

# On the Economic Feasibility of Using Nuclear Energy to Produce Electricity in Israel

Lior Gallo

BMI 9<sup>th</sup> Annual Conference

Tel Aviv University

Under the supervision of Prof. Itai Sened and Prof. Asher Tishler

[liorgallo@mail.tau.ac.il](mailto:liorgallo@mail.tau.ac.il)

May 2024



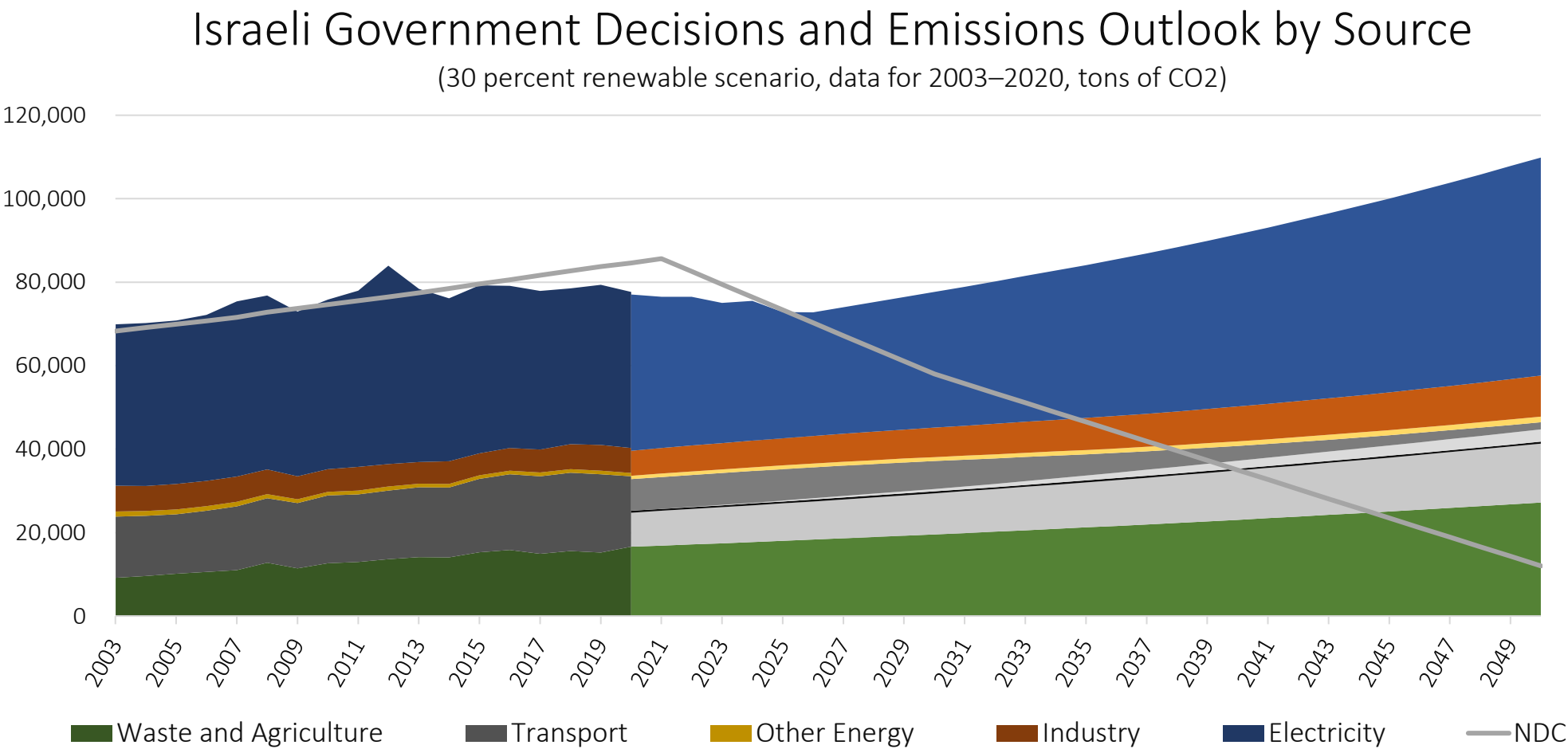
**The Boris Mints Institute  
for Strategic Policy Solutions to Global Challenges**  
The Gershon H. Gordon Faculty of Social Sciences  
Tel Aviv University

# Outline

1. Israel's Future Energy and Environmental Policy Challenges.
2. The Renaissance of Nuclear Energy in the Global Landscape.
3. The Paper's Contribution to the Energy and Environmental Policy Challenge.

# Aiming for Net-Zero: Israel's Decarbonization Ambitions

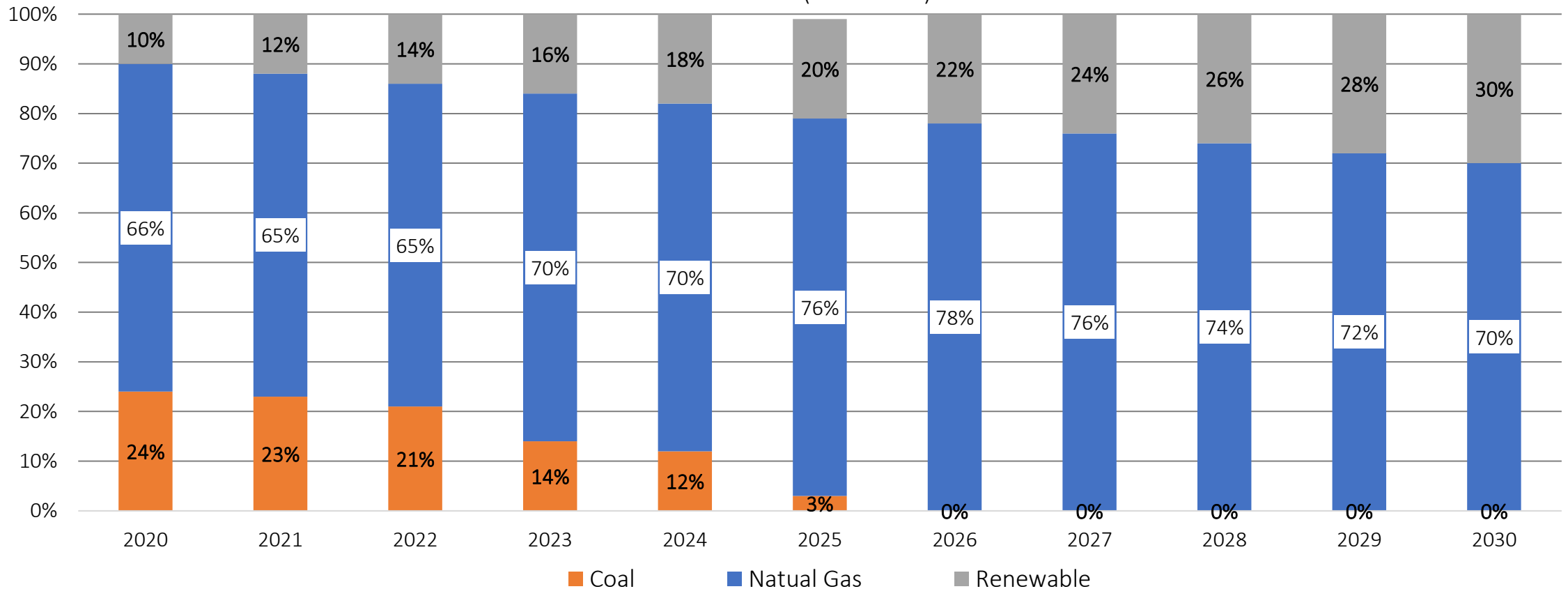
(Source: Israel's energy security, nationally determined contribution to the fight against global warming, and emissions outlook, Bank of Israel 2021)



# Israel's Energy Challenge: Transitioning Away from Fossil Fuels

(Source: Development of the Natural Gas Sector - Special Committee for Supervising the Fund for Managing State Revenues for the Natural Gas and Oil Levy, Ministry of Energy.)

Israel's Future Mix of Energy Sources for Electricity Production  
(2020-2030)

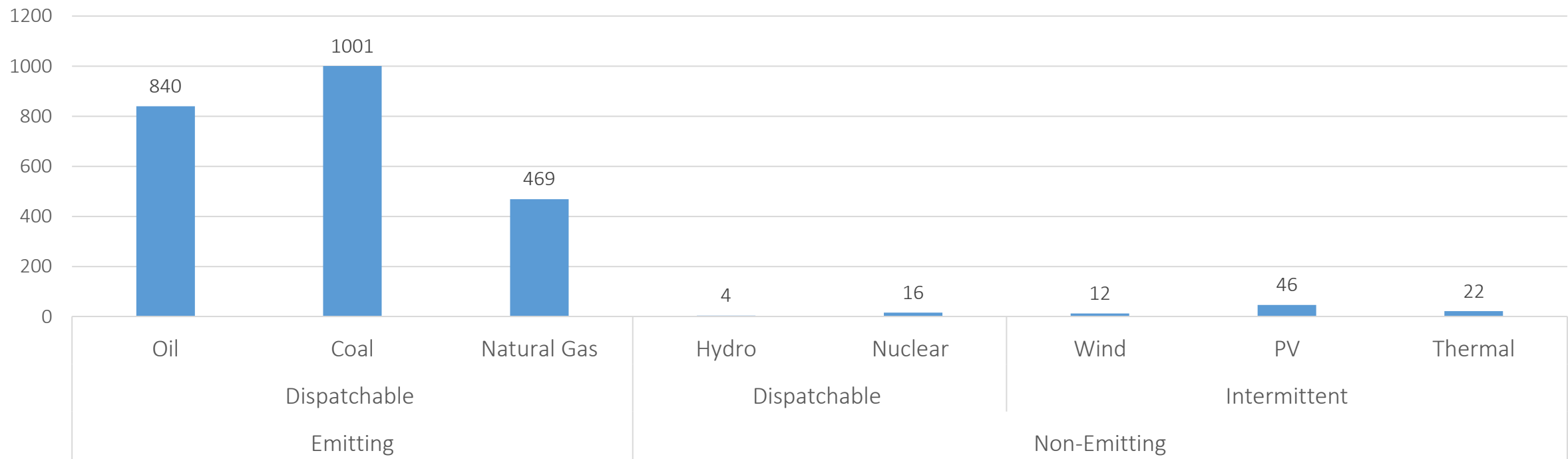


# Several Alternatives to Fossil Fuels in the World.

(Source: Annex II: Methodology. In IPCC: Special Report on Renewable Energy Sources and Climate Change Mitigation, 2011.)

Lifecycle Greenhouse Gas Emissions by Electricity source

(50th percentile, g CO<sub>2</sub>eq/kWh).

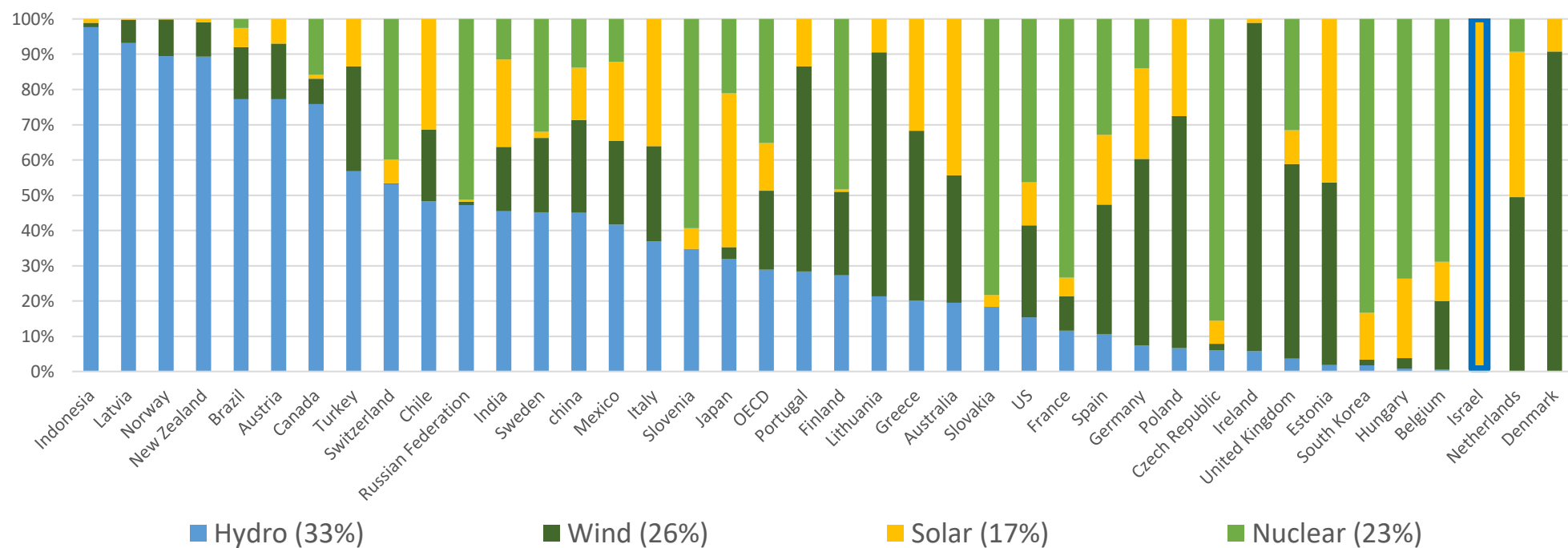


# Too Few Possible Solutions for Israel.

(Source: Israel's energy security, nationally determined contribution to the fight against global warming, and emissions outlook, Bank of Israel 2021)

## Energy Consumption from Zero-Emission Sources by Primary Source

(OECD Countries and 5 Largest Emitters\*, percentage of total emission-free energy, 2022)



\*The five non-OECD countries, namely China, India, Brazil, and Indonesia. The sampled countries constitute 70% of the overall global refugee population in this study.

# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance

## INFLATION REDUCTION ACT GUIDEBOOK

PROGRAM	AGENCY	BUREAU	FUNDING AMOUNT	FUNDING MECHANISM
+ Availability of High-Assay Low-Enriched Uranium (HALEU)	Department of Energy	Office of Nuclear Energy	\$700,000,000	Grants, Contracts
+ Funding for Department of Energy Loan Programs Office	Department of Energy	Loan Programs Office	\$3,600,000,000	Loan Guarantees
+ Idaho National Laboratory Infrastructure Investments	Department of Energy	Office of Nuclear Energy	\$150,000,000	Direct Federal Spending

ENERGY.GOV

SCIENCE & INNOVATION

ENERGY ECONOMY

SECURITY & SAFETY

SAVE ENERGY, SAVE MONEY



Department of Energy

At COP28, U.S., Canada, France, Japan, and UK Announce Plans to Mobilize \$4.2 Billion for Reliable Global Nuclear Energy Supply Chain

DECEMBER 7, 2023

# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance



 **GOV.UK**

[Home](#) > [Environment](#) > [Energy infrastructure](#) > [Low carbon technologies](#)

Press release

## Biggest expansion of nuclear power for 70 years to create jobs, reduce bills and strengthen Britain's energy security

Roadmap sets out how UK will increase nuclear generation by up to 4 times to 24GW by 2050.

From: [Department for Energy Security and Net Zero](#), [Great British Nuclear](#), [The Rt Hon Claire Coutinho MP](#), [Andrew Bowie MP](#) and [The Rt Hon Rishi Sunak MP](#)

Published 11 January 2024

Last updated 11 January 2024 — [See all updates](#)



# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance



REUTERS®

World ▾ Business ▾ Markets ▾ Sustainability ▾ Legal ▾ Breakingviews ▾ Technology ▾

The Switch

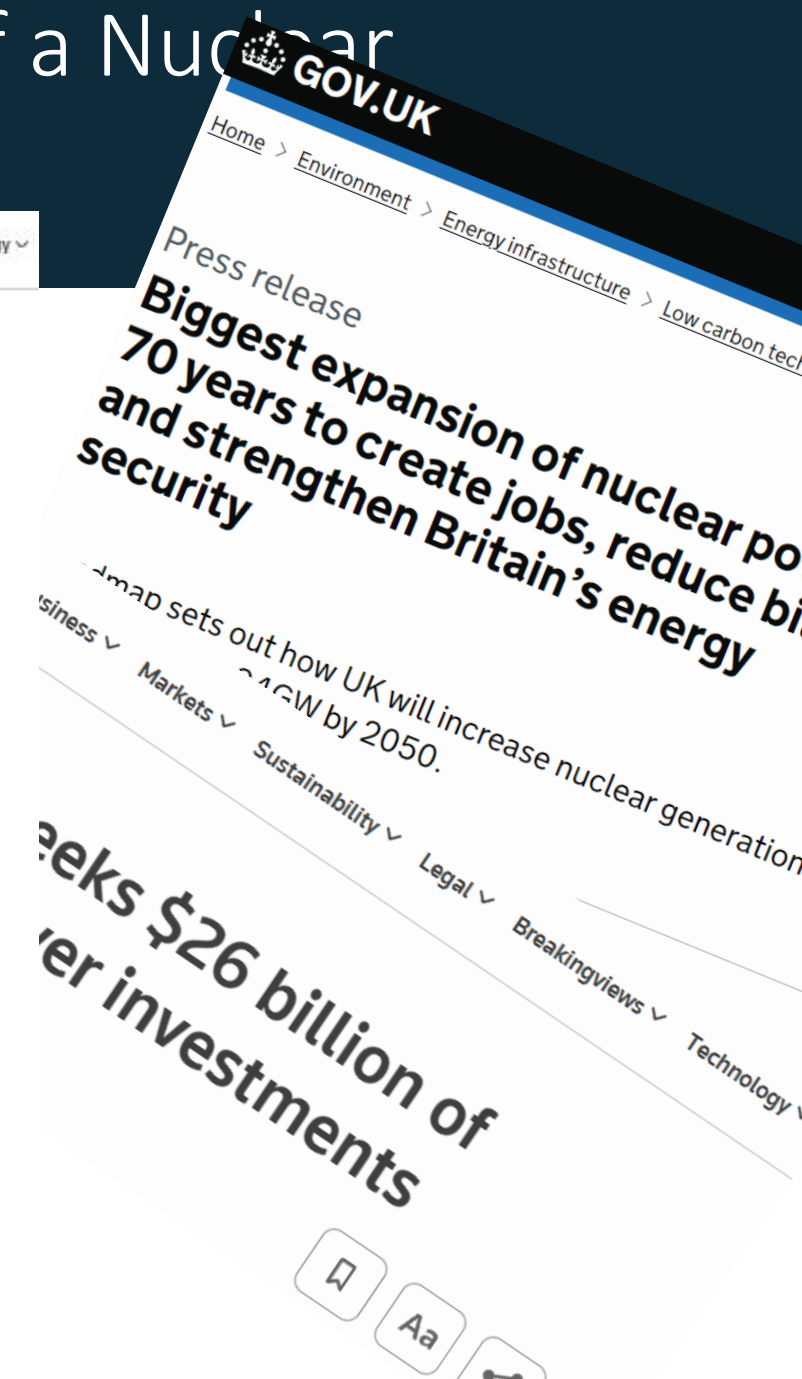
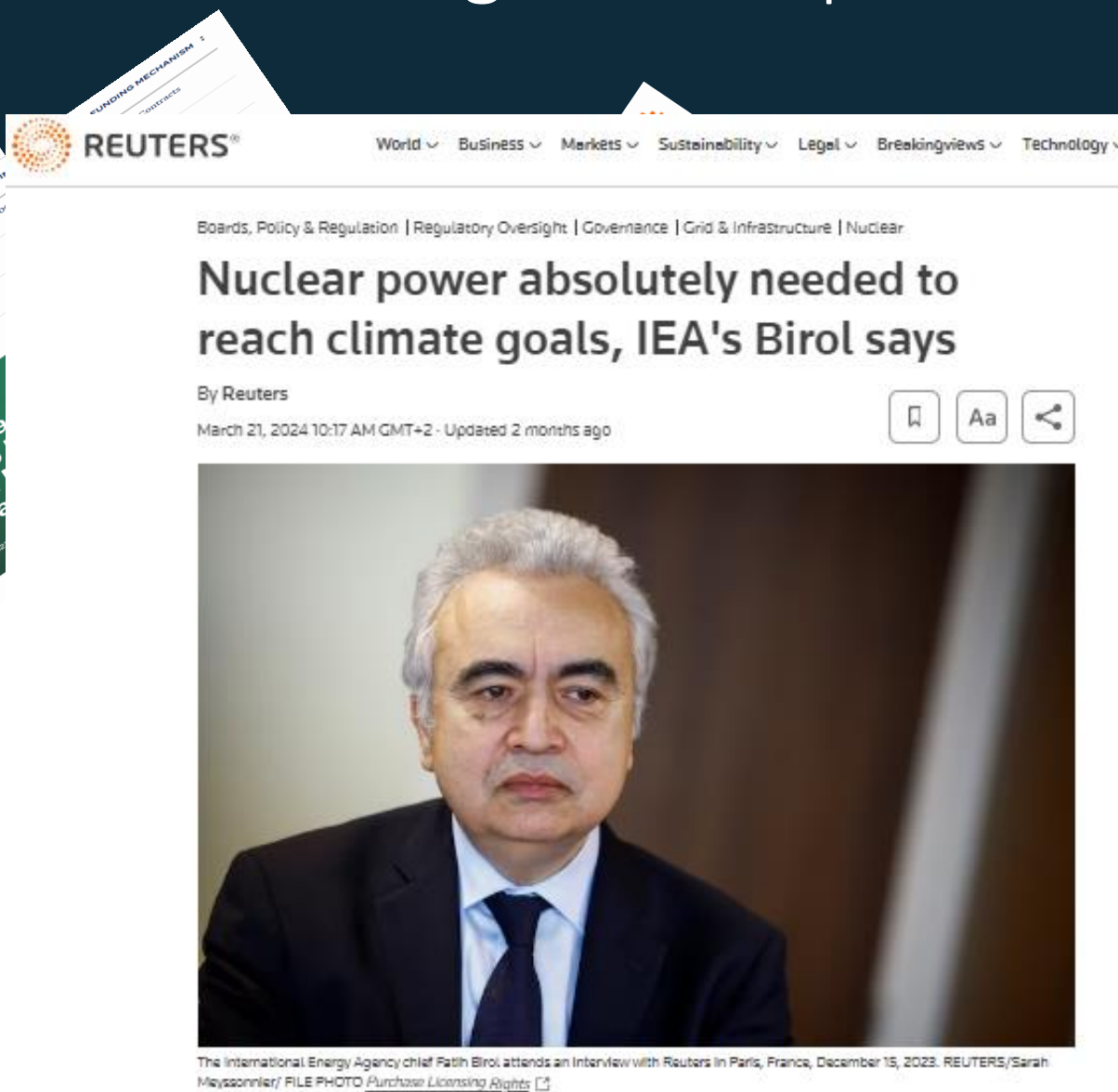
## Exclusive: India seeks \$26 billion of private nuclear power investments

By Sarita Chaganti Singh

February 21, 2024 9:23 AM GMT+2 · Updated 3 months ago



# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance



# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance



IAEA

## Declaration on Nuclear Energy

We, the leaders of countries operating nuclear power plants, or expanding or embarking on or exploring the option of nuclear power, and the Director General of the International Atomic Energy Agency (IAEA), gathered in Brussels for the inaugural Nuclear Energy Summit to **reaffirm our strong commitment to nuclear energy as a key component of our global strategy to reduce greenhouse gas emissions from both power and industrial sectors, ensure energy security, enhance energy resilience, and promote long-term sustainable development and clean energy transition.** We are determined to do our utmost to fulfil this commitment through our active and direct engagement, in particular by enhancing cooperation with countries that opt to develop civil nuclear capacities in order to reduce greenhouse gas emissions in a nationally determined manner, including for transitioning away from fossil fuels, in a just, orderly and equitable manner, as outlined in the First Global Stocktake of the 28th United Nations Climate Change Conference.

Argentina, Armenia, Bangladesh, Belgium, Bulgaria, Canada, China, Croatia, the Czech Republic, Egypt, Finland, France, Hungary, India, Italy, Japan, Kazakhstan, Netherlands, Pakistan, Philippines, Poland, Romania, Saudi Arabia, Serbia, Slovakia, Slovenia, South Korea, Sweden, Turkey, United Arab Emirates, UK, and the USA.

GOV.UK

Home > Environment > Energy infrastructure > Low carbon tech

Press release

Fast expansion of nuclear power  
aims to create jobs, reduce bills  
strengthen Britain's energy

out how UK will increase nuclear generation  
24GW by 2050.

Security and Net Zero. Great British Nuclear. The Rt Hon  
Bowie MP and The Rt Hon Rishi Sunak MP

See all updates

Ability

Legal

Breakingviews

Technology

billion of  
vestment

INFLATION REDUCTION  
ACT GUIDEBOOK

FUNDING MECHANISM  
Grants, Contracts  
Loan guarantees  
Local spending

At COP28, U.S., Canada, France  
and UK Announce Plans to  
Supply 10 Billion for Reliable Global  
Supply Chain

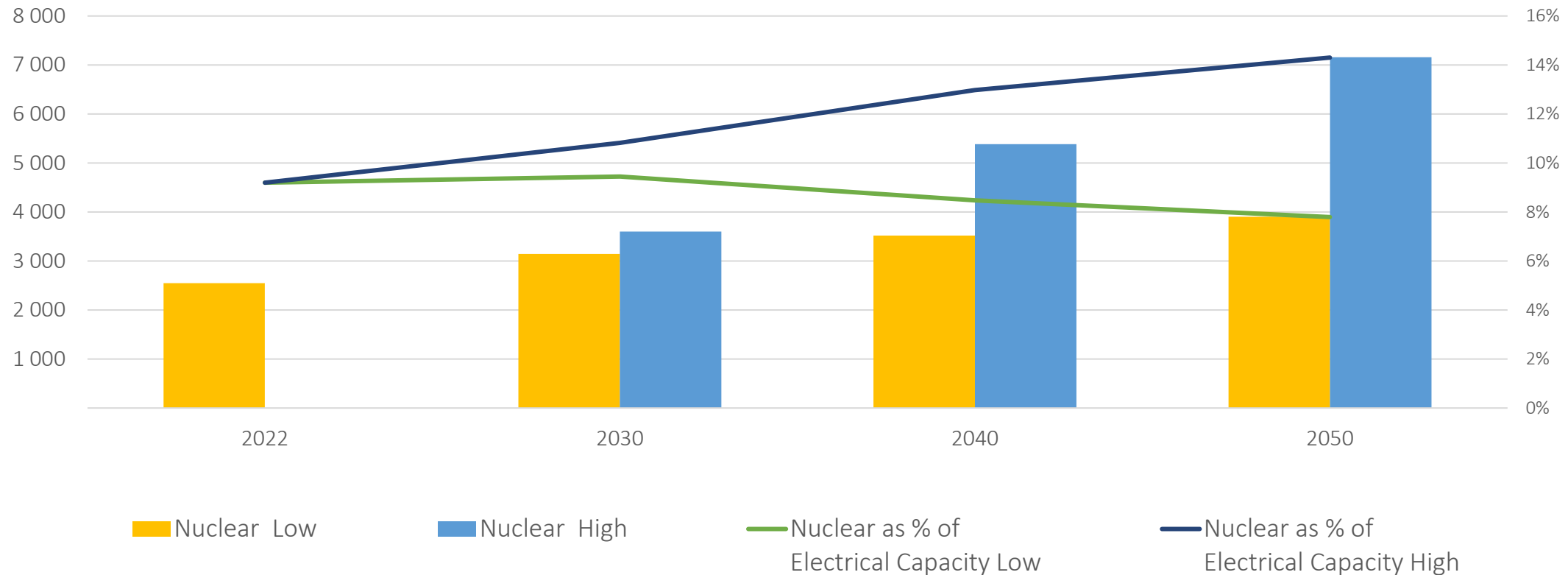
Reuters  
Nuclear power  
reach climate

# Is Nuclear Back? Examining the Prospects of a Nuclear Renaissance

(Source: International Atomic Energy Agency, Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, 2022.)

## World Total and Nuclear Electrical Production Outlook

(IAEA, 2022, Tw-h)



# Nuclear Renaissance: Powering the Future or Déjà Vu?

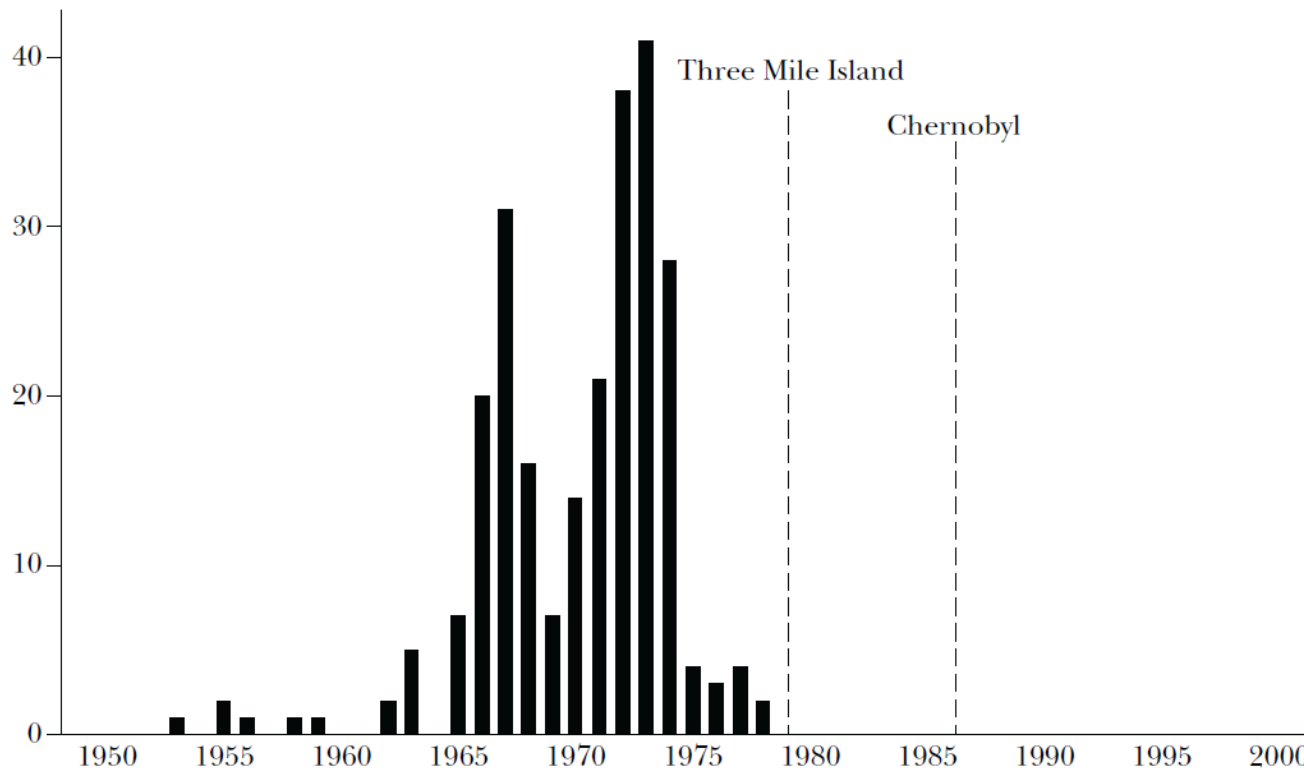
- Why not before?
  - Risky, Nuclear accidents.
  - Public objection - NIMBY.
- Why now?
  - The energy crisis.
  - Climate crisis.
  - Technology.
- It's the economy, stupid!



# Beyond Accidents: Why the West Shifted Away from Nuclear Power

(Source: Davis, L. W. (2012). Prospects for nuclear power. Journal of Economic perspectives, 26(1), 49-66.)

*Figure 1*  
**U.S. Nuclear Power Reactor Orders**



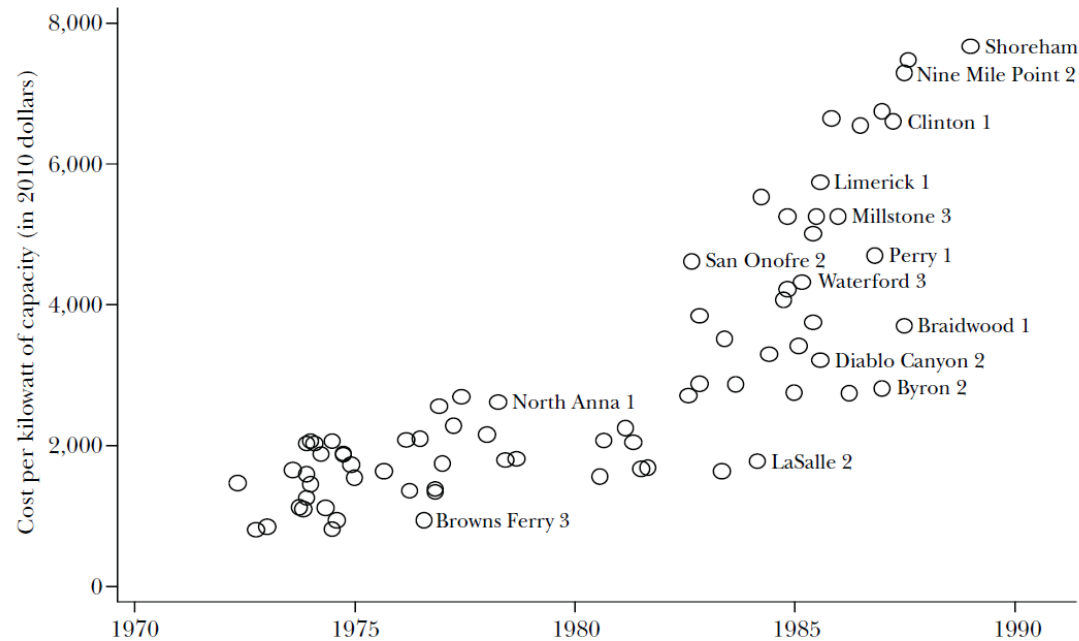
*Source:* Author based on data from U.S. Department of Energy (1997).

# The Rising Price of Nuclear Energy

(Source: Davis, L. W. (2012). Prospects for nuclear power. *Journal of Economic perspectives*, 26(1), 49-66.)

Figure 3

## Construction Costs for U.S. Nuclear Reactors by Year of Completion



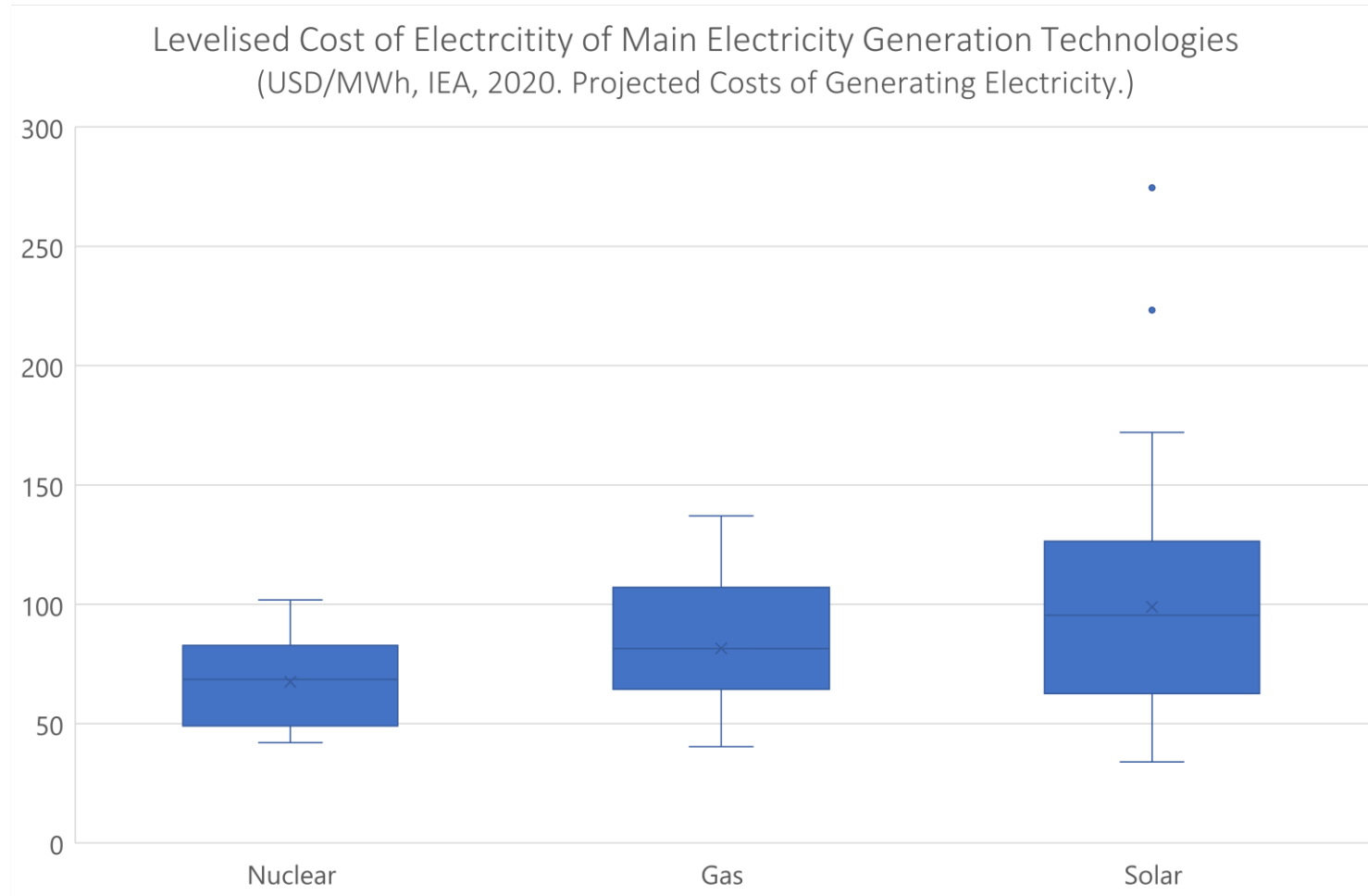
Source: U.S. DOE (1986), table 4.

Notes: Figure 3 plots “overnight” construction costs for selected U.S. nuclear power plants from the U.S. Department of Energy (1986). The figure includes *predicted* costs from the same source for a handful of reactors that were under construction but not yet in operation in 1986.

Source: Davis, L. W. (2012). Prospects for nuclear power. *Journal of Economic perspectives*, 26(1), 49-66.

# Can We Predict Nuclear Costs? Challenges of Pre-Production Pricing

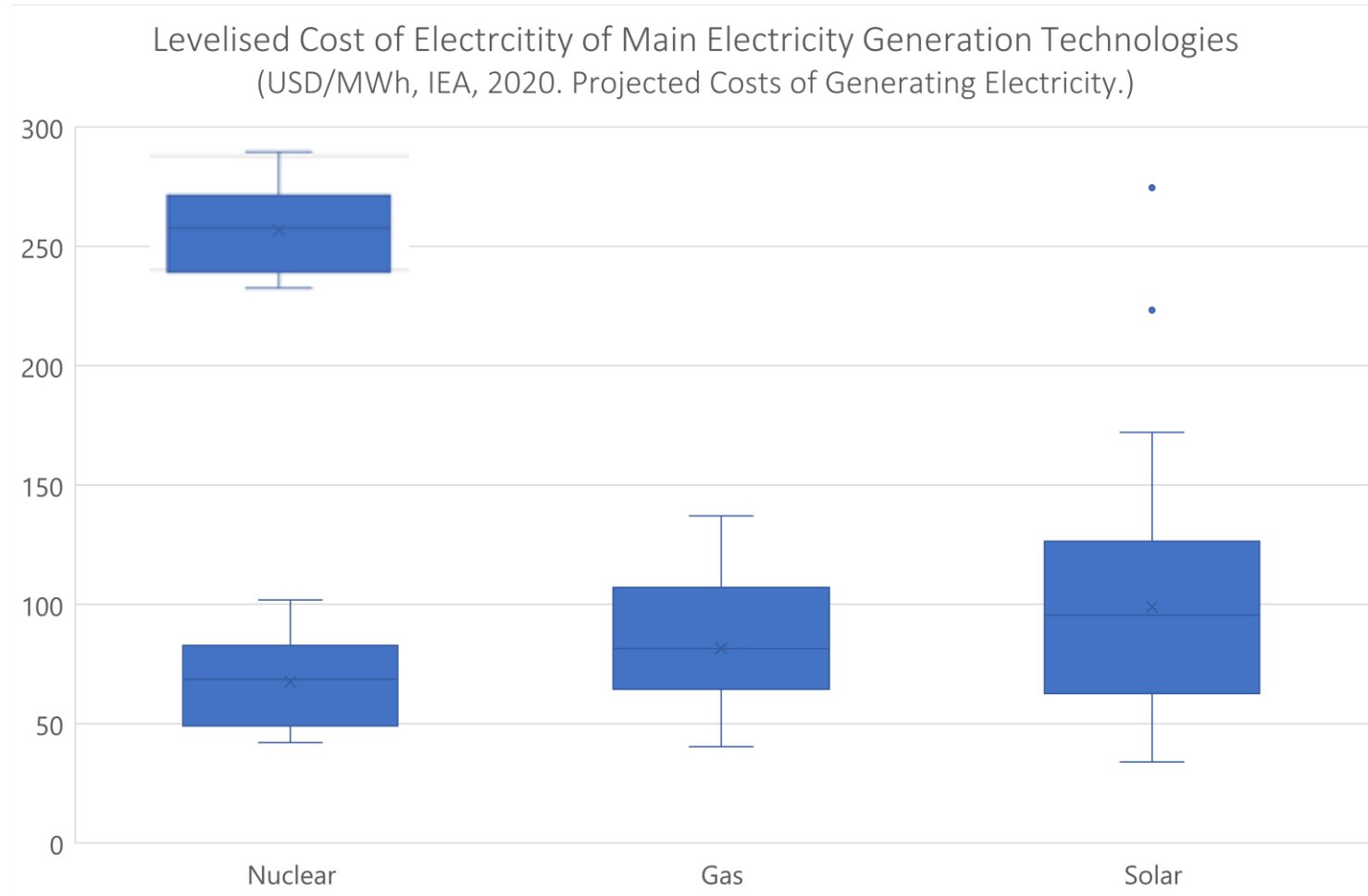
(Source: the PRIS database, IAEA. Last update on 2023-07-11.)





# Can We Predict Nuclear Costs? Challenges of Pre-Production Pricing

(Source: the PRIS database, IAEA. Last update on 2023-07-11.)



# On the Economic Feasibility of Using Nuclear Energy to Produce Electricity in Israel

- Murphy, F. H., & Smeers, Y. (2005). Generation capacity expansion in imperfectly competitive restructured electricity markets. *Operations Research*, 53(4), 646–661.
- Milstein, I., & Tishler, A. (2012). The inevitability of capacity underinvestment in competitive electricity markets. *Energy Economics*, 34(1), 62–77.
- Milstein, I., Tishler, A., & Woo, C.-K. (2022). Wholesale electricity market economics of solar generation in Israel. *Utilities Policy*, 79, 101443.
- Newbery, D. M. (2023). High renewable electricity penetration: Marginal curtailment and market failure under “subsidy-free” entry. *Energy Economics*, 126.
- Milstein, I., Tishler, A., & Woo, C.-K. (2024). Carbon-free Electricity Supply in a Cournot Wholesale Market: Israel. *The Energy Journal*, 45.

# On the Economic Feasibility of Using Nuclear Energy to Produce Electricity in Israel - Model Characteristics

- Oligopolistic Competition.
- Two Stage Game - Long Lead Times from Investment to Supply
- Cost Structure: Lower Fuel Costs, But High Initial Investment.
- Optimal Capacity Mix of Multiple technologies: Nuclear, Natural gas, and PV.
- Future Research: Storage and Electric Vehicles.

# Market Design Matters: Structure & Conduct Drive Performance in Electricity

(Borenstein, Severin, and James Bushnell. "The US electricity industry after 20 years of restructuring." Annu. Rev. Econ. 7.1 (2015): 437-463.)

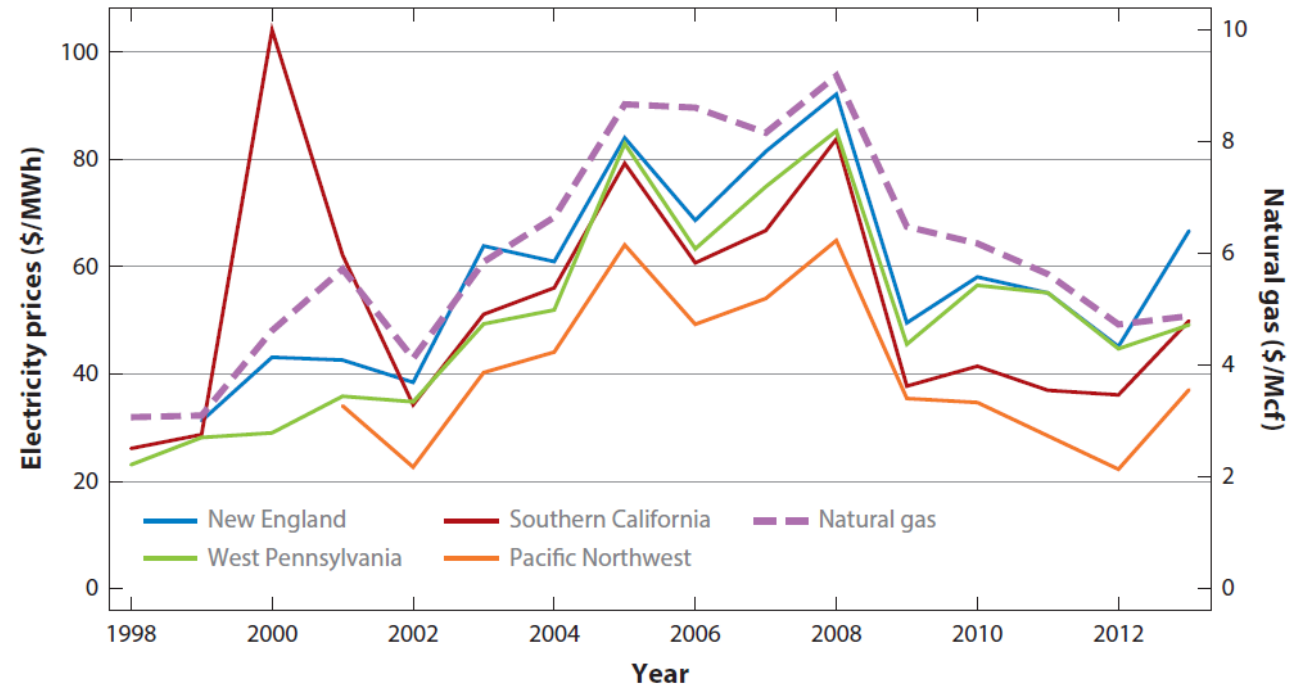


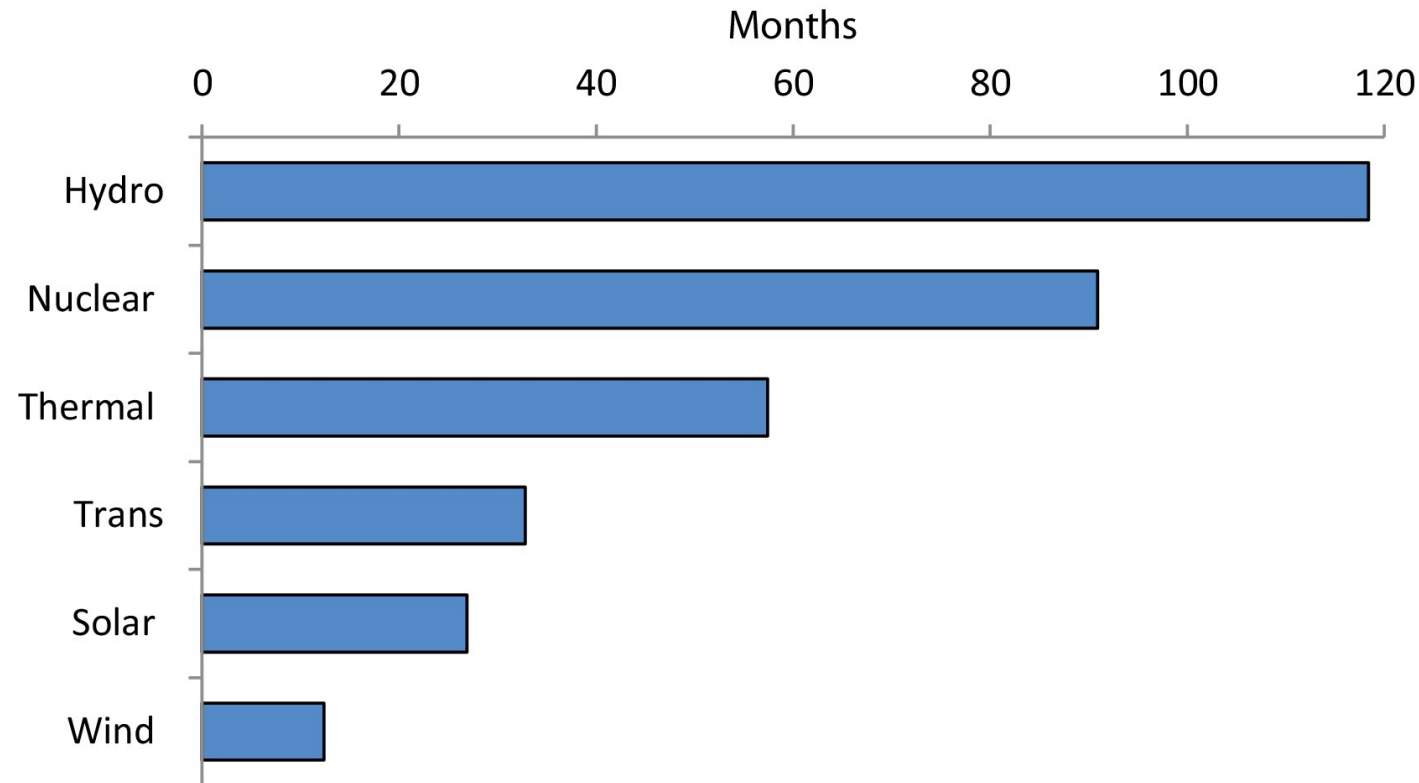
Figure 5

Wholesale electricity and citygate natural gas prices. The dashed line summarizes the US average citygate natural gas price, taken from the Energy Information Administration. The years 1998–2000 represent independent system operator hourly average prices, whereas 2001–2013 represent Intercontinental Exchange peak power contracts. Data are from Bushnell et al. (2008) for 1998–2000 and from the Intercontinental Exchange for 2001–2013.

# Two Stage Game - Long Lead Times from Investment to Supply

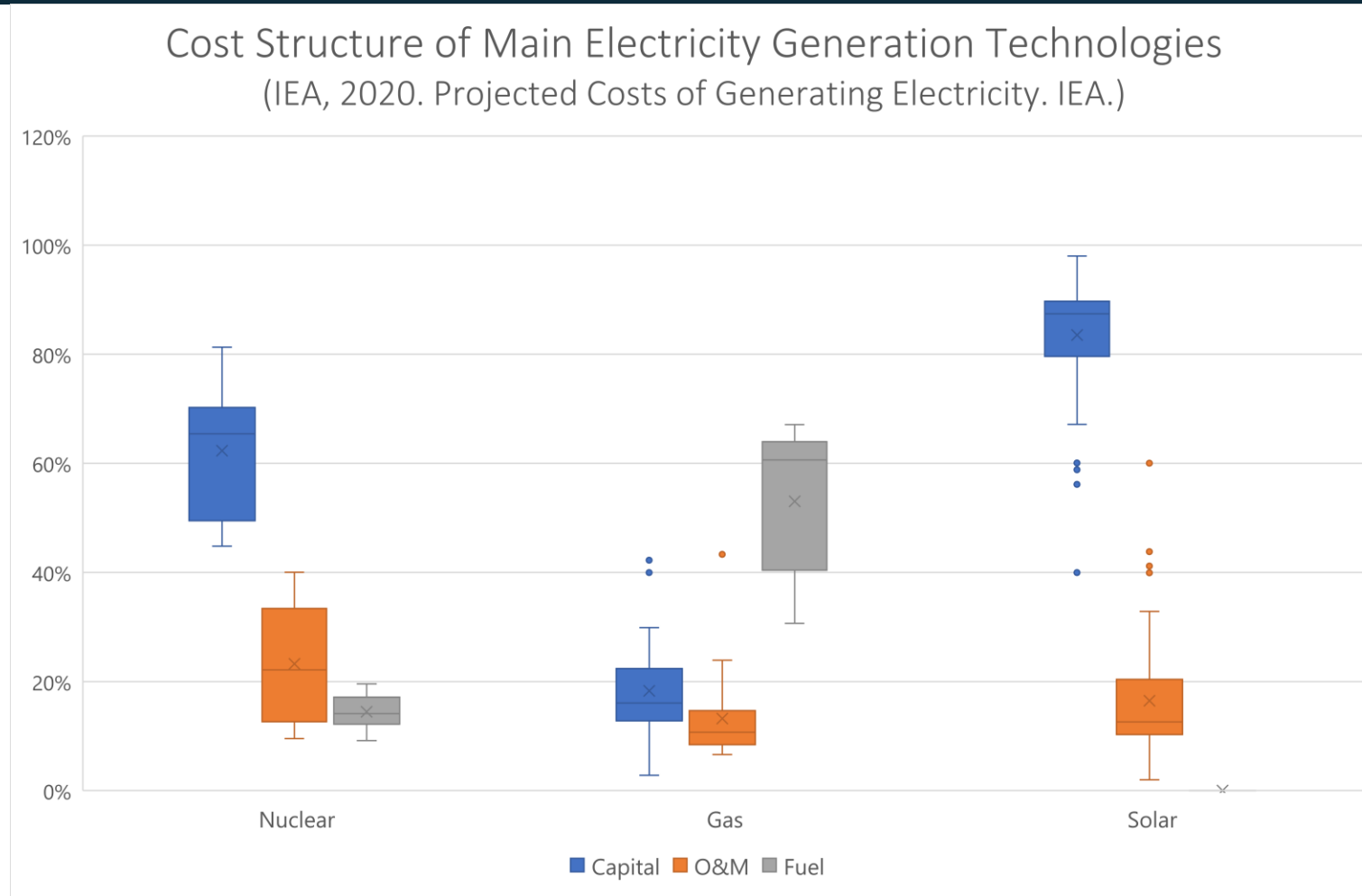
(Source: Sovacool, Benjamin K., Alex Gilbert, and Daniel Nugent. "An international comparative assessment of construction cost overruns for electricity infrastructure." Energy Research & Social Science 3 (2014): 152-160.)

Mean construction time for electricity infrastructure projects by reference class  
(Capacity adjusted)



# Cost Structure: Lower Fuel Costs, But High Initial Investment.

(Source: the PRIS database, IAEA. Last update on 2023-07-11.)



# Summary

- Israel's Energy Challenges: Transitioning Away from Fossil Fuels and Moving from Cartelized to Competitive .
- Nuclear Energy: Sustainable and Secure. Economic?
- The Paper's Objective: Assessing the Economic Feasibility of Nuclear Power in Israel. Is it Economic?
- Structural Empirical Industrial Organization Model: Two-Stage Oligopolistic Competition with Uncertainty and Multiple Technologies.

# Thank You!

Lior Gallo

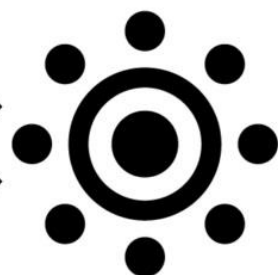
BMI 9<sup>th</sup> Annual Conference

Tel Aviv University

Under the supervision of Prof. Itai Sened and Prof. Asher Tishler

[liorgallo@mail.tau.ac.il](mailto:liorgallo@mail.tau.ac.il)

May 2024



**The Boris Mints Institute  
for Strategic Policy Solutions to Global Challenges**

The Gershon H. Gordon Faculty of Social Sciences  
Tel Aviv University



# The Safety of Nuclear Energy for Electricity Generation

(Source: <https://ourworldindata.org/energy>)

## Death Rates Per Unit of Electricity Production

(Death rates are measured based on deaths from accidents and air pollution per terawatt-hour (TWh) of electricity.)

