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EPZ: A giant 315 kV double-circuit interconnection tower

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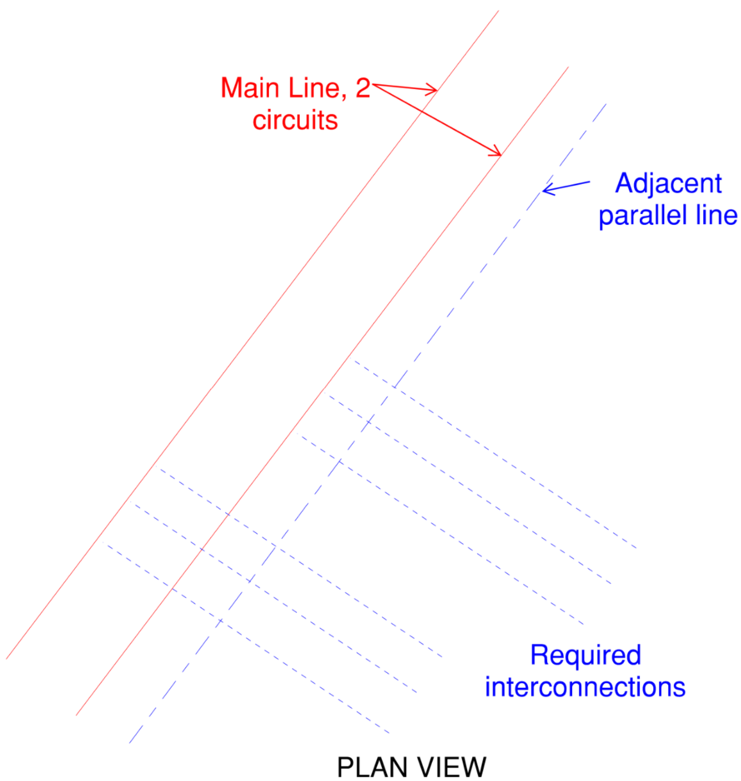
SUMMARY

A giant 315 kV tower was designed by CIMA+, for Hydro-Québec, to allow for the interconnection of two parallel 315 kV lines, deriving at 90° towards other structures or substations and having to pass over or under other adjacent parallel lines.

The idea was to do so in congested areas with limited possibilities of adding new structures, and to minimize the impact on adjacent lines.



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KEYWORDS

315 kV, tower, interconnection, congested area, small footprint.

Concept:

A giant 315 kV tower was designed by CIMA+, for Hydro-Québec, for the following objectives:

- To allow for the derivation at 90 degrees of two parallel 315 kV circuits, running in parallel to other adjacent lines;
- To maintain electrical clearances to ground and to other parallel lines;
- To do so with a small footprint and with one single tower;
- To avoid modifying adjacent lines;
- To minimize outages and coordination.

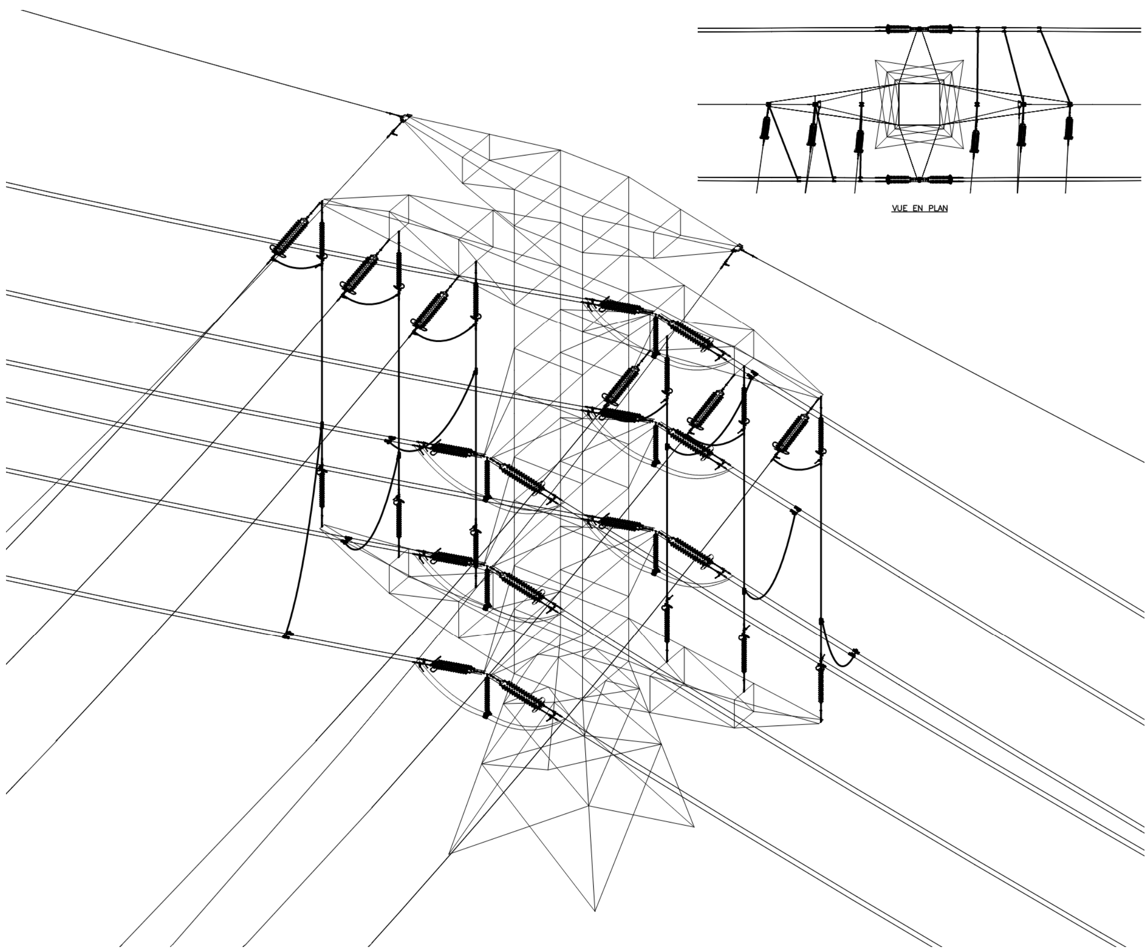


FIGURE 1
EPZ CONFIGURATION 1
3D and PLAN VIEWS

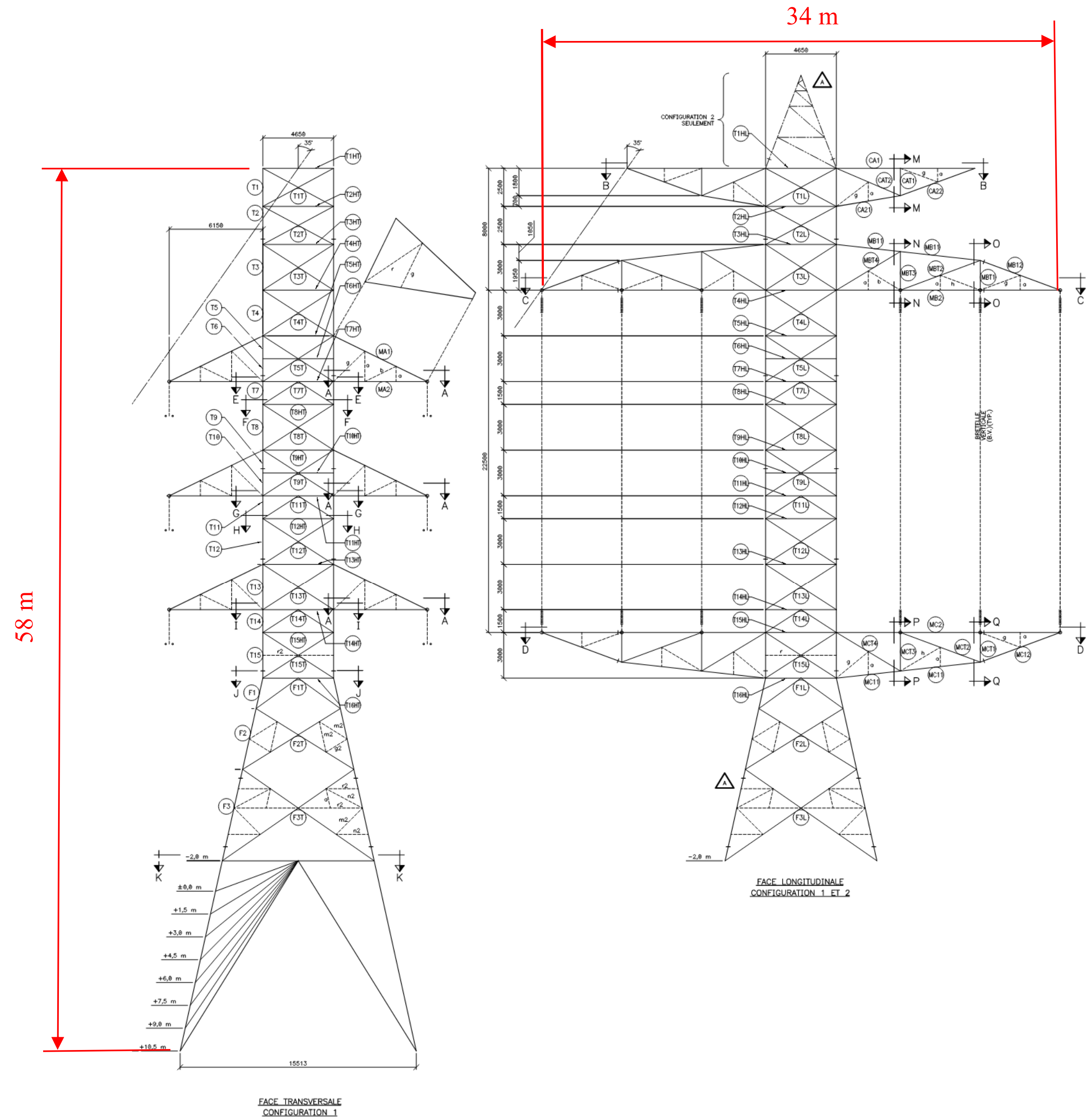
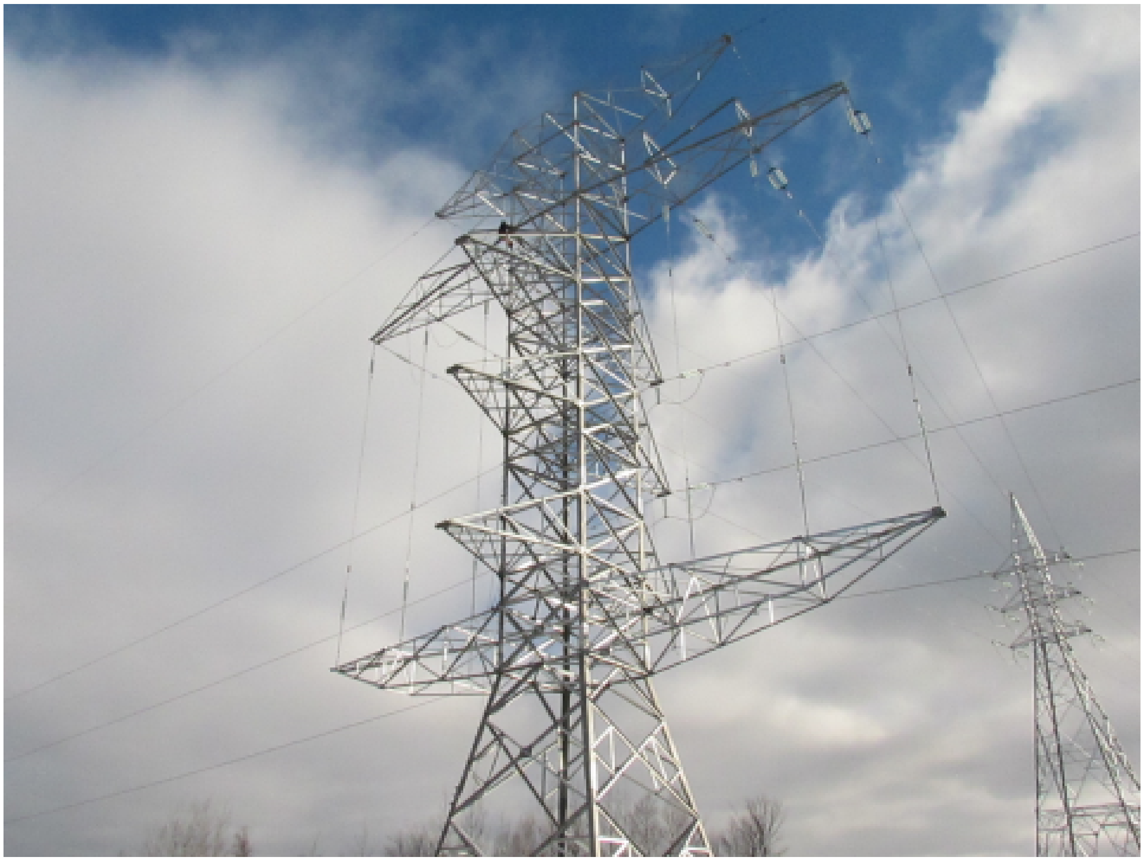


FIGURE 2
EPZ TOWER OUTLINE

Concept:

Hydro-Québec came up with the basic concept for the EPZ tower that answers all the objectives described above. CIMA+ was then mandated to model, analyse, design and test the tower.



This concept allows for the interconnection phases to go either over or under adjacent lines. Transition from main line to interconnection phases is made by taping on six vertical cables attached to two long crossarms, perpendicular to the main lines crossarms, as show in Figure 1 and the above picture.

This tower, named EPZ, has two basic configurations: Configuration 1 which allows the derived lines to pass over the other parallel running lines (shown in Fig. 1) and Configuration 2 that allows the derived lines to pass under such lines.

Challenges:

Electrical clearances:

> As can be seen in Fig. 1, there is a lot of conductors, jumpers and vertical cables around this tower and ensuring electrical clearances under all configurations and wind conditions presents a challenge.

Interaction between the vertical cables and the structure:

> There was also a concern that the vertical cables would act as stressed members and influence the load distribution in the tower in a way that would be hard to evaluate and control. Also, there was a possibility for these cables to get overstressed under different loading conditions. At

first, systems for decoupling the vertical cables to the tower were considered. For example, a system with weights and connecting arms was elaborated and is illustrated by Fig. 3.

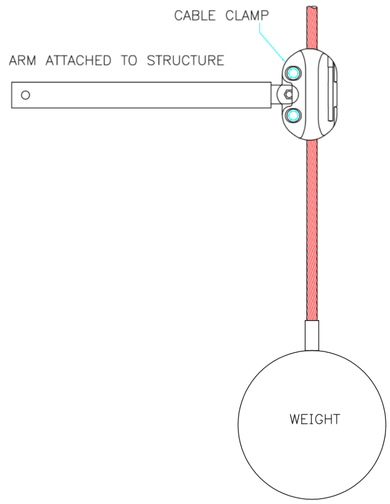


FIGURE 3
VERTICAL CABLE TENSIONING SYSTEM

The idea was to maintain a constant tension in the vertical cables despite tower displacements while maintaining the cable in its position. The system had to keep working even in the presence of ice.

Another concern was with the effect on electrical clearances of cables with a varying tension. There are a lot of cables going in all directions with some of them attached to vertical cables, hence the possibility of having issues with electrical clearances as the tension in the vertical cables changes.

Design:

Since the behaviour of the structure with fixed vertical cables was still unknown, instead of designing a decoupling system for the vertical cables, it was decided to analyse further to see if it could be avoided. The vertical cables were thus included in the PLS-TOWER models used for analysis and design and the result was that the tension variation in the cables was acceptable, both for structural capacity and effect on electrical clearances. For this verification, the steel modulus of elasticity used in the model was lowered to reflect the difference in displacement expected between values obtained from analysis and the ones typically obtained during full scale tests.
Those tension variations measured during full scale testing were in line with expected values, confirming the validity of the models used for analysis.
Final design was made with the vertical cables fixed to the structure at both ends.
In the model used to verify electrical clearances, the initial tension in the vertical cables could not be defined, as the software expects a value for horizontal tension. To alleviate this problem, the cables were modelled with a fixed length slightly smaller than the distance between attachment points. Some trial and error was required to find values that would produce a stable model.

Results:

The resulting tower uses L305x305x35 sections for some of the main members and weighs in at 94 metric tons at maximum height.
Maximum load in the main members is in the range of 5 800 kN in compression.
It has overall dimensions of 58 m high and 34 m wide in the direction of the derived spans.
It can be maintained under load, except for the lower "interconnection" crossarms on which it is not permitted to walk with live lines.

Full scale testing:

The tower was tested at full scale (but minimum height) at Transrail installations near Nagpur, India. It successfully resisted loads equivalent to 130% of design loads and the final test was stopped due to the failure of one of the cables used to apply conductor loads on the tower. The following picture shows the prototype being tested.

Alternatives:

Present solutions for such a situation imply the addition of several towers and/or modifications to the adjacent lines.
Fig. 4 shows an example of such a solution. This one allows the interconnection of two circuits by passing underneath adjacent lines. It implies the addition of at least three special towers and only works if there is sufficient clearance under the adjacent lines, since it doesn't allow passing over.

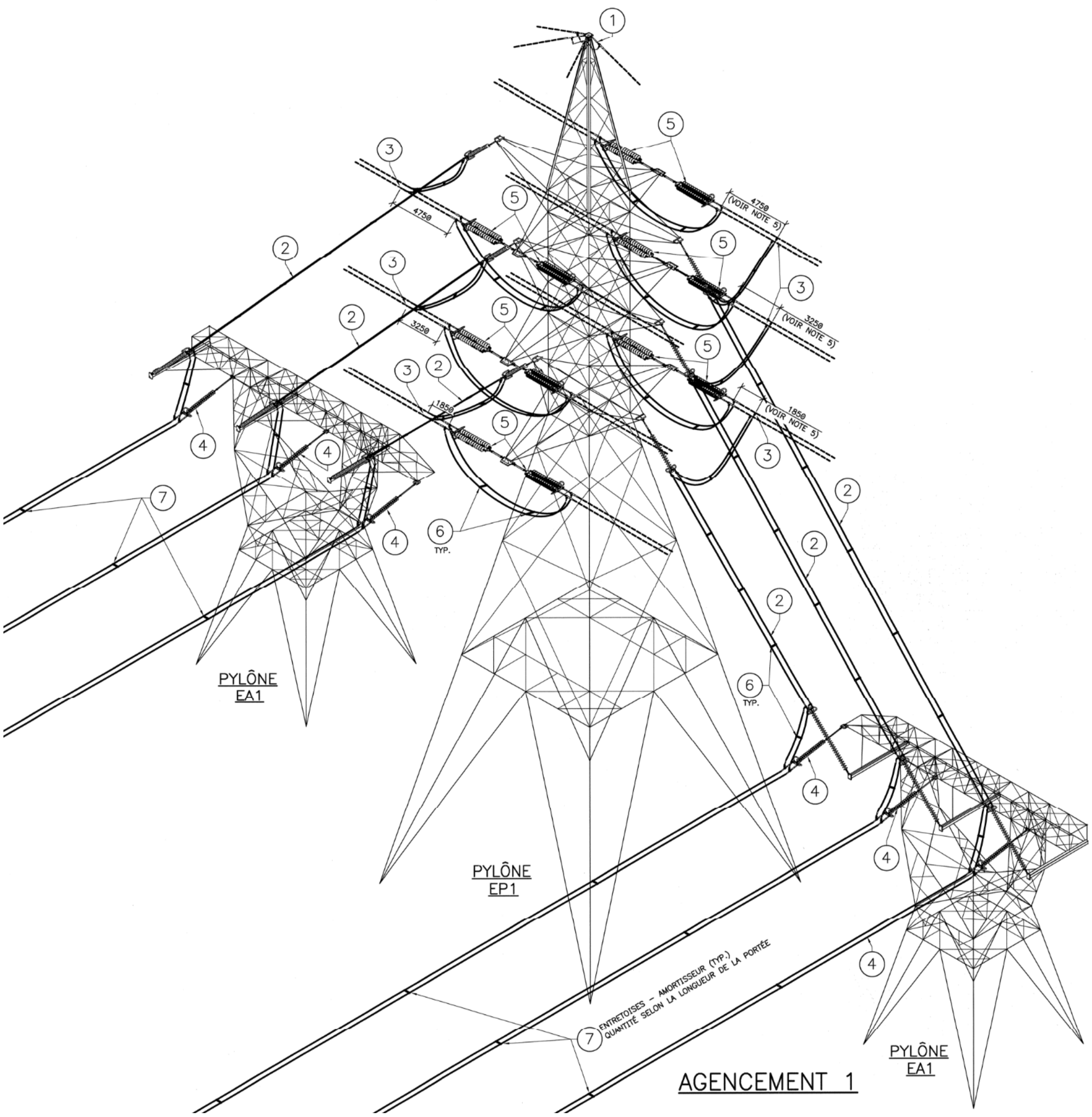


FIGURE 4
ALTERNATIVE SOLUTION