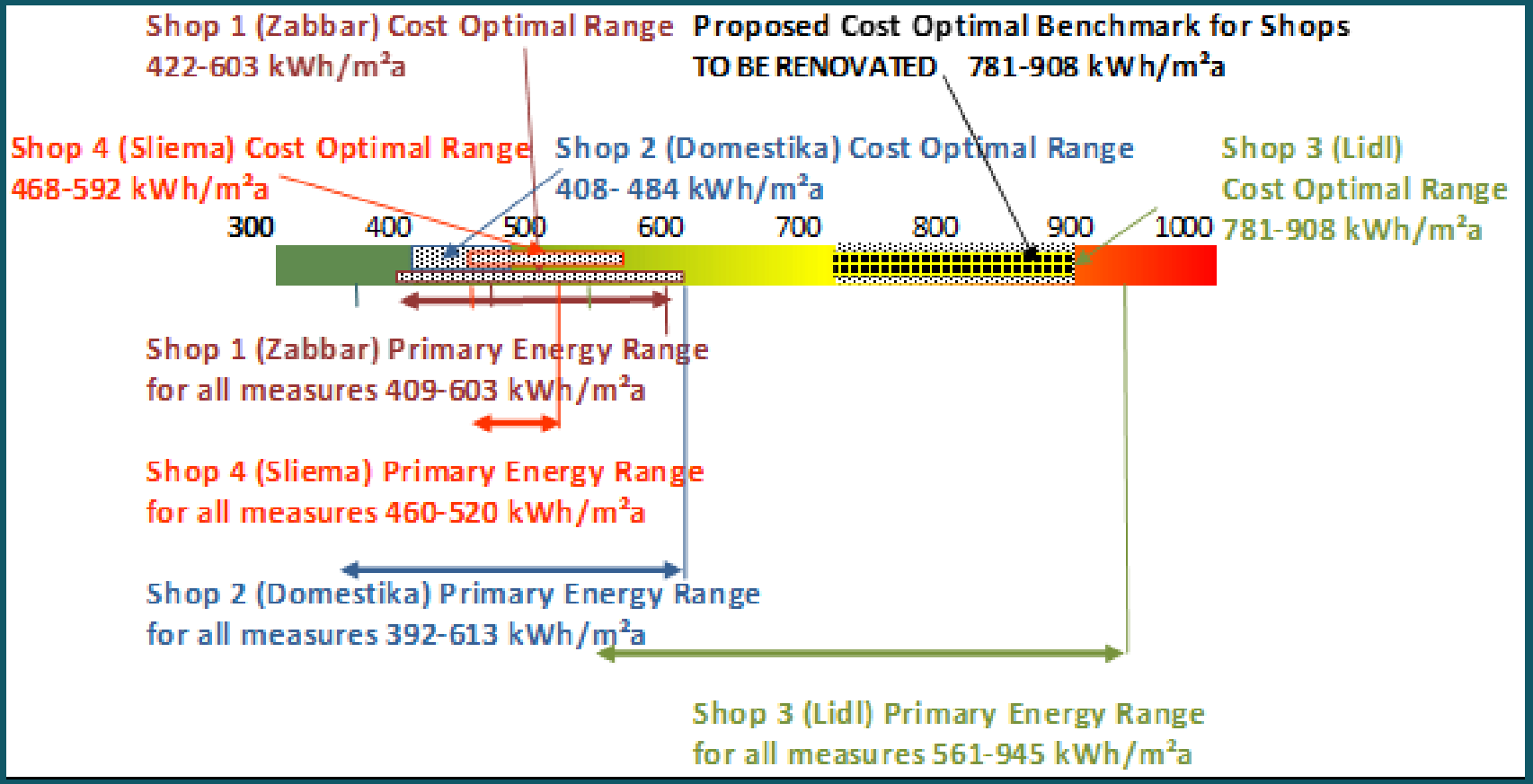


Cost Optimal: New Shops



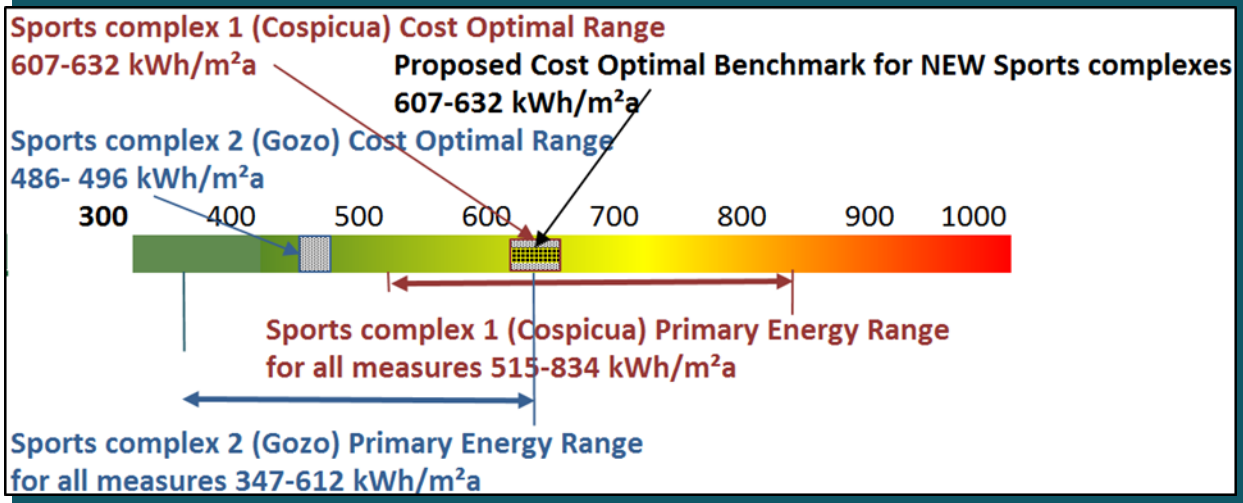
- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- ***Renewable electricity of 5% minimum.***

Cost Optimal: Renovated Shops



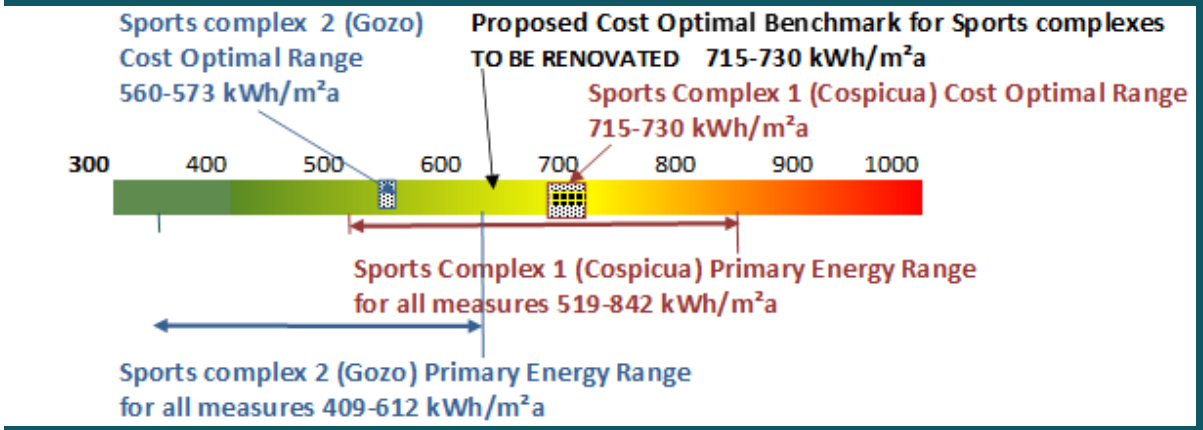
Cost Optimal: Sports Complexes

New

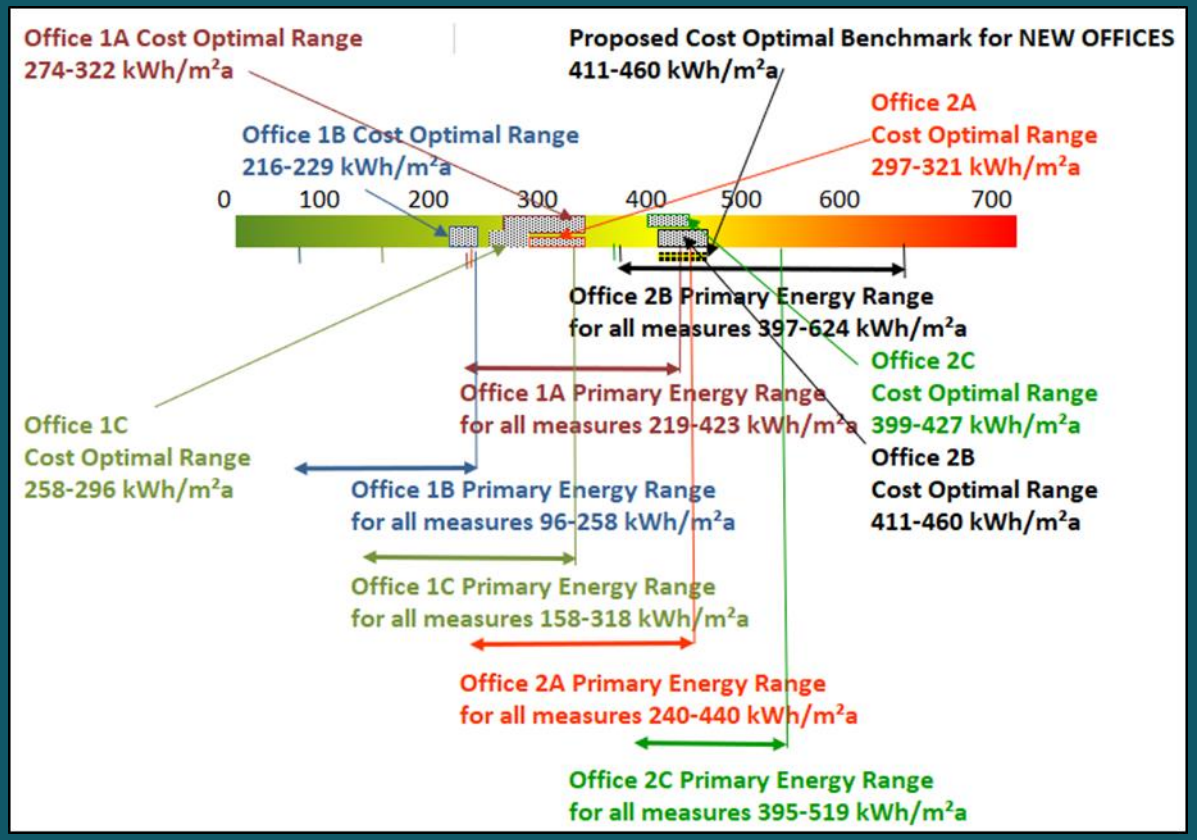


- Wall *U-value 1.57 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- *At least 5% of total hot water needs from solar heating or heat pump.*
- ***Renewable electricity of 5% minimum.***

Renovated



Cost Optimal: New Offices



- Wall *U-value 1.57 Roof 0.4 W/m²K*
- *Glazing U-value 4 W/m²K*
- *Min. Shading of factor of 0.5 under certain criteria*
- *High COP of at least 4 for air-conditioners*
- ***Renewable electricity of 5% minimum for office with own unshaded roof***

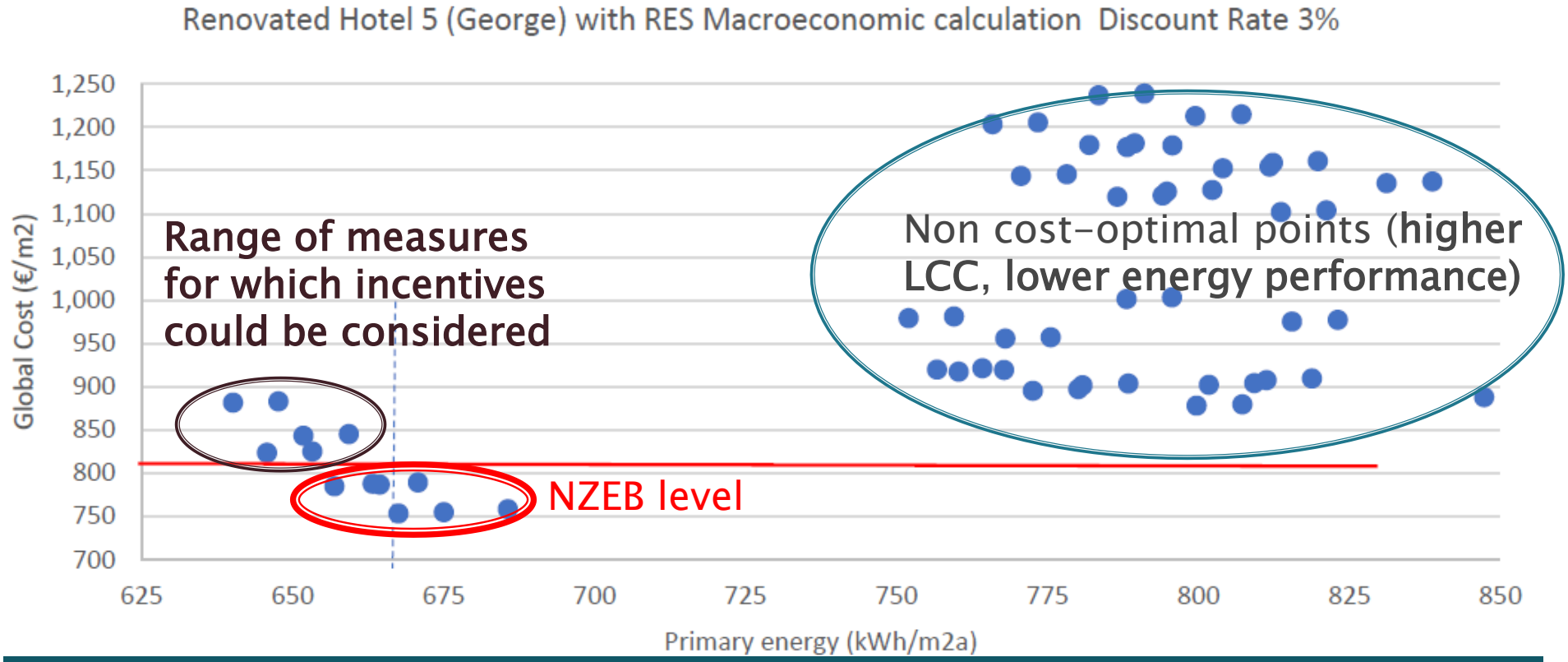
Cost Optimal energy performance requirements Summary

Renewables not considered to define cost optimal energy performance requirements

Building	Cost Optimal Range kWh/m².year	
	New	Renovated
Homes for the Elderly	731–778	735–898
Hotels	786–841	901–977
Restaurants	1534–1904	1552–1960
Schools	318–397	327–417
Shops	775–826	781–908
Sports Complexes	607–632	715–730
Offices	411–460	

NZEB Levels

NZEB levels performed with DR3% Macro-economic Analysis with RES



Nearly zero energy performance requirements Summary

Renewables considered to define nearly-zero energy performance (NZEB) requirements

Building	NZEB Range kWh/m².year	
	New	Renovated
Homes for the Elderly	698 – 749	703 – 791
Hotels	757 – 841	890 – 977
Restaurants	1534 – 1904	1552– 1960
Schools	182 – 260	191 – 281
Shops	556 – 606	561 – 693
Sports Complexes	515 – 632	630 – 730

Analysis of results – way forward for defining minimum energy performance requirements

- Discussion on proposed required upgrades for Technical Document F (Minimum Energy performance requirements) can be found in the report:

- For the building envelope elements (both new and renovated buildings)
- For technical building systems (both new and renovated buildings)

Conclusion

- Updated NZEB overall energy performance requirements need to be set as statutory energy performance benchmarks and published in the revised Technical Document F, based on the derived cost-optimal range stated in this report for each category of building (both new and renovated), by March 2020.
- Elemental building envelope and technical systems requirements in Technical Document F need also to be updated to reflect the measures that fall within the cost-optimal range for each building category (also as highlighted in the discussion section for each report).
- The executive summary of the reports provide the most important findings.
- Additional statutory energy performance requirements emanating from the latest revision of the EPBD in connection with e.g. electromobility and building automation (smart bldgs) will also be included.

Link to 2018 cost-optimal reports

https://ec.europa.eu/energy/en/content/eu-countries-2018-cost-optimal-reports

EU funds for Malta

ZEROCO2 Interreg Europe

L-Università ta' Malta

Thanks for your attention

INTERREG EUROPE Programme
Sharing solutions for better regional policies
Programme part financed by the European Union
European Regional Development Fund (ERDF)
Co-financing rate: 85%/75% EU Funds; 15%/25% National Funds
Investing in your future