Introduction

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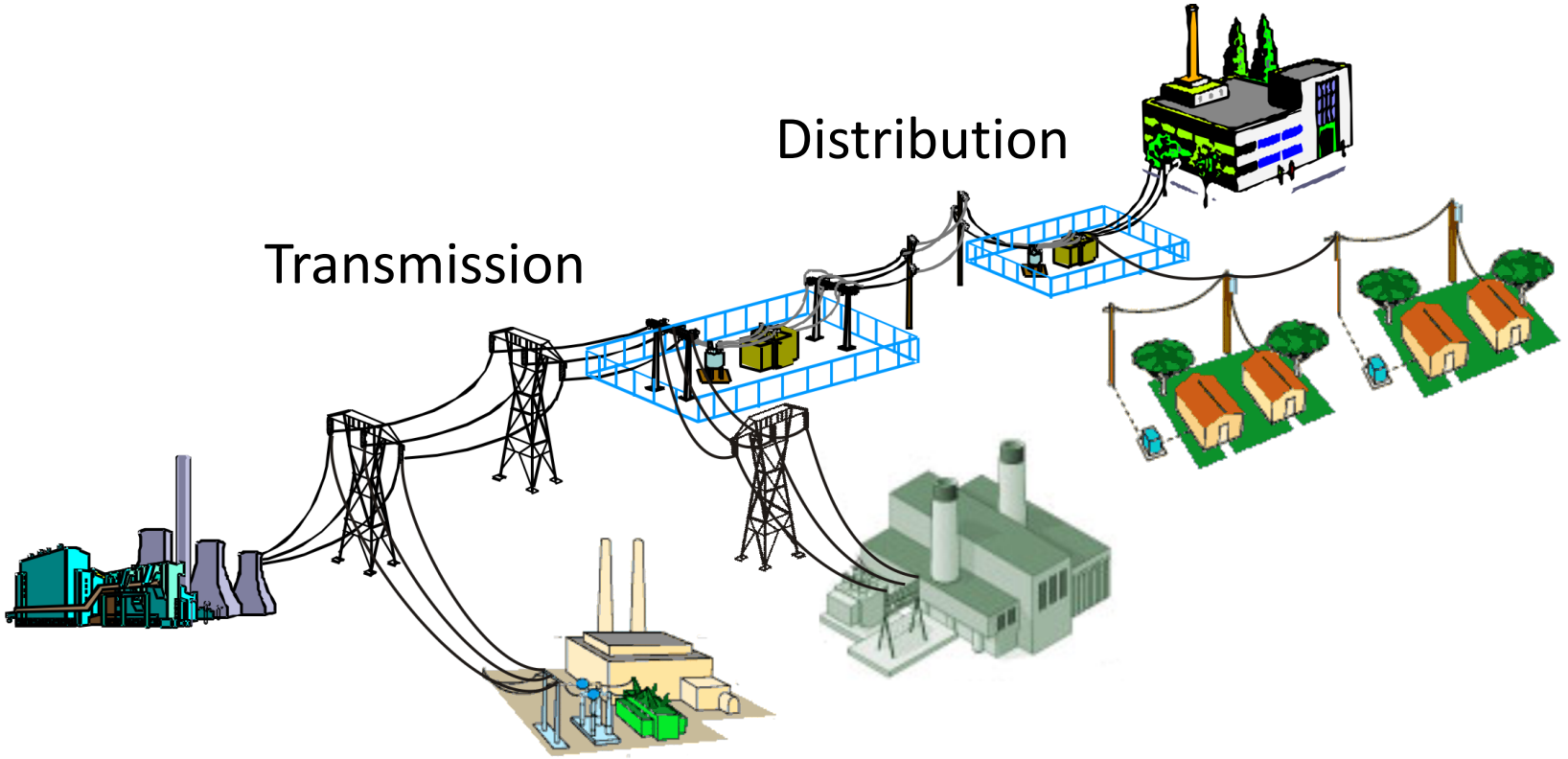
Source: chapter 1.1, Papavasiliou [1]

Evolutions in our professional field

- **Operations research** is more important than ever in the energy field
- Policy changes
  - Deregulation
  - Integration of renewable energy sources
- Technological progress
  - Evolution of solvers
  - Parallel and distributed computing

Electricity supply chain

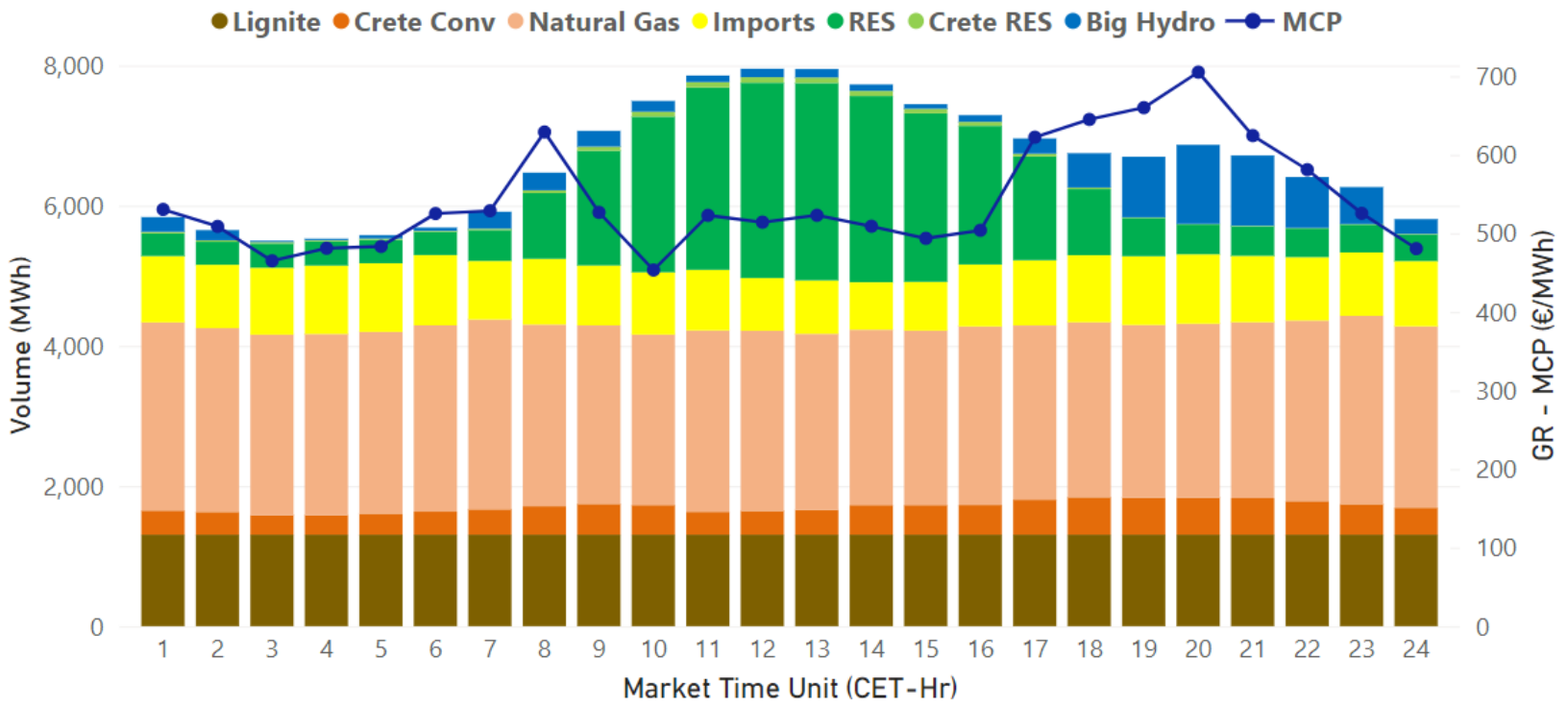


The integrated operation of the electricity supply chain …

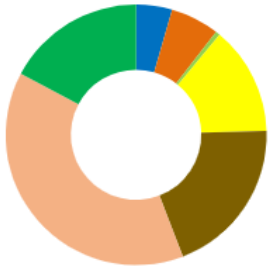
Deregulation

EnEx Energy Exchange Group

Delivery Date: 02/09/2022

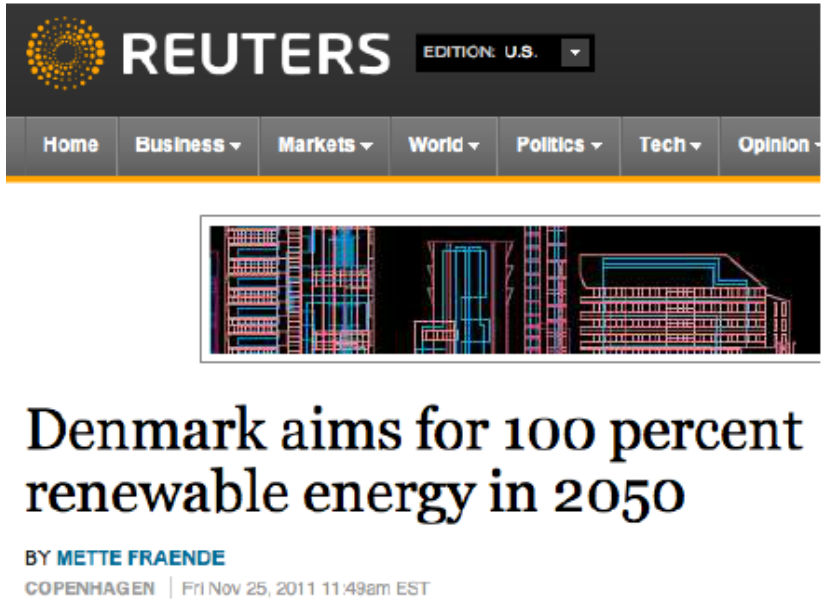


Energy Mix	Volume (MWh)	% Total
Natural Gas	61,520.93	38.59%
Lignite	31,344.00	19.66%
RES	27,485.38	17.24%
Imports	21,462.29	13.46%
Crete Conv	9,647.15	6.05%
Big Hydro	7,101.17	4.45%
Crete RES	859.00	0.54%

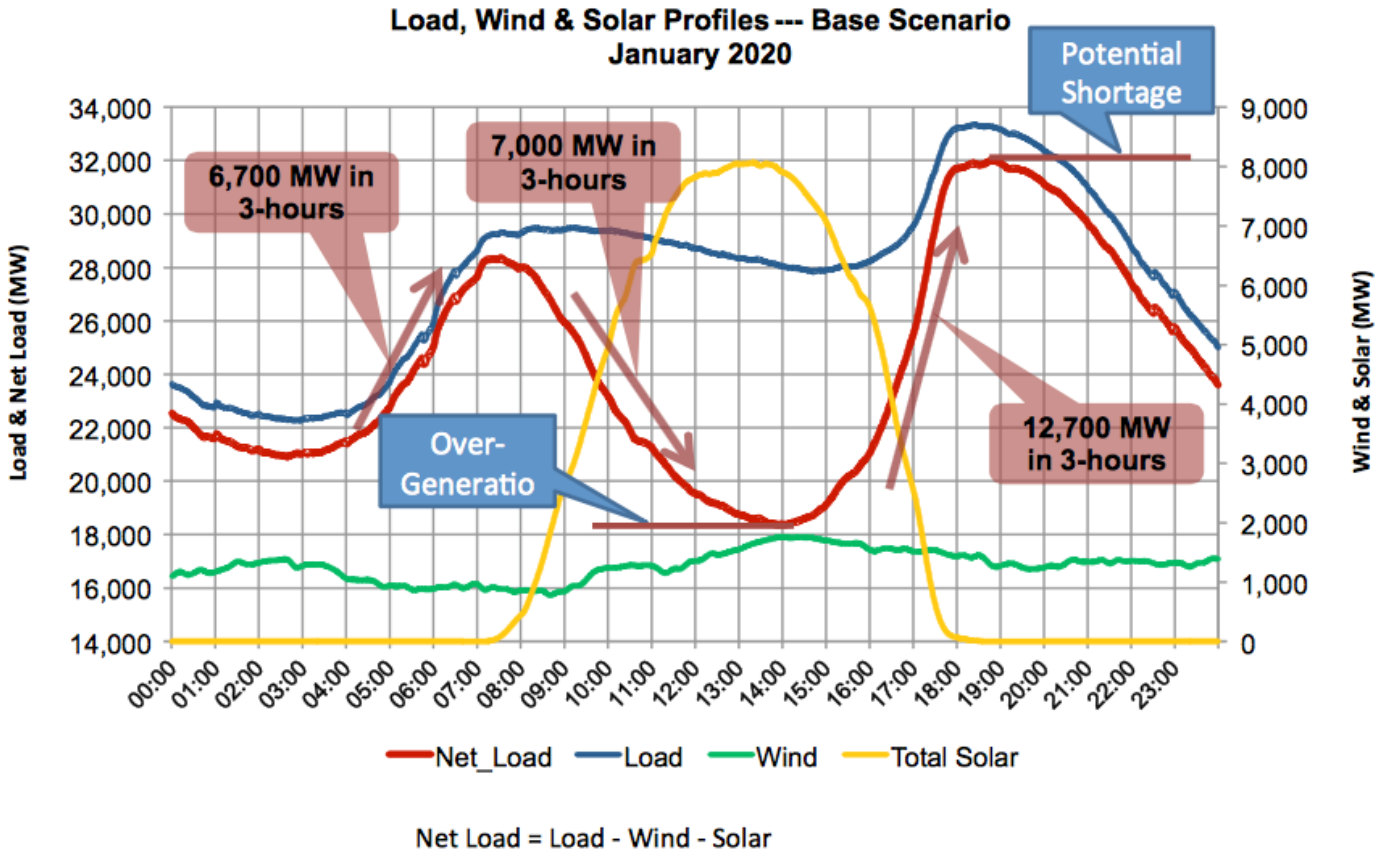


… has been replaced by markets

Renewables making headlines



The “duck curve”



Evolution of solvers

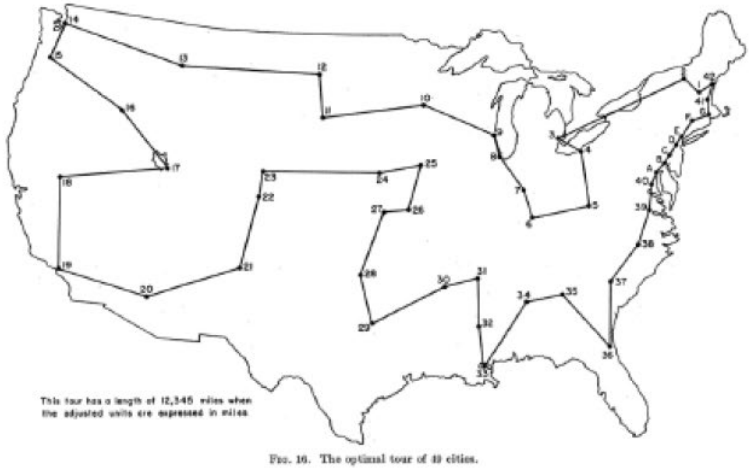


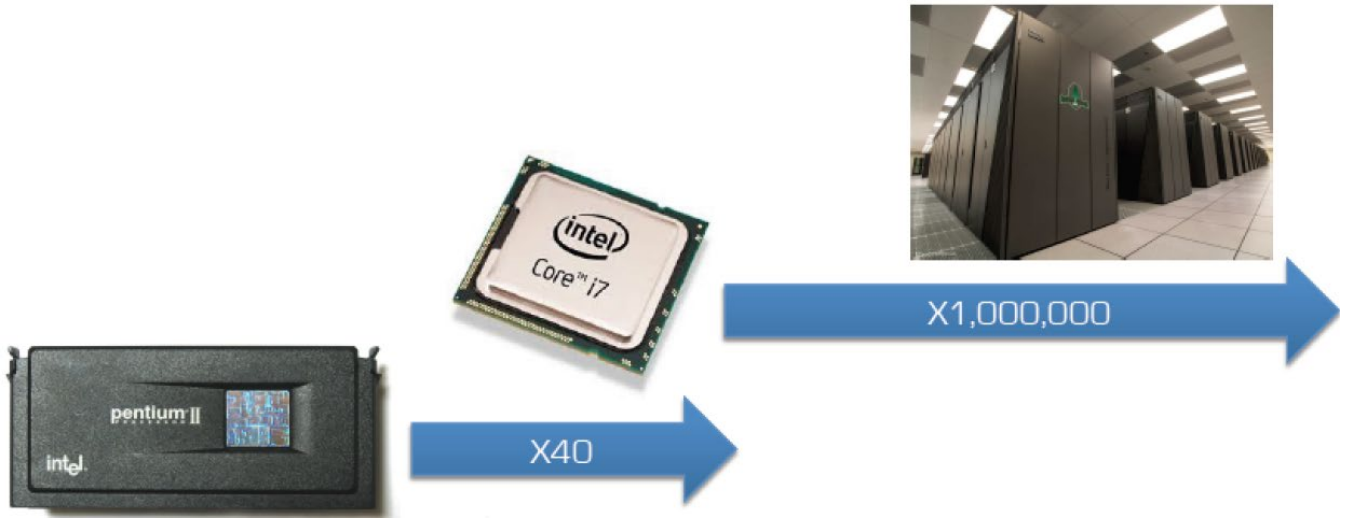
Fig. 16. The optimal tour of 49 cities.

In 1952, Dantzig et al. solve an instance of the Traveling Salesman Problem with 49 cities **by hand**

In 2006 Cook et al. solve a problem with 85,900 'cities' (the one above has 37,000 cities)

It took	It takes
> 4 months (early 90s)	1 second (2007)
> 7 years (early 90s)	1 second (now)

Parallel computing



Intel Pentium II (97-99)	Intel Core i7 975 (14)	Sequoia Cluster (12)
233-450 MHz	3.33 GHz	PowerPC A2 2.3 GHz
1 core	4 cores	1.6 million cores

Operations research in the energy industry

- The energy industry is a *very active* user of OR
  - Late 1980s: Lagrange relaxation applied to unit commitment
  - Early 2000s: adoption of branch-and-bound in unit commitment, MISO reports $2.1-$3 billion in savings between 2007 and 2010 and receives the INFORMS Franz Edelman award in 2011 (https://www.youtube.com/watch?v=w_MYQEMy0h0&t=121s)
  - Late 1980s: stochastic dual dynamic programming solves medium-term hydrothermal scheduling, used in most hydrothermal systems today to determine water levels and prices (Brazil, Scandinavia, Turkey, Switzerland)

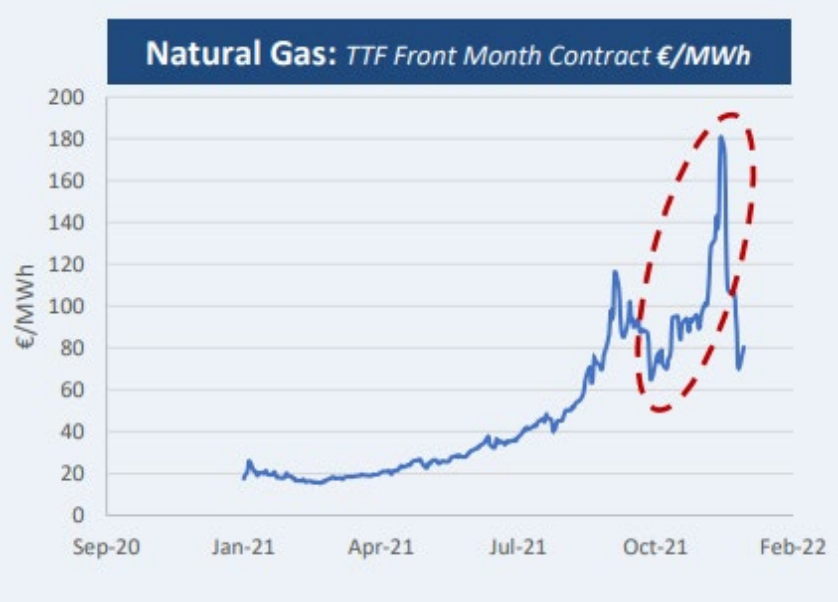
Example: PJM day-ahead market model

- 1210 generators, 3 part offers (startup, no load, 10 segment incremental energy offer curve)
- 10000 demand bids – fixed or price sensitive
- 50000 virtual bids/offers
- 8700 eligible bid/offer nodes (pricing nodes)
- 6125 monitored transmission elements
- 10000 transmission contingencies modeled

- Solved by mixed integer linear programming
- PJM traded $50.03 billion (!) in 2014

The recent energy crisis

- The war in Ukraine has underscored the challenge of energy security
- And there is a barrage of proposals for coping
- The decisions that are reached by the European Union and Member States during this time are crucial, and can determine how fast we can move towards clean energy systems



The price of natural gas (TTF) has increased eightfold from early 2021 to early 2022

Barrage of proposals

INFORMATION NOTE

From:	General Secretariat of the Council
To:	Council
Subject:	Any other business Proposal for a power market design in order to decouple electricity prices from soaring gas prices - Information from the Greek delegation

Delegations will find in the Annex an information note from the Greek delegation in view of the Extraordinary Transport, Telecommunications and Energy Council on 26 July 2022.

The Greek market design proposal would be the end of electricity markets as we know them

DISCLAIMER: All opinions in this column reflect the views of the author(s), not of EURACTIV Media network.

By Christoph Maurer, Ingmar Schlecht and Lion Hirth Jul 28, 2022

UK energy crisis - time to split the power market?

Published on August 18, 2022

Opinion
Kyriakos Mitsotakis

Europe Can Fight Putin By Capping Gas Prices

Russia has weaponized energy. Here is how the EU can strike back.

Why Spanish-Portuguese proposal to intervene in wholesale energy markets is problematic

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By Christoph Maurer and Lion Hirth Apr 13, 2022

Barrage of proposals

- https://www.bloomberg.com/opinion/articles/2022-10-03/greece-pm-mitsotakis-europe-must-put-a-cap-on-natural-gas-prices?sref=FLtkTsMX
- https://data.consilium.europa.eu/doc/document/ST-11398-2022-INIT/en/pdf
- https://www.europarl.europa.eu/plenary/en/vod.html?mode=unit&vodLanguage=EN&vodId=b839936a-22b6-fdd1-03bd-487b76155158&date=20220608#
- https://www.kathimerini.gr/economy/562025260/klimatiki-allagi-energeiaki-krisi-kai-energeiakes-agores/
- https://energypress.gr/news/papalexopoylos-i-protasi-toy-ypen-gia-dihotomisi-tis-dam-einai-kontofthalmi-lanthasmeni
- https://www.linkedin.com/pulse/uk-energy-crisis-time-split-power-market-michael-liebreich/
- https://www.euractiv.com/section/electricity/opinion/the-greek-market-design-proposal-would-be-the-end-of-electricity-markets-as-we-know-them/
- https://www.euractiv.com/section/energy/opinion/why-spanish-portuguese-proposal-to-intervene-in-wholesale-energy-markets-is-problematic/
- https://www.news247.gr/gnomes/gianhs-varoyfakhs/ora-na-anatinaxoyme-tis-agores-ilektrikis-energeias.9744425.html

References

[1] A. Papavasiliou, Optimization Models in Electricity Markets, Cambridge University Press

https://www.cambridge.org/highereducation/books/optimization-models-in-electricity-markets/0D2D36891FB5EB6AAC3A4EFC78A8F1D3#overview