We are *not on track* to meet the Paris Agreement's objectives. What should we do?

World Energy Markets
Observatory 2024 | 26th Edition

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05

Primary energy demand is an *outdated* concept

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Key points

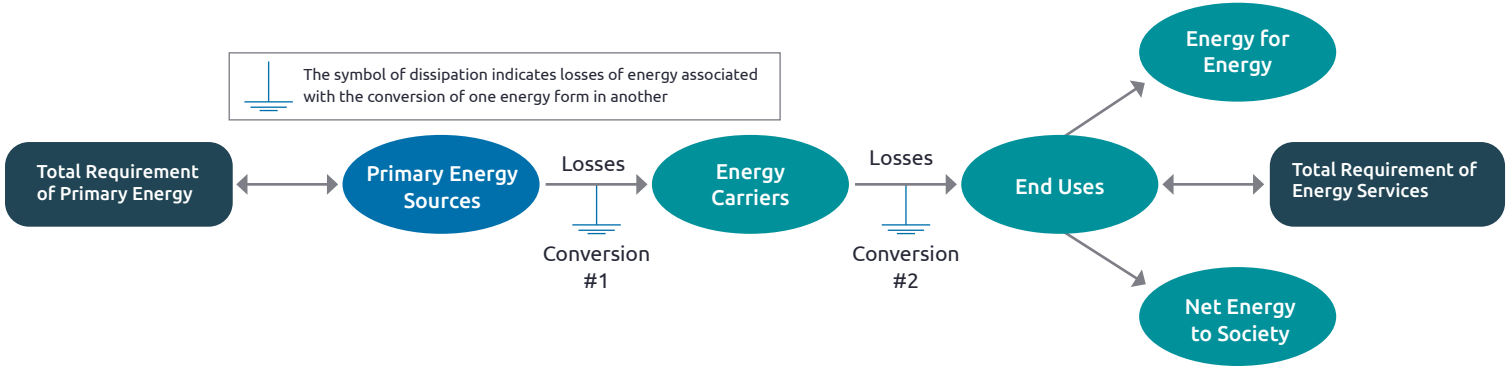
1. There is too much focus on the present analysis of replacing all current energy usage with clean energy.
2. This ignores several facts: that new electric services are generally more efficient; that a lot of fossil fuels are wasted in the generation of energy; and that a lot of energy is wasted on finding and processing fossil fuels.
3. The world will need a lot less clean electricity than fossil fuels for the same end-energy services.

Introduction

For years, the U.S. Energy Information Agency (EIA) and International Energy Agency (IEA) have measured primary energy demand. Governments have used this measure extensively and it has proven very useful in previous energy crises. It is defined as follows: Primary energy consumption refers to the direct use at the source, or supply to users without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process.

FIGURE 1

Primary Energy Demand definition



Source: IEA, EIA

Reducing CO_2 in the energy transition requires widespread electrification of energy uses (e.g., electric vehicles (EVs), domestic heat, and industrial heat). All climate change scenarios have electrification moving from 20% today to dominating the energy systems in the future. Electricity energy demand to perform these tasks is significantly lower than primary energy as measured for fossil fuels. If we replaced all the fossil 'primary energy' today in the new electric world, we would need a lot less energy.

As economies grow, switching focus to energy services work done and not primary energy as the input will help us make better decisions. As result, we believe the concept of primary energy demand is flawed and not a relevant concept for energy transitions, since it reinforces the old world.

The new electric energy services

Electrification will dominate the new energy system

Energy is required for many purposes around the world: mobility, heating, lighting, industrial processes, and agricultural processes. Most of the net zero scenarios published by the IEA envisage new electricity services to reduce the CO_2 footprint.

For transport, the world is well on the way to electrification. Globally 18% of cars sold were electric last year, albeit there are concerns on the deployment of charging networks.

Heat pumps are revolutionizing domestic heating and will become universal once the costs of gas are equalized. Electrification of building heat is progressing well.

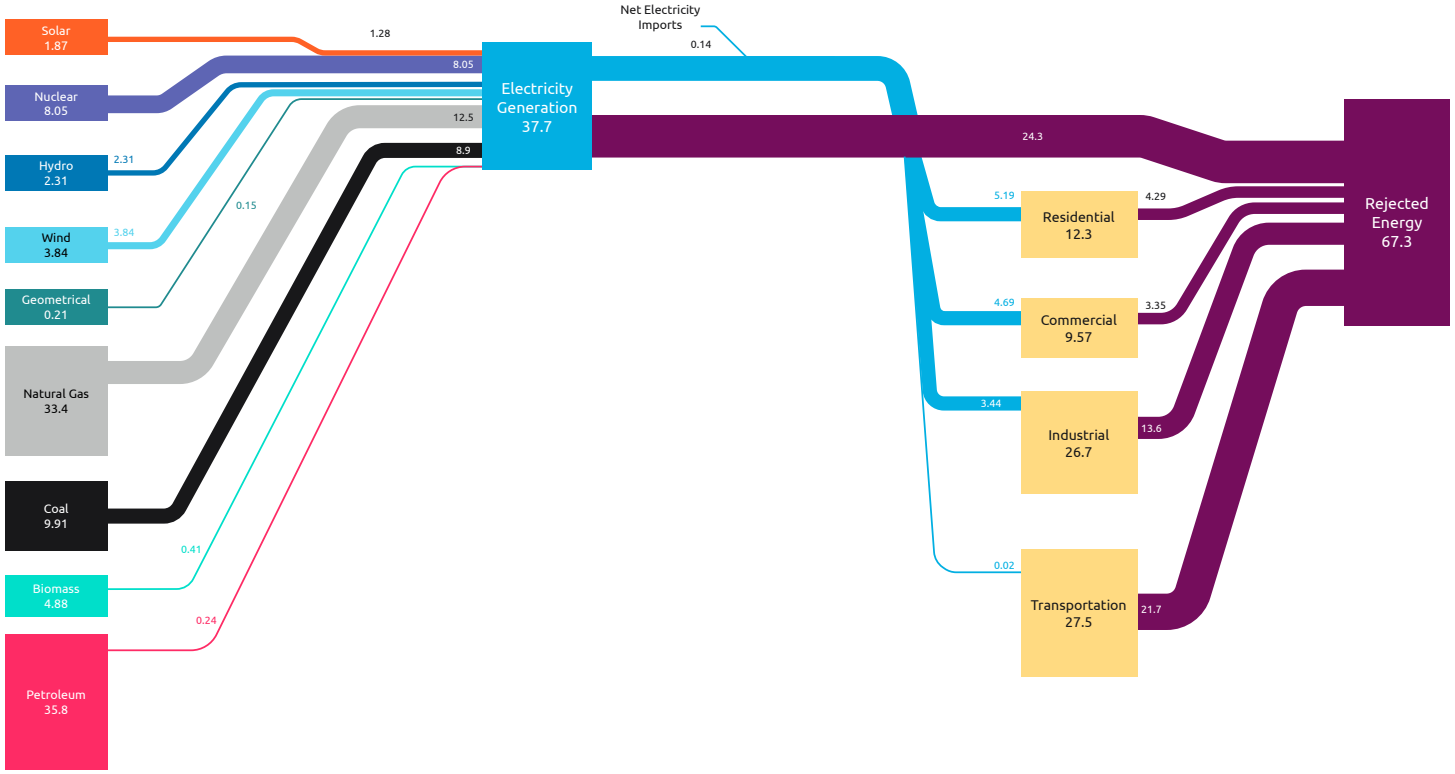
Industry is electrifying (e.g., aluminium and steel), though there is still work to be done.

'Hot rocks' are moving fast for industry process below 1200 degrees. Commercial solutions are becoming available and there is more activity required.

Energy lost burning fossil fuels to generate electricity

FIGURE 2

USA energy lost to generation



Source: Lawrence Livermore National Laboratory

Energy lost in generation

The average efficiencies of power generation are 35% for coal, 45% for natural gas, and 38% for oil-fired power generation. What this means is that 35% of the energy in coal results in electric power, while the 55-65% that is wasted goes "up the stack" as heat. The latest analysis from Lawrence Livermore (see Figure 2) shows that for the USA in 2022, 64% of energy wasted was on burning coal and gas.

Energy lost in low-carbon generation

Of course, wind, solar and nuclear also have inefficiencies that are being improved upon. However, unlike fossil fuels the energy is not wasted, it is just an opportunity to harvest more energy from the sources. All electricity generation suffers loss in transmission and distribution of approximately 10%. High voltage direct current (HVDC) lines are being introduced to reduce these losses over longer distances.

EVs/LEDs and heat pumps are more efficient

Most people around the world are moving towards LED light for homes and and offices. Figure 3 shows that LEDs are more efficient and use 13% of the energy of a normal bulb. It also shows that primary energy demand is the wrong way to look at the low-carbon generation available to support the new, more efficient lighting service.

Electric vehicles are also more efficient. For every dollar you put in your diesel or petrol car, only 30 cents is used for moving you forward—the rest is wasted heat. EVs provide the same transportation service, but for every dollar you put in, 90 cents is used for moving you forward.

Finally, gas boilers have become much more efficient. For every kilowatt hour (kWH) of energy you put in, 10% is waste heat. However, with air source heat pumps, the latent energy in air is used. So for for every kWh of energy you put in, you get between 2 and 4 kWh of energy back. This is transformational compared to gas boilers.

Example

FIGURE 3

Why Primary Demand creates the wrong measure of progress

Let's say you light your living room in rural India with a 75-watt normal lightbulb for five hours every night and consume 135 kWh per year. If you power the bulb with electricity from a coal plant with 35% efficiency and add10% grid loss, then you create a primary energy demand of 435 kWh.

The same amount of light can be delivered by a 10-watt LED bulb. India is moving rapidly to solar, so if you run the LED on local panels, you will consume 18 kWh per year and you will have reduced your primary energy demand by 96% and eliminated its CO_2 emissions. However, you have still delivered the same energy service.

Source: The Better India News

Energy lost to find, mine, refine and transport fossil fuels

Bloomberg New Energy Finance estimates that 15% of global energy is used to find, extract, and transport fossil fuels.

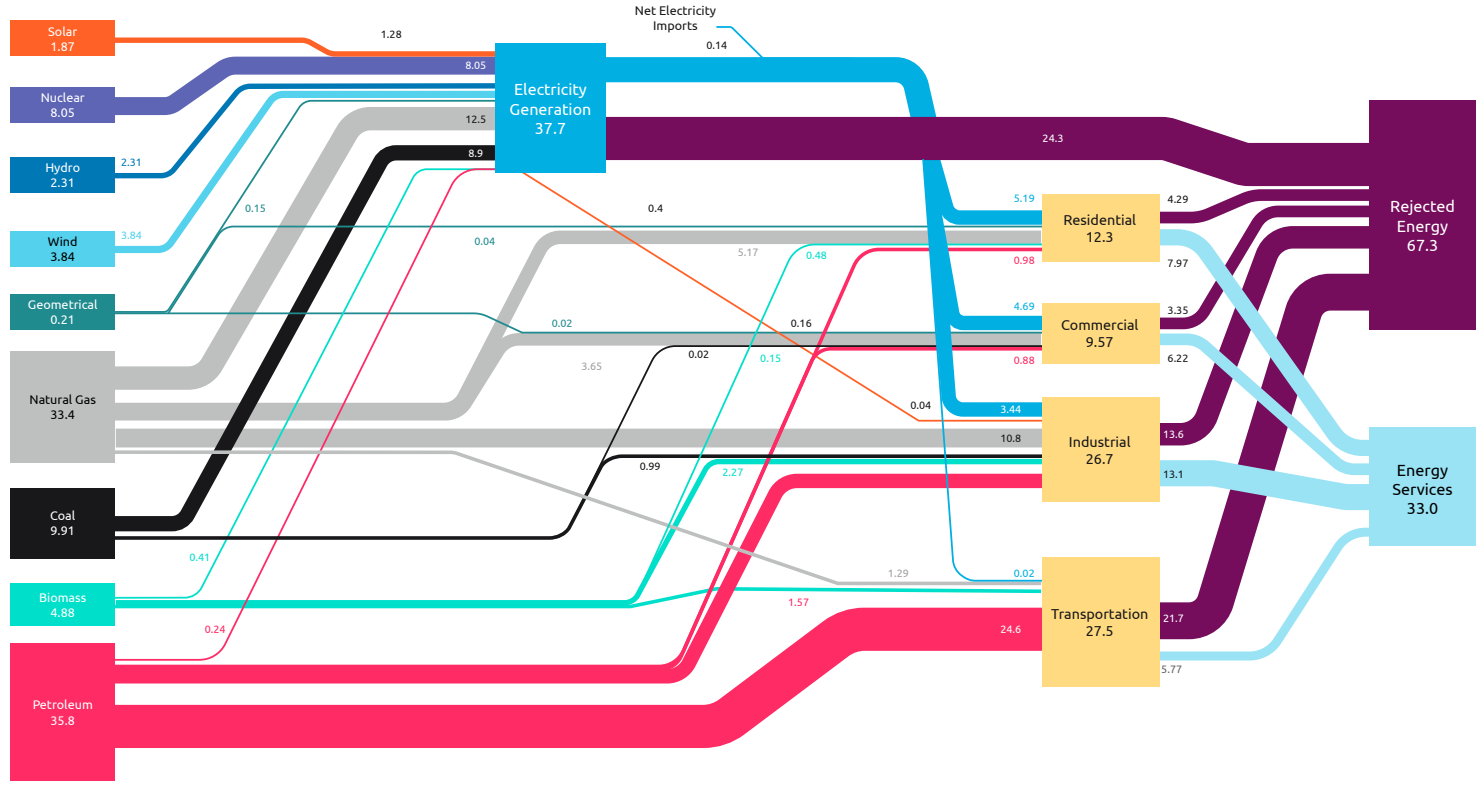
In the USA, oil and gas extraction consumes nearly 2% of energy; refining crude oil consumes nearly 8%, while transportation consumes approximately 3%.

Of course, we need to offset the savings here with the energy used to build new sources of generation, such as wind turbines, solar panels and expanding the use of batteries. In general, these costs are one-off and have a lot less energy consumption when compared to the yearly energy usage outlined above.

Putting it all together: The final numbers

FIGURE 4

Estimated USA Energy Consumption in 2022: 100.3 Quads



Source: Lawrence Livermore National Laboratory

Putting it all together: The final numbers

A good estimation of the how much energy we would use if everything was electricity is the Lawrence Livermore work in the USA. If we take the USA as a proxy for advanced economies, this analysis shows 67% rejected or wasted energy (see Figure 4 – this is shown in the Sankey diagram). This analysis also shows that if most services were electric and more efficient, then the USA would only need 33% of the energy it currently uses to satisfy the the existing energy services demand. However, we need to add back in the losses in the electric world, such as transmission and distribution losses.

Saul Griffiths has done some detailed work on all the energy services in the USA and estimates that if services were significantly electrified, the USA would need 42% of the primary energy demand today. Capgemini estimates that the range is 40-50%, depending on the take up of the new electrified energy services (e.g. the adoption of heat pumps and the electrification of industrial heat).

If we continue to use primary energy demand, we will over inflate the energy that the world requires, as we electrify our energy services and confuse government policy.

Therefore, the decarbonization challenge is a lot smaller than primary energy demand would suggest. The concept of primary energy demand is outdated and should shift towards a focus on energy services, emphasizing the amount of clean energy required to fulfill future needs.

Our Convictions

- Primary energy demand was a useful concept in previous energy crises.
- Today, with the energy transition well underway, it is an outdated concept.
- Retaining it confuses the progress that is being made to a low-carbon future and the electrification of energy services.
- It would be much better to to talk about the kWh required to deliver the energy services that the world demands.

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