Is it Possible to Decouple Energy Use and Economic Growth?

Glen Sweetnam
Distinguished Fellow
Energy Policy Research Foundation
April 24, 2026

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Outline

The link between energy use and economic growth

Technologies that increase energy efficiency

Accelerating energy intensity reductions

What about data centers?

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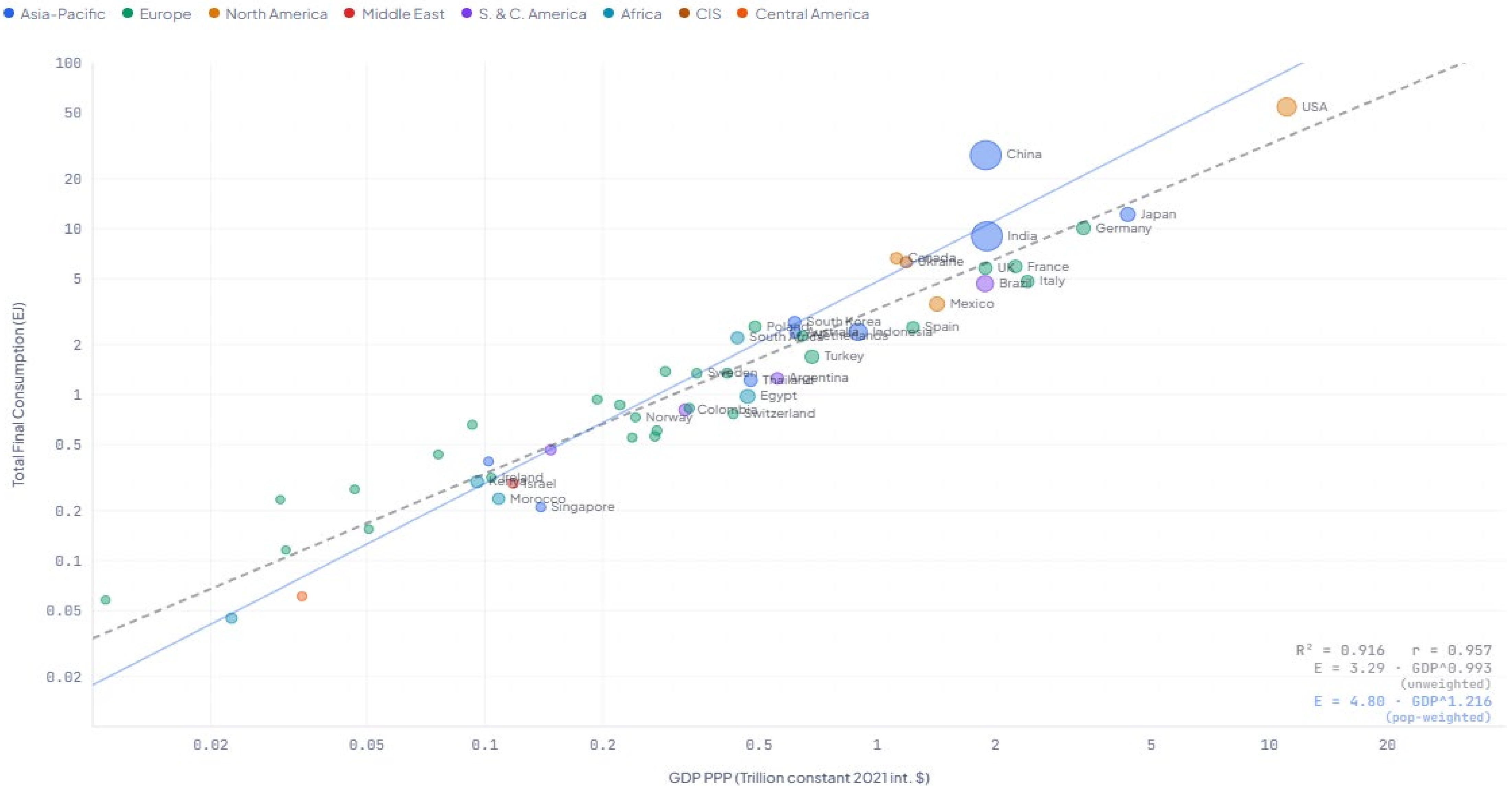
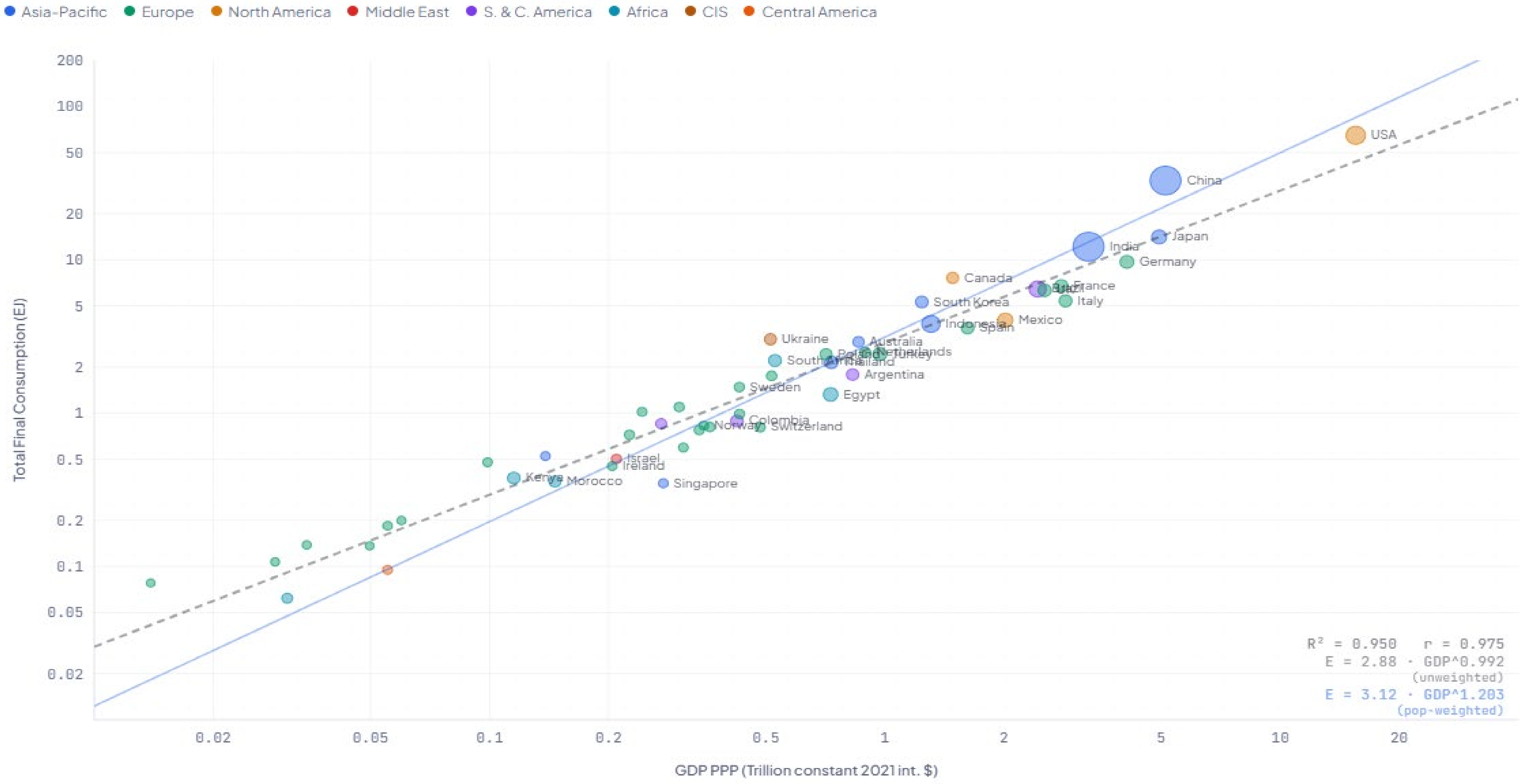
1990



IEA Energy Statistics (TES & TFC) · World Bank GDP PPP (constant 2021 int. $) · Bubble size = population

2000



IEA Energy Statistics (TES & TFC) · World Bank GDP PPP (constant 2021 int. $) · Bubble size = population

2010

Asia-Pacific
Europe
North America
Middle East
S. & C. America
Africa
CIS
Central America
Total Final Consumption (EJ)
200
100
50
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.02
0.05
0.1
0.2
0.5
1
2
5
10
20
GDP PPP (Trillion constant 2021 int. $)
China
USA
India
Japan
Brazil
Germany
Canada
South Korea
France
UK
Italy
Mexico
Indonesia
Spain
Thailand
Turkey
Ukraine
Netherlands
South Africa
Argentina
Sweden
Colombia
Norway
Switzerland
Singapore
Israel
Morocco
Ireland
Kenya
R² = 0.961 r = 0.980
E = 2.52 · GDP^0.985
(unweighted)
E = 2.30 · GDP^1.194
(pop-weighted)
IEA Energy Statistics (TES & TFC) · World Bank GDP PPP (constant 2021 int. $) · Bubble size = population

2023

IEA Energy Statistics (TES & TFC) · World Bank GDP PPP (constant 2021 int. $) · Bubble size = population

Understanding the energy-GDP link

Energy is the capacity to do work (force × distance), and GDP is the total market value of all the “work” an economy performs — in the form of goods manufactured, materials moved, buildings constructed, food grown and transported, services delivered, etc.

GDP is essentially a dollar scorecard of how much useful physical and economic work a society gets done every year — and since every bit of that work (lifting, heating, moving, transforming, computing, lighting…) requires energy as its fuel, energy consumption and GDP are almost definitionally locked together.

So why doesn’t the income elasticity of final energy consumption equal 1.0

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Technologies reduce energy loss

Application	New Technology	Loss Reduction Efficiency Gain
Lighting	Light Emitting Diodes (LEDs)versus Incandescent Filaments	75-90% less electricity for same light output
Industrial & Commercial Motors	Variable frequency drives (VFDs) and copper vs. aluminum rotors, improved steels and insulation.	Motor efficiency increased from 80-85% to 92-97%. Largest total impact FEC.
Road Transport	EVs vs. ICE vehicles	Tank/battery to wheels: Gasoline 17-30%; Diesel 30-45%; BEV 85-90%
Space Heating & Refrigeration	Heat pumps move latent heat rather than generate new heat. Variable speed/invertor compressors	Transferring heat 3-5x more efficient than new heat. Refrigeration losses can be reduced 50-75%.

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Accelerating energy intensity reductions is challenging

- Four structural realities create challenges
  - Country fixed effects dominate energy intensity (geography, climate, population density, and economic structure)
  - Energy price increases are politically difficult
  - Capital stock turnover is slow
  - Technological trends are largely outside government control

A meaningful share of the apparent decline in domestic energy intensity in OECD countries is structural offshoring rather than within-country efficiency or technological progress.

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What about data centers?

- Increased energy use likely to be regionally concentrated
  - USA and China expected to account for > 80% of energy increase
  - Strains to local infrastructure could slow adoption
  - Efficiency gains (better chips, cooling, software) will temper growth, but unlikely to complete offset it.

The current consensus is that AI will likely raise energy intensity in the near-term (through 2030) but will lower it in the long term as productivity gains are realized.

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Conclusions

- The link between energy use and GDP is strong, but less than 100%.
- New technologies do reduce energy intensity.
- But it is difficult for governments to accelerate energy intensity reductions.
- The timing and magnitude of AI energy use are uncertain.

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Thank you for your attention

glens@eprinc.org

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