

VACUUM TUBES WALL DESCRIPTION AND DEVELOPMENT. PATENTED BY EnCambio S.L.

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WALL OF VACUUM TUBES. The new paradigm

What are the functions of a house or building ?:

- Provides **security** against intrusions,
- **Protects against elements** (rain, cold, wind, noise, etc.),
- Provides **thermal & light comfort, and air quality**, which have an impact on health and life quality, and
- **Aesthetic and distinctive function**, even if it is with a significant cost increment.

The VT wall or wall of vacuum tubes meets all these requirements and is an additional architectural element that improves current solutions based on opaque solid walls plus glazing, which require significant energy input to provide such thermal & light comfort and air quality.

These energy consumptions represent about **15%** of greenhouse emissions and **20%** of global energy consumption. However for an average household they represent **50%** of the energy consumption and it is a serious problem for that **15%** of the national population that is in energetic poverty in Spain.

The VT Wall represents a paradigm shift. The envelope of the building can harvest thermal energy and the comfort no longer depends mainly on the energy consumption. And all of that, complying with the other requirements and without significant cost increments, which may even decrease.

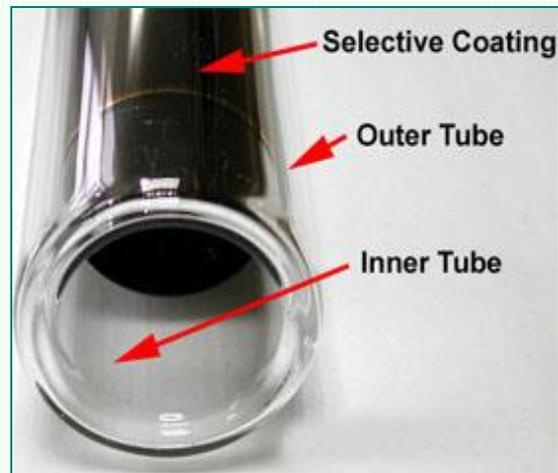
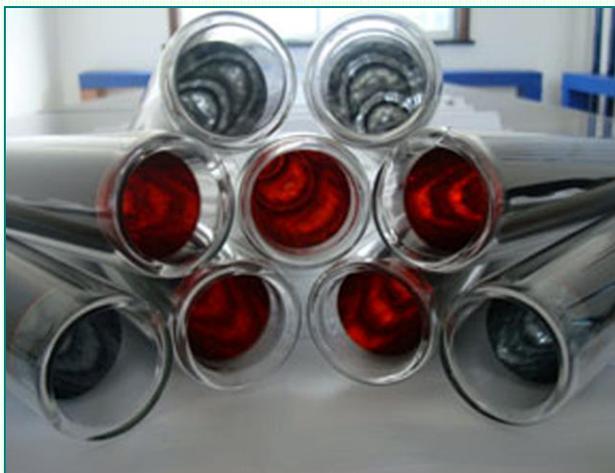


A VT Wall consists of a front and a rear glass and between them there is a row of vacuum tubes or evacuated tubes embedded in receptacles of a cradle and separated by optimized gaskets. All this surrounded by an external frame that provides greater rigidity.

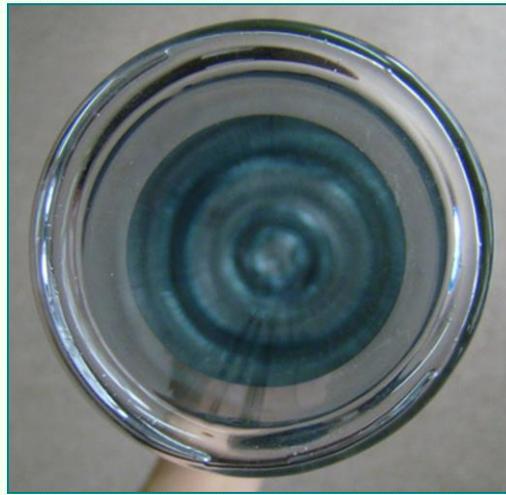


Vacuum tubes are widely used in solar energy harvesting because of the high insulation characteristics of vacuum. They have a selective inner coating, although in our case totally transparent tubes are used.

Actually, evacuated tubes for solar harvesting comprise an outer tube and an inner tube with vacuum between them, which gives that high insulating characteristic. Nevertheless space inside the inner tube can locate slats or other elements.



The following photographs show a configuration with transparent tubes, whose main function is to let light and radiation pass while at the same time maximizing thermal insulation.



AESTHETIC CHARACTERISTICS.

Its aesthetic qualities, novelty, distinction and exclusivity are excellent.

In fact, our solution has been prescribed by the international engineering company ARUP to the candidate architect of the **future Guggenheim museum in Helsinki.**



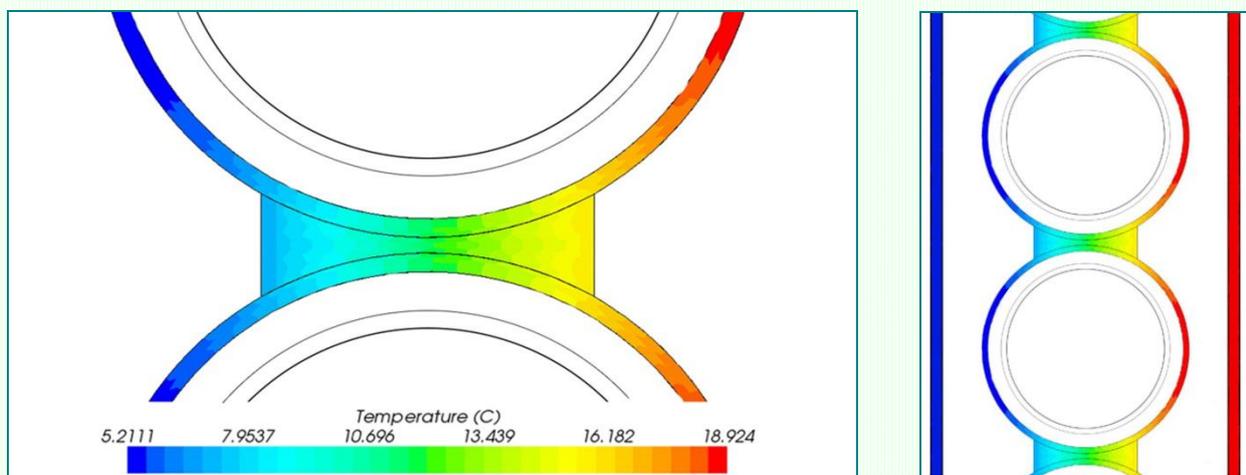
EXTREMELY HIGH THERMAL AND ACOUSTIC INSULATION.

Thermal conductivity of VT Wall is around $0.5 \text{ W/m}^2/\text{K}$ according to finite element analysis, twice as good as a conventional wall and more than 6 times better than a double glazing.

Herein lies the true paradigm shift. In north façades or high latitudes the VT wall provides a room full of light, as if it were full of windows, but consuming the sixth part of heating or none at all, since the diffused exterior radiation passes into the interior.

The front and/or rear glasses of the VT wall can be low-emissive, solar-controlled, transparent, etc. Also VT wall can be filled with Argon to increase insulation even more.

Acoustic insulation has not been quantified but very high values are expected since vacuum does not transmit the sound.



Heat transfer calculations by finite elements for the evacuated tubes and for the VT Wall

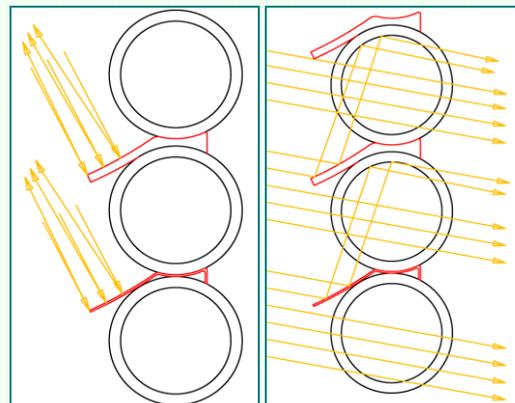
LIGHT AND RADIATION CONTROL

On very sunny facades besides the thermal insulation it is necessary to make a control of incoming solar radiation.

In an arrangement of vertical evacuated tubes, vertical rotating slats can be introduced inside them, leaving a composition similar to that of the vertical blinds, in which slats can rotate to control light and radiation.



Vertical rotating slats inside the vertical tubes



Horizontal tubes with optimized fixed gaskets

With the proviso that the heat collected by the inner slats remains in the interior of the vacuum tubes, since the vacuum between the inner tube and the outside provides an strong insulation.

However with conventional curtains or blinds the radiation heats the fabric or the slats and that heat stays in the room.

In the case of the VT wall the heat captured on the slats can be conducted to the outside or to the interior of the room by circulating air inside the tubes, turning the VT wall into a thermal energy collector. It can harvest electric energy also if the slats are photovoltaic.

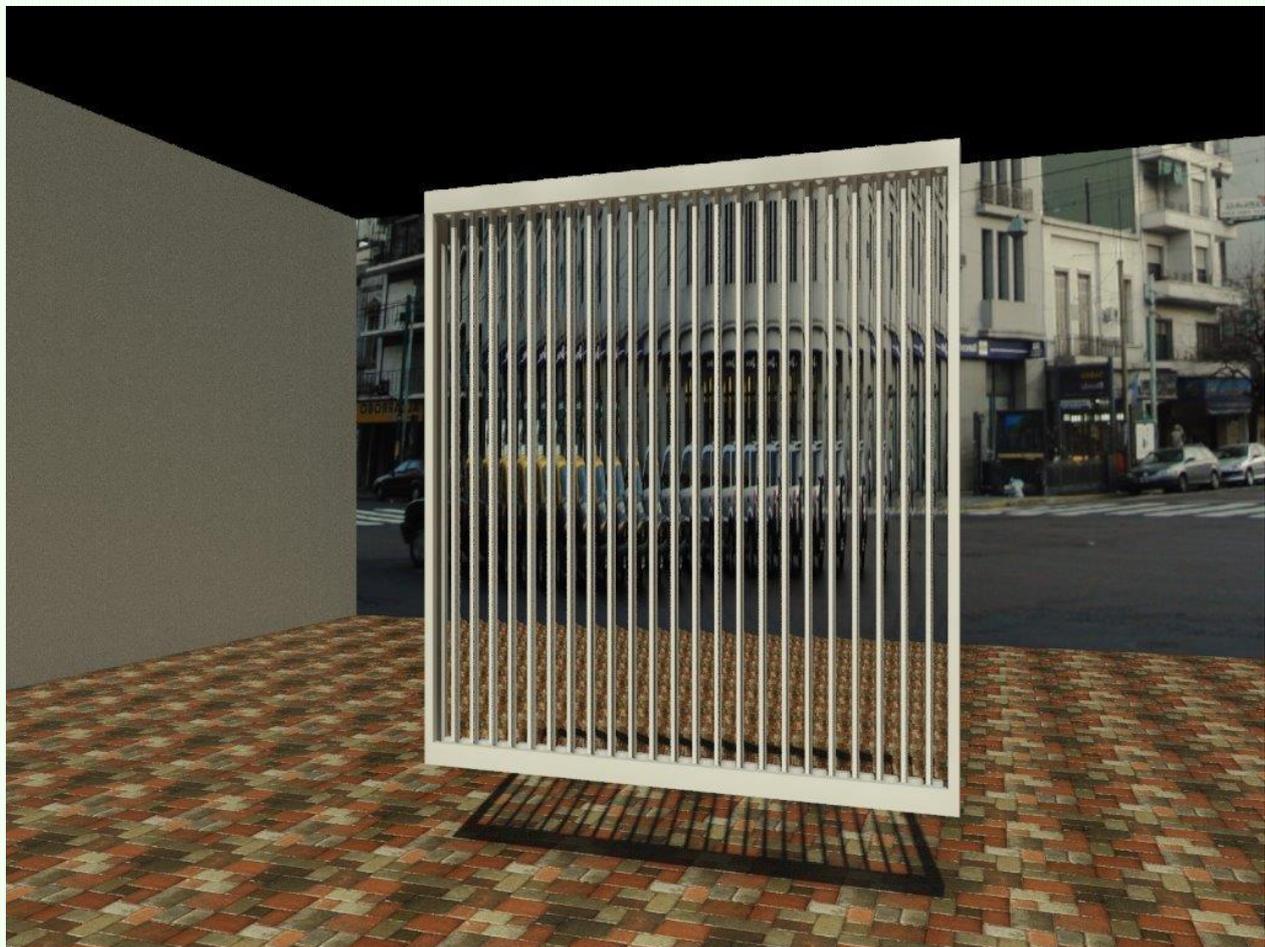
If the arrangement of the tubes is horizontal, the gaskets between tubes are optimized to reflect the radiation back to the sky in summer and to the interior of the room in winter.

As in the previous case this is another facet of the paradigm shift, a glazed surface that in summer reduces the passage of heat to the interior, even more than an opaque wall and much more than a conventional glazing with sunscreen.

INTIMACY AND DISCRETION

The VT Wall directly provides the necessary privacy and discretion requirements since the images are distorted as it passes through the tubes.

Whereas in the parts that a clear image is required conventional glazings can still be used.



COMPARATIVE WITH CURRENT CONSTRUCTIVE ELEMENTS

Windows let pass light, radiation, image and air if they open, but they have a bad thermal and acoustic insulation.

On the other hand, windows need external blinds and / or curtains that improve some of those characteristics but also imply additional costs.

If the **curtains** remain closed to provide privacy they avoid light and radiation pass inside in winter, while in summer the heat of radiation stays inside the room.

And also, the drum of the external blind occupies around 20% of the useful surface of the window.

VT wall do not require exterior curtains or blinds. Intimacy is inherent to it and control of light and radiation is performed with vertical slats inside the tubes, which control the light and capture or reflect the incident radiation

With the appropriate design of the cribs where the tubes are embedded, the air can circulate from the exterior of the house to its interior or vice versa, producing a continuous renovation of the same that is a sine qua non for the health of the people.

Additionally, passage of air through the tubes reconditions its temperature, which does not occur when a window is opened.

The **U-glass** is more expensive, much less insulation and does not allow ventilation.

U-glass are translucent solid glass profiles of 6 mm thickness in U shape and cost from 90 €/m² (similar to the wall VT) if it is simple and without arming, to 240 €/m² if it is armed and making chamber. Blinds and / or curtains are also needed to control light and radiation pass.

Solid opaque walls do not allow to take advantage of the external light or radiation, they are less insulating, are cheaper if there are not special facades or design, the security against intrusions is greater, although the VT wall can have metal slats and bars inside the tubes.

However having sufficient natural light in the room is a requirement for the health and well-being of people and in north countries they pay "whatever it costs".

COSTS

Costs are of the same order of magnitude as that of a conventional wall, to which it replaces entirely, and about 30 €/m² more than a triple crystal.

WEIGHT

It is around 10-30% higher than a triple crystal. The row of tubes weighs 22 kg / m²

DIMENSIONS

Given the variety of evacuated tubes, any facade or surface can be covered without the need for custom fabrications.

The standard dimensions of the tubes range from 120 cm to 210 cm in length, with 70 mm in diameter, but considering that the tubes need a cradle and that the VT wall can be supported in the slab or on a low brick wall, any exterior surface can be covered elegantly.

ROBUSTNESS AND SAFETY

Su diseño compacto y el propio espesor del muro, en torno a 12 cm, junto con el espesor de los vidrios confieren al Muro VT unas características estructurales y de seguridad muy importantes.

Adicionalmente el interior de los tubos puede contener lamas o tubos metálicos sin mermar las características aislantes o captadoras.

Its compact design and the thickness of the VT wall, around 12 cm, together with the thickness of the front and rear glasses, give the Wall VT a very important structural and safety characteristics.

Additionally, the inside of the tubes may contain metal slats or tubes without reducing the insulating or energy harvesting characteristics.

APLICABILITY

The VT wall is especially useful in cold or low light climates, on north facades, or where sun or shade control is needed.

The most appropriate application of this wall is to replace opaque enclosures, but not to curtain walls or windows when it is necessary to see clear images.

It is a very advantageous alternative solution for:

- All types of façades with slats or solar control,
- In offices in the street that need privacy,
- In noisy environments,
- In the lower or upper sides of a window,
- For roofs and skylights,
- For sports facilities, indoor swimming pools, industrial buildings, etc.

MANUFACTURE BUDGET FOR THE FIRST FUNCTIONAL PROTOTYPES

The objective is to create one or several functional prototypes to verify thermal and sound insulation, attractive aesthetics, light transmittance, image distortion, etc.

Vacuum tubes with 70 mm diameter are only produced in China and need to be imported. They can be one or both sides opened, clear or with inner coating to harvest solar energy.

We can import tubes for several prototypes for about 1100-1900 € depending on the number of tubes, although really the biggest impact on that cost is for the transportation.

For these first prototypes we estimate an additional cost of around 500 € / m² for the assembly, and we both will decide the appropriate size and number of prototypes.

These costs include:

- The gaskets between the tubes.
- The frame and the cradles, where the tubes are fitted, for each prototype.

These costs do not include:

- The work and materials of the glassware (the front and rear glasses, glue them to that frame, and possibly put a thin U-shape frame along the whole contour to give greater rigidity).

It is not necessary in principle to disburse these amounts but to acquire the commitment to pay them against invoice.

The project is very appropriate for a joint venture between several companies and there is already **a glass processing company that has shown interest** and puts its facilities and glass to develop the prototypes and in principle at no cost until the project demonstrates its feasibility.