Doctoral Dissertation
Doctoral Program in Energy Engineering (XXXVII cycle)

Guiding Long-Term Energy Planning

A Scientific Approach for Torino Airport

By

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Politecnico di Torino
2025

Declaration

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2025

* This dissertation is presented in partial fulfillment of the requirements for **Ph.D. degree** in the Graduate School of Politecnico di Torino (ScuDo).

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With the tightening of European climate regulation, recent years have witnessed a sprawling wave of carbon neutrality commitments to 2050. Moving down from state obligations, these net-zero emission targets are now being embraced by non-governmental entities, such as large businesses. While this deep involvement of the private sector could support national policies towards the achievement of the stated targets, it also presents companies with a daunting task: to radically transform the way they source, produce and consume energy in the following three decades.

The task is exceptional, not only for the magnitude of the change but also for the extension of the time span over which these changes are needed. Realising long-term commitments would require a robust plan of the transition pathway, carefully accounting for future uncertainties on the development of energy and technology markets. However, current companies' planning practices rarely extends to such time horizons, especially when dealing with non-core parts of the business, as it is the case – with due exceptions – for their energy system. The lack of expertise and established practices in long-term energy planning poses a serious threat to the environmental ambition of businesses, with the risk that the stated net-zero targets fail to be met.

Intercepting this modern necessity, this doctoral thesis proposes a scientific approach to support the roll-out of long-term decarbonisation plans in companies. The proposed methodology envisages the use of mathematical models to inform decisions on the most robust alternative paths available to achieve the stated targets. To this aim, the methodology relies on two key steps: 1., the selection of the most economically effective technological pathways to achieve the target; and 2., the evaluation of the performance of these technological pathways in alternative future scenarios.

In the first step, a techno-economic model is employed to determine the optimal technological pathways under a given set of assumptions on the evolution of the energy and technology markets. The model selects from a group of available solutions the technology mix able to deliver the imposed decarbonisation targets while min-

imising the total costs of the energy system. In the second step, the performance of the selected technological pathways are evaluated against alternative future scenarios. Following this approach, it is possible to determine the additional costs and emission penalties which the company would incur in the case of unexpected developments of the energy and technology markets. Robust decarbonisation paths can thus be identified as those limiting these additional costs and emissions.

The proposed methodology was applied to the case-study of Torino Airport, which has recently committed to achieve net-zero emissions from the operation of its energy system by 2050. To achieve this target, the airport plans to gradually introduce several innovations, among which large shares of renewable generation, electrification and efficiency measures, cogeneration with fuel cells and, in the medium term, storage technologies such as batteries and on-site hydrogen production. The variety of solutions explored, together with the level of ambition of the decarbonisation target, makes Torino Airport an exemplary case for the application of the designed methodology.

The analysis led to the identification of four pillars which should constitute at the basis of the decarbonisation roadmap of the airport:

I. Increased self-sufficiency: shifting from the current consumer to energy producer role is fundamental to minimise the costs of the transition.

II. Diversification of resources: electrification of end-uses must be paired with the transition from fossil to renewable fuels in order to achieve ambitious medium-term targets.

III. Need for green energy supplies: although the self-efficiency of the airport must increase, achieving energetic autharchy would be too costly for the airport. Therefore, large shares of renewable energy supply (grid electricity, biomethane, green hydrogen) will still be needed in the long-term.

IV. Integration in local hydrogen economy: as the on-site hydrogen production potential of the airport is limited, the success of any strategy largely based on this energy vector will rely on the availability of a low-cost, local supply.