NORTH PROJECT – AQABA, JORDAN

Recommended Energy Efficiency and Renewable Energy Measures for the Premium Villa

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

NREC
NATIONAL REAL ESTATE CO. JORDAN

IDG MATRIX

NAVIGANT

Suitable Options for Premier Villas

The Villa options offered by the North Project in Aqaba range from modest Premier Villas on small plots to big Executive Villas on spacious parcels. It does not matter if the villas are designed and built by the buyers themselves or if they choose one of the options provided by NRECJ. The options for energy efficiency fit all of them or may be customised to suit the specific needs of the customer.

This brochure shows the most suitable and cost-optimal efficiency measures for the Premier Villa.

Possible examples are **shading structures** to provide the inhabitants with shade during daytime where there is no shade from the building itself. Free areas on rooftops may be used for **solar thermal collectors** or **photovoltaic (PV) panels**. **Efficient lighting** and **efficient cooling devices** save electrical energy and reduce energy costs. Furthermore, **green roofs** are an excellent option to reduce solar radiation on flat roofs and to reduce the heat island effect in the neighbourhood.

All measures together can provide **energy cost savings up to €4.000 per year**. On top of that, the reduced energy demand helps decrease greenhouse gas emissions and increase the well-being of inhabitants.

Possible Measures for
Premier Villa

Reduced Demand

Renewable Energy Sources

Efficient Technologies

Objectives

This brochure indicates the optimal solutions for energy savings and efficient building design. It gives customers an easy overview of possible and cost-optimal measures for their building in North Project (Aqaba), including possible savings and expected payback times.

The approach for energy efficiency in buildings follows the Trias Energetica, which is introduced on the following page. The presented measures in this brochure are listed according to this approach.

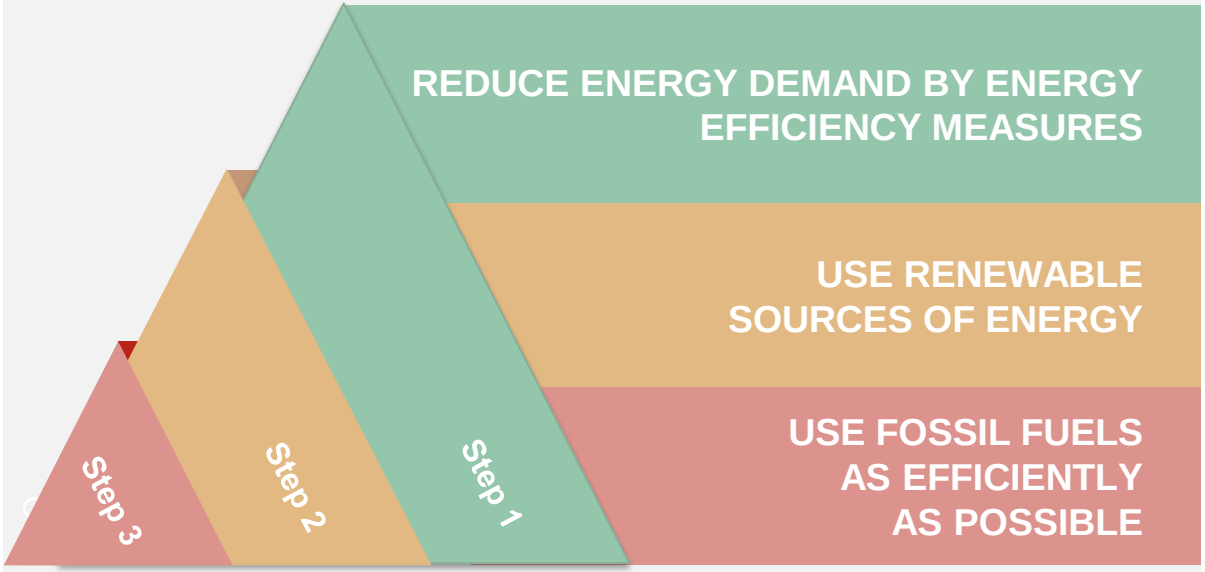
With targeted measures, the energy requirements of a house can be significantly reduced. With insulation from the roof and façade, new windows, or the installation of a new heating system, there are numerous ways to energetically upgrade buildings so that less energy is consumed overall and more money can be saved.

Energy production in power plants generates an extremely large number of climate-damaging substances that pollute our environment. Specifically, greenhouse gases such as CO_2 should be avoided because they contribute to the greenhouse effect and thus to climate change. The more energy is saved, the less has to be produced and supplied. Energy efficiency and renewable energy measures are, therefore, helping to protect the environment.

Energy efficiency measure implementation enhances quality of life for residents. Modern and efficient technologies are silent, improve the indoor climate, and reduce the heat island effect in the local community. This means higher comfort in the neighborhood through lower emissions and temperatures.

Concept – Trias Energetica

"The most sustainable energy is saved energy."
– Trias Energetica



Trias Energetica is a concept developed by the Delft University of Technology to act as a guideline for energy sustainability in the building sector. It follows the principle: "The most sustainable energy is saved energy." Therefore, the first measures should always limit the energy demand through energy savings (such as insulation, shading, etc.). The remaining energy demand should be met by renewable resources (e.g., solar energy). Only then should fossil fuels be used to meet the remaining demand as efficiently and cleanly as possible (e.g., efficient cooling devices, efficient lighting, etc.).

Recommended for
Premier Villa

Reduced Demand

Renewable Energy Sources

Efficient Energy Use

Selected Measures to Save Energy

Reduce Energy Demand

- Energy efficient design
- Natural ventilation
- Shading structures
- Thermal insulation
- Green roof

Renewable Energy Sources

- Solar thermal collectors
- PV panels

Efficient Use of Fossil Fuels

- Cooling devices
- Lighting

Possible Savings for
Premier Villa[1]

Reduced Demand
~€2,200/yr

Renewable Energy Sources
~€1,200/yr

Efficient Energy Use
~€1,500/yr

[1] Savings not additive.

Energy Efficient Design

The **optimised orientation** of a building reduces solar heat gains and thus the related cooling load, leading to lower operational costs. On the north and south façade solar radiation is normally lower than on the east and west facade. Therefore, the building should be orientated along the east-west axis, with the largest surfaces facing north and south. Also, shading of the building can create comfortable outdoor areas and reduce internal solar gains.

A **bright envelope colour** for roof and external walls is an effective measure to reduce solar heat gains. The brighter the colour, the better the surface reflects solar radiation, absorbing less heat. Thus, bright colours with a Solar Reflectance Index (SRI) of more than 78 for roofs and more than 40 for external walls are recommended (bright natural stones—e.g., lime stone).

Reducing the window fraction for façades facing the south, east, and west is recommended to minimise solar heat gains and decrease the cooling energy demand. This is an economical measure that saves energy, leads to lower operational and investment costs, and increases thermal comfort. The reduced window fraction should be less than 20, based on the Window Wall Ration (WWR). Furthermore, vertical layout windows are recommended.

Characteristic Parameters:	**WWR max.: 20%** (east, west, south) **SRI min.: 78/40** (roof/walls)
Costs:	**Possibly higher planning effort**
Return:	**About €500/yr**
Payback Period:	**Short term**

Hints:

- ✓ **Qualified architect for optimised building design**

Benefits of
Energy Efficient Design

- **Economical measures**
- **Saves energy**
- **Lower operation costs**
- **Lower investment costs**
- **Increase thermal comfort**

Natural Ventilation

Natural ventilation uses wind and temperature differences to reduce the cooling load of buildings, increase thermal comfort, and improve indoor quality. Possible strategies are wind-driven ventilation and buoyancy ventilation.

Wind-driven ventilation
Single-sided ventilation is applicable when a space only has openings on one side. If applicable, windows and other openings should be oriented towards the prevailing wind direction.
Cross ventilation is used when openings (inlet and outlet) are placed at the diagonal of the indoor space. Building orientation should be towards the prevailing wind direction as well, and inlet and outlet sizes should be calculated by a qualified consultant.

Buoyancy ventilation can be induced by temperature (known as stack ventilation) or by humidity (known as wind tower).
Stack ventilation refers to the effect of hot air rising, which creates a natural draft and removes the heat from the building. The effect refers to the height between openings, inlet and outlet sizes, and differences of temperature.
Additionally, a *wind tower* (catcher) can be installed as an architectural element to capture the prevailing wind on top of the building and redirect the air flow into the indoor space.

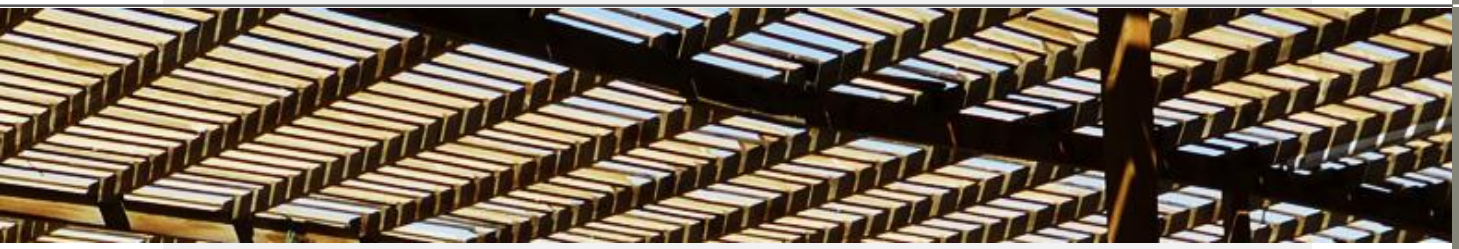
Costs:	**Possibly higher planning effort**
Payback Period:	**Short term**

Hints:
- ✓ **Qualified architect/consultant should be commissioned for detailed calculation and planning of eligible ventilation strategies**

Benefits of
Natural Ventilation

- **Reduced cooling demand**
- **Reduced energy costs**
- **Low tech design elements**
- **Increased thermal comfort**

Shading Structures



To provide the inhabitants with shade during daytime, **shading structures** should be installed where there is no shade from the building itself.

Shading structures in front of windows are important for the climate conditions inside the building, especially in the east, south, and west directions. External shading devices for windows are a lot more efficient than internal window coverings. They reduce heat gains by 70%-85%, whereas internal coverings can reduce heat gains by as little as 15%. Shading devices should allow for ventilation on the outside of the window. If shading is fitted too closely to the window, warm air can be trapped and heat conducted into the apartments and/or common areas.

Even more beneficial is the use of PV panels, which serve as window shading. They produce electricity and may decrease the local electricity consumption and electricity costs.

Costs:	**Additional investment costs: ~€600**
Return:	**About €400/yr**
Payback Period:	**Short term**

Hints:
- ✓ **Include central control (per orientation)**
- ✓ **Take wind safety into account**

Benefits of
Shading Structures

Cost Savings up to **€400/yr**

Reduced Energy Demand **2,500 kWh/yr**

Reduced CO_2 Emissions **1,500 kg/yr**

Thermal Insulation and Windows

Improved wall and roof insulation: Reduces heat loss or gain and lowers the energy demand for heating and cooling systems. Walls and roofs should achieve a minimum insulation level. Due to the variety of building insulation, materials available, and the various building elements that may require insulation, there are many ways to install thermal insulation. Therefore, it is the task of construction professionals and local contractors to achieve the required U-values for walls, floors, and roofs. Common insulation materials used to reduce heat loss include: polyurethane foam, mineral wool, stone wool, polystyrene, cellulose, and vermiculite.

Improved windows: The (transmission) energy losses from windows are approximately four times the losses of massive building elements. Because of this there is a high potential to save energy by using optimised glazing for buildings with a large number of windows and window fronts. To minimise transmission energy losses, windows should achieve an insulation level of at least 1.50 W/m²K. The reduced cooling demand saves energy and leads to lower operating costs.

Characteristic Parameters:	**U-value (walls): Min. 0.35 W/m²K U-value (windows): Min. 1.50 W/m²K**
Costs:	**Additional invest costs: Windows ~3.000€ Walls ~10.300€**
Return:	**About 550€/yr (walls) About 350€/yr (windows)**
Payback Period:	**Long term**

Hints:

- ✓ **Qualified and experienced architect and construction team**
- ✓ **Use eco-friendly insulation materials**

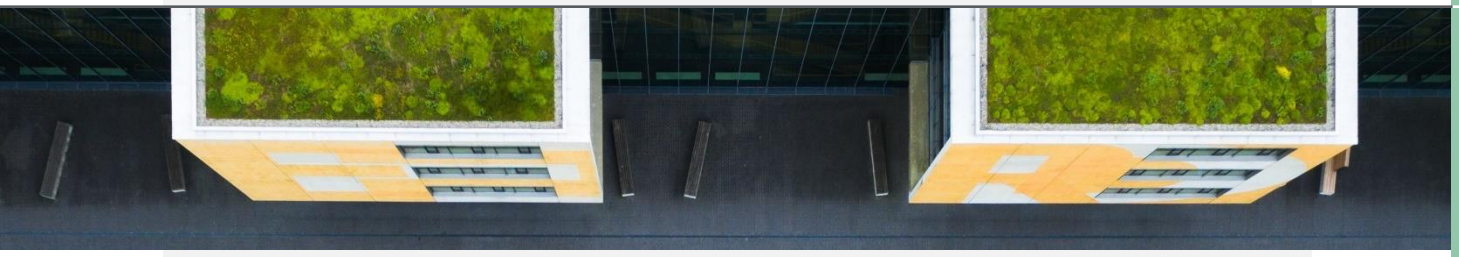
Benefits of **Insulation**

Cost Savings up to **€1,000/yr**

Reduced Energy Demand **7,800 kWh/yr**

Reduced CO_2 Emissions **4,200 kg/yr**

Green Roofs



An excellent option to reduce solar radiation on flat roofs is to implement **green (vegetative) roofs**. The rooftop vegetation moderates extreme temperatures and UV radiation, which extends the lifespan of the roof for around 20 years. Additionally, the vegetation collects storm water, filters particulates and pollutants, and serves as a cooling layer on the roof once the sun is shining again. The evaporation process helps to cool air temperatures and reduces the heat island effect, which benefits the whole area. The cooling effect also has a positive impact on the efficiency of PV modules on the roof. The amount of run-off diversion for a vegetative roof varies depending on the design and the rain pattern of the local climate.
Flat roofs support storm water collection, aggregated drainage layers, and deep vegetation (benefits up to a depth of 12.5 cm).

Costs:	**Additional invest costs: ~€6.000**
Return:	**About €370/yr**
Payback Period:	**Long term**

Hints:
- ✓ **Consult planning authority early to determine any planning constraints**
- ✓ **Appoint qualified consultant for detailed feasibility assessment incl. review of subsidy schemes**

Benefits of **Green Roofs**

Cost Savings up to **€370/yr**

Reduced Energy Demand **2,500 kWh/yr**

Reduced CO_2 Emissions **1,500 kg/yr**

Solar Thermal Collectors

Free areas on rooftops may be used for hot water generation with **solar thermal collectors**. The collectors are affordable and beneficial in terms of energy efficiency.

A typical option for single-family houses is a combination of small-scale collectors with integrated hot water storage. They are sufficient to cover low or medium hot water demands and have economical advantages compared to big systems.

For multifamily houses with medium to high hot water demand, systems with an external hot water storage (e.g., in the basement) should be installed. This assures a sufficient hot water supply.

Common technologies for buildings are flat plate and evacuated tube collectors. Evacuated tube collectors are more efficient but more expensive than flat plate collectors.

Characteristic Parameters:	**Used rooftop area: 5m²**
Costs:	**Investment costs: ~€2.200**
Return:	**About €300/yr**
Payback Period:	**Medium term**

Hints:

- ✓ **Qualified consultant for detailed feasibility study incl. national grants/subsidies**

Benefits of
Solar Thermal Collectors

Cost Savings up to **€300/yr**

Reduced Energy Demand **2,000 kWh/yr**

Reduced CO_2 Emissions **1,200 kg/yr**

Photovoltaic (PV) Panels

PV panels consist of solar cells that convert light directly into electricity. Solar cells produce direct current (DC) electricity from light, which can be used to power equipment or to recharge a battery. The majority of PV modules are used for grid-connected power generation. In this case an inverter is required to convert DC to alternating current (AC). For Aqaba, a minimum solar yield of 1,350 kWh/kWp needs to be proven by a dynamic simulation tool (e.g. PV Sol, PV Syst, Polysun).

PV competes against solar thermal collectors in terms of space on the roof. Solar thermal collectors have proven to be more economical, although the cooling effect of green roofs in combination with PV modules may influence this estimation. Therefore, solar thermal collectors should be used to cover the domestic hot water demand and if there is still roof space, PV panels could be installed.

Characteristic Parameters:	**Used rooftop area: 4m²**
Costs:	**Additional invest costs: ~€3.200**
Return:	**About €900/yr**
Payback Period:	**Medium term**

Hints:

- ✓ **Qualified consultant for detailed feasibility study incl. national grants/subsidies**

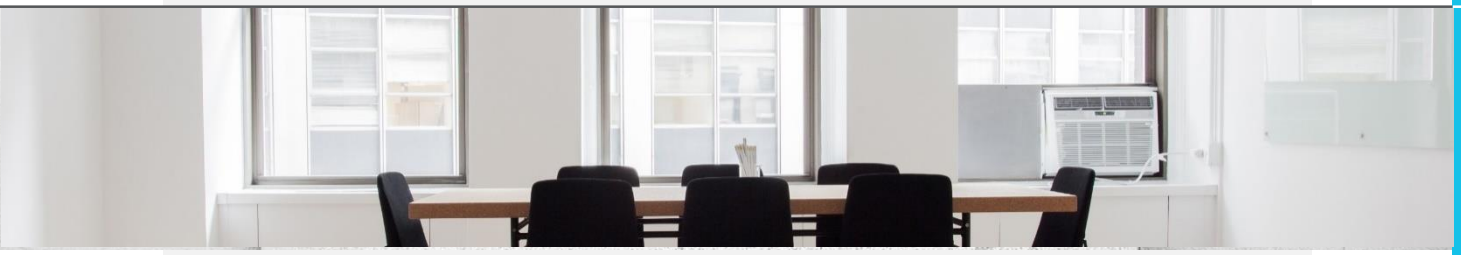
Benefits of **PV Panels**

Cost Savings up to **€900/yr**

Reduced Energy Demand **6,000 kWh/yr**

Reduced CO_2 Emissions **3,600 kg/yr**

Cooling Devices



Ventilation efficiency: A ventilation system preserves a good indoor climate and ensures that high air quality is maintained to control condensation and remove pollutants. Nevertheless, an active ventilation system uses electrical energy to drive the ventilation fans. As a result, the implementation of highly efficient fans should be taken into consideration.

Efficient cooling systems: Using cooling systems with a COP of greater than 4.5 is recommended. Air intake on top of the roof should be at 2 meters to ensure cooler air temperatures. The nearer the air intake gets to the roof top, the warmer the supply air due to reflected radiation of the HVAC equipment.

Characteristic Parameters:	**COP min. 4.5** **Supply air intake 2 m above roof**
Costs:	**Additional investment costs: ~€1.300**
Return:	**About €1.400/yr**
Payback Period:	**Short term**

Hints:

- ✓ **Qualified HVAC engineer for system sizing and design**
- ✓ **Minimise shading of solar thermal/PV devices by appropriate positioning**

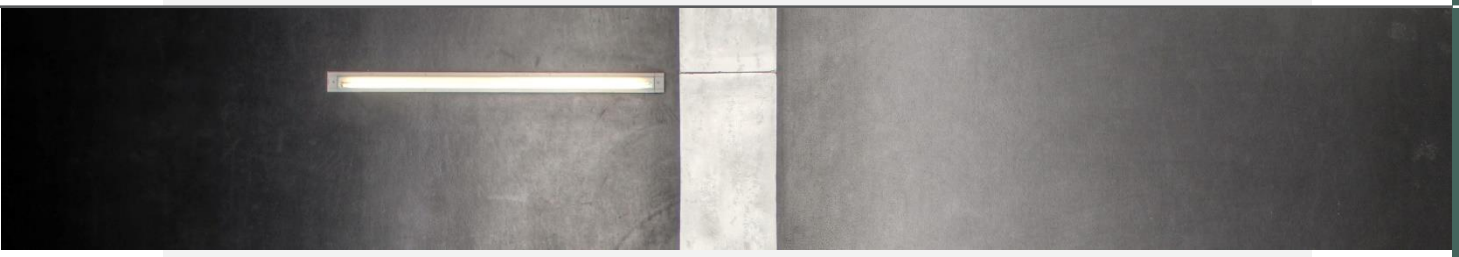
Benefits of **Cooling Devices**

Cost Savings up to **€1,400/yr**

Reduced Energy Demand **9,000 kWh/yr**

Reduced CO_2 Emissions **6,200 kg/yr**

Lighting



Efficient lighting is one of the easiest measures to apply with a payback time of approximately 1.5 years. Energy efficient light bulbs include **compact fluorescent lamps (CFLs)** and **light-emitting diodes (LEDs)**. These lamp types use between 25% and 80% less energy than traditional incandescents and can last 3 to 25 times longer.

Traditional light bulbs produce a lot of heat, which raises indoor temperatures and leads to high energy demands for cooling devices. Efficient bulbs like LEDs produce way less heat, helping to reduce air conditioning costs.

LED and CFL light bulbs are available in a broad variety of colours and light levels and may be used as architectural design elements.

Characteristic Parameters:	**Life expectancy between 10,000 and 25,000 hours**
Costs:	**Additional investment costs: ~€200**
Return:	**About €150/yr**
Payback Period:	**Short term**

Hints:

- ✓ **Select LED lamps with a high quality**

Benefits of **Efficient Lighting**

Cost Savings up to **€150/yr**

Reduced Energy Demand **1,000 kWh/yr**

Reduced CO_2 Emissions **600 kg/yr**

Results and Conclusion

Investing in efficiency measures is strongly recommended for economical and ecological reasons. For the Premier Villa, payback times for single measures range from under 1 year to 15 years. If all presented measures are taken into account, a payback time of around 8 years with annual savings of around €2.900 are possible.

First and foremost, the building should be planned after the guidelines for energy efficient design, including (passive) natural cooling, following the Trias Energetica concept. These efficient design measures offer huge benefits for no or low additional costs and should be discussed with the responsible architect during the planning process.

The effects of single measures are larger than in combination with other efficiency measures because most measures target similar goals (e.g., room temperature). However, savings will rise as more measures are taken. A combination of all measures leads to the biggest long-term savings and will benefit the neighbourhood by decreasing the heat island effect.

While Trias Energetica should be respected, the best options regarding cost-optimality and lifetime are:

1. Efficient building design
2. Shading structures
3. Cooling efficiency
4. PV panels
5. Efficient lighting
6. Insulation
7. Solar thermal modules
8. Green roofs

Costs:	**Additional invest costs: ~€25,000**
Return:	**About €2,900/yr**
Payback Period:	**Medium (8-9 yrs)**

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Benefits of **Combination**

Cost Savings up to **€2,900/yr**

Reduced Energy Demand **20,000 kWh/yr**

Reduced CO_2 Emissions **12,000 kg/yr**

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