SAVANNAH ENERGY

The troubled energy transition

How to find a pragmatic path forward

Daniel Yergin, Peter Orszag and Atul Arya
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In 2024 global production of wind and solar energy reached record levels – levels that would have seemed unthinkable not long before. Over the past 15 years, wind and solar have grown from virtually zero to 15% of the world's electricity generation, and solar panel prices have fallen by as much as 90%. Such developments represent a notable advance in what is called the energy transition – the shift from the current hydrocarbon-dominated energy mix to a low-carbon one dominated by renewable sources.

Yet 2024 was a record year in another regard, as well: the amount of energy derived from oil and coal also hit all-time highs. Over a longer period, the share of hydrocarbons in the global primary energy mix has hardly budged, from 85% in 1990 to about 80% today.

In other words, what has been unfolding is not so much an "energy transition" as an "energy addition." Rather than replacing conventional energy sources, the growth of renewables is coming on top of that of conventional sources. And with Donald Trump's return to the US presidency, priorities will focus again on conventional energy production and what his administration calls "energy dominance".

This was not how the energy transition was expected to proceed. Concern about climate change had raised expectations for a rapid shift away from carbon-based fuels. But the realities of the global energy system have confounded those expectations, making clear that the transition – from an energy system based largely on oil, gas, and coal to one based mostly on wind, solar, batteries, hydrogen, and biofuels – will be much more difficult, costly, and complicated than was initially expected. What's more, the history of past energy transitions suggests that this should not come as a surprise: those were also "energy additions", with each adding to rather than eliminating prior sources.

Daniel Yergin is Vice Chairman of S&P Global and the author of *The Prize: The Epic Quest for Oil, Money, and Power* and *The New Map: Energy, Climate, and the Clash of Nations.*

Peter Orszag is CEO and Chairman of Lazard and was director of the Office of Management and Budget in the Obama administration.

Atul Arya is Chief Energy Strategist at S&P Global.

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(L-R) Daniel Yergin, Peter Orszag, Atul Arya

As a result, the world is far from on track to achieve the often-stated target of reaching, by 2050, "net zero emissions" – a balance in which any residual emissions are offset by removals of emissions from the atmosphere. And there is no clear plan for getting on track or for delivering the magnitude of investment that would be required to do so. The International Energy Agency projected in 2021 that, for the world to meet 2050 targets, greenhouse gas emissions would need to decline from 33.9 gigatonnes in 2020 to 21.2 gigatonnes in 2030; thus far, emissions have gone in the other direction, reaching 37.4 gigatonnes in 2023 (and there's no reason to think that a 40% decline in just seven years will be remotely feasible). Other facts similarly reflect the challenges of transition. The Biden administration set a goal of electric vehicles accounting for 50% of new cars sold in the United States by 2030; yet that number remains just 10%, with automakers slashing investment in electric vehicles as they face multibillion-dollar losses. Offshore wind production in the United States was supposed to reach 30 gigawatts by 2030 but will struggle to reach just 13 gigawatts by that date. And Trump administration policy changes will make these gaps even larger.

Part of the problem is sheer cost: many trillions of dollars, with great uncertainty as to who is to pay it. Part of the problem is the failure to appreciate that climate goals do not exist in a vacuum. They coexist with other objectives – from GDP growth and economic development to energy security and reducing local pollution – and are complicated by rising global tensions, both East-West and North-South. And part of the problem is how policymakers, business leaders, analysts, and activists expected the transition to go, and how plans were shaped accordingly.

What is becoming clear is that the shift in the global energy system will not unfold in a linear or steady manner. Rather, it will be multidimensional – unfolding differently in different parts of the world, at different rates, with different mixes of fuels and technologies, subject to competing priorities and shaped by governments and companies establishing their own paths. That requires rethinking policies and investment in light of the complicated realities. For the energy transition is not just about energy; it is about rewiring and re-engineering the entire global economy. The first step in this rethinking is understanding why the key assumptions behind the transition have fallen short. That means grappling with the geopolitical, economic, political, and material trade-offs and constraints rather than wishing them away.

A transformation without precedent

Much of the current thinking about the energy transition took shape during the COVID-19 pandemic, when both energy demand and carbon emissions plummeted. These sharp declines sparked optimism that the energy system was flexible and could change quickly. That thinking was reflected in the International Energy Agency's May 2021 Net Zero Roadmap, which postulated that no investment in new oil and gas projects would be required on the road to 2050. Such thinking shaped the dominant theory of a linear transition, with emissions reaching net zero in many countries by 2050 (and later for some others, such as China, by 2060, and India, by 2070). This ambition, however, has collided with the magnitude and the practical constraints of completely overhauling the energy foundations of a US$115 trillion global economy in a quarter century.

The fundamental objective of the energy transition is to replace most of today's energy system with a completely different system. Yet throughout history, no energy source, including traditional biomass of wood and waste, has declined globally in absolute terms over an extended period.

The first energy transition began in 1709, when a metalworker named Abraham Darby argued out that coal provided "a more effective means of iron production" than wood. And the ensuing "transition" took place over at least a century. Although the 19th century has been called "the century of coal", the energy scholar Vaclav Smil has observed that coal did not overtake traditional biomass energy sources (such as wood and crop residues) until the beginning of the 20th century. Oil, discovered in western Pennsylvania in 1859, would overtake coal as the world's top energy source in the 1960s. Yet that did not mean that the absolute amount of coal used globally was falling – in 2024, it was three times what it had been in the 1960s.

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Abuja, capital city of Nigeria

The same pattern is playing out today. About 30% of the world's population still depends on traditional biomass for cooking, and demand for hydrocarbons has yet to peak or even plateau. The portion of total energy usage represented by hydrocarbons has changed little since 1990, even with the massive growth in renewables. (In the same period, overall energy use has increased by 70%.) And the global population is expected to grow by approximately two billion in the coming decades, with much of that growth taking place in the global South. In Africa – a demographically young continent whose population has been projected to increase from 18% of the global population today to 25% – almost 600 million people live without electricity, and roughly one billion lack access to clean cooking fuel. Traditional biomass energy still fuels almost half the continent's total energy consumption. As Africa's population grows, more people will require food, water, shelter, heat, light, transportation, and jobs, creating further demand for secure and affordable energy. Without that economic development, migration will become an even greater problem.

It's the economy

Past transitions, such as the shift from wood to coal, were motivated by improved functionality and lower costs, incentives that are not yet present across much of the entire energy system. The scale of the transition means that it will also be very costly. Technological, policy, and geopolitical uncertainty makes it challenging to estimate the costs associated with achieving net zero by 2050. But one thing is certain: the costs will be substantial.

The most recent estimate comes from the Independent High-Level Expert Group on Climate Finance, whose numbers provided a framework for the COP29 meeting – the UN's annual forum on climate change – in Azerbaijan. It projected that the investment requirement globally for climate action will be US$6.3 to US$6.7 trillion per year by 2030, rising to as much as US$8 trillion by 2035. It further estimated that the global South countries will account for almost 45% of the average incremental investment needs from now to 2030, and they have already been falling behind in meeting their financing needs, especially in sub-Saharan Africa.

Based on such estimates, the magnitude of energy transition costs would average about 5% a year of global GDP between now and 2050. If global South countries are largely exempted from these financial burdens, global North countries would have to spend roughly 10% of annual GDP – for the United States, over three times the share of GDP represented by defence spending and roughly equal to what the US government spends on Medicare, Medicaid, and Social Security combined. These costs reflect the pervasiveness of fossil fuels in modern society – not just oil and gas, but also the production of cement, plastics, and steel – as well as what Bill Gates has called the "green premium", with lower-emissions technologies being more expensive than those with higher emissions profiles.

In other words, achieving net zero will also require an unprecedented reorganisation of capital flows from the global North to the global South, which will necessitate substantial investments in renewable energy infrastructure at a time when, according to the International Monetary Fund, 56% of low-income countries are "at high levels of debt distress". While innovative financing mechanisms (such as debt-for-climate and debt-for-nature swaps) will help, low sovereign debt ratings throughout the developing world present a major obstacle to outside investment and raise capital costs. As a result, the bulk of the financial burden will be borne by advanced economies. But even there, debt has risen considerably – average public debt today is over 100% of GDP, a level not seen since World War II and a major constraint on governments' ability to finance the transition through public spending.

Financing by the private sector also faces challenges, and there is little indication that voluntary portfolio decisions will be adequate. Without a sufficient market incentive, either through some direct or implicit price on carbon or through regulatory requirements, expecting asset managers or investment advisers to voluntarily steer money toward transition-friendly investments will work only in limited circumstances. After all, asset managers have a fiduciary responsibility to follow the directions of the asset owner (such as a pension plan or insurance company), and ESG funds (those that invest in companies that consider environmental, social, and governance practices) in the United States have seen capital outflows in the last couple of years because of underwhelming returns.

Energy insecurity

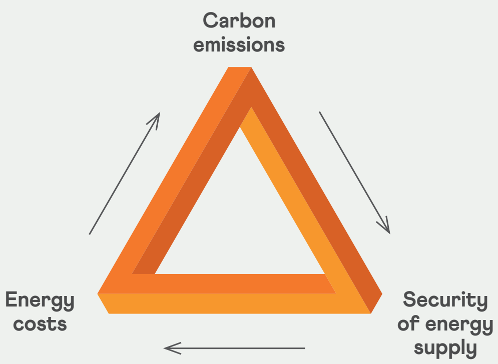
The next challenge is energy security, which was underappreciated until relatively recently. Although COVID-19 presented other, more pressing needs, Russia's invasion of Ukraine and the subsequent disruption to global energy markets put the issue back on the table. Even before the war, in November 2021, the US Government had tapped its Strategic Petroleum Reserve to address what President Joe Biden called "the problem of high gas prices". Since then, the United States has drawn down almost half the oil from that reserve to combat price shocks (although a modest refilling has begun).

European governments, suddenly caught off-guard, took steps of their own. After Russia cut off natural gas exports to Europe, German Chancellor Olaf Scholz flew to Canada to urge it to increase its flow of gas. Berlin is proposing billions of dollars of subsidies for new gas-fired electric generation to balance intermittent power from wind and solar and keep the lights on.

Governments simply cannot tolerate disruptions to, shortages of, or sharp price increases in energy supplies. Energy security and affordability are thus essential if governments want to make the transition acceptable to their constituencies. Otherwise, a political backlash against energy and climate policies will occur – what in Europe is known as "greenlash" – the impact of which is showing up in elections. Assuring that citizens have access to timely supplies of energy and electricity is essential for the well-being of populations. That means recognising that oil and gas will play a larger role in the energy mix for a longer time than was anticipated a few years ago, which will require continuing new investment in both hydrocarbon supplies and infrastructure.

"The trilemma of energy security, affordability, and sustainability looks very different in Africa."

The energy trilemma



The new divide

The biggest emphasis on reliable and affordable energy is in the developing world, where 80% of the global population lives. Indeed, a new North-South divide has emerged on how to balance climate priorities with the need for economic development. This is a key factor behind rethinking the pace and shape of the energy transition. In the global South, the transition competes with immediate priorities for economic growth, poverty reduction, and improved health. The trilemma of energy security, affordability, and sustainability looks very different in Africa, Latin America, and developing Asia than it does in the United States and Europe. As Malaysia's prime minister, Anwar Ibrahim, put it, "the need for transition" must be balanced against the "need to survive, to ensure that our present policies eliminating poverty in providing education, health and basic infrastructure" are not "frustrated because of the dictates of others that do not place adequate consideration on what we have to face".

At the moment, almost half the population of the developing world – three billion people – annually uses less electricity per capita than the average American refrigerator does. As energy use grows, "carbonising" will precede "decarbonising." Natural gas is a readily available option, and it's a better alternative to coal, as well as to traditional biomass fuels that produce harmful indoor air pollution. Although global oil demand seems slated to plateau in the early 2030s, natural gas consumption is expected to continue to increase well into the 2040s. Production of liquefied natural gas is on track to increase by 65% by 2040, meeting energy security needs in Europe, replacing coal in Asia, and driving economic growth in the global South.

The preference for economic growth is evident, for example, in the most recent budget in India, which depends on coal for about 75% of its electricity. Indian Finance Minister Nirmala Sitharaman has promised "energy transition pathways" that emphasise "the imperatives" of employment and economic growth in tandem with "environmental sustainability". It is also evident in Uganda, with a per capita income of US$1,300, which aims to build a multibillion-dollar pipeline running from its Lake Albert oilfields to a port in Tanzania that would enable selling into global markets. The Ugandan Government sees the overall project as a major engine to promote economic development, but it has been met with intense criticism and opposition from the developed world, including from the European Parliament.

The clash of priorities between the North and the South is especially striking when it comes to carbon tariffs. Many global North governments have, as part of their efforts to reduce emissions, put up barriers preventing other countries from taking the same carbon-based economic development path that they took to achieve prosperity. The European Union has launched the first phase of its Carbon Border Adjustment Mechanism. The CBAM is intended to support European climate objectives globally by initially imposing import tariffs on products such as steel, cement, aluminium, and fertiliser based on the carbon emissions embedded in their production and then expanding to more imports. Critics in the global North have argued that such measures would be ineffective because of the enormous complexity of supply chains and the associated difficulty of tracking embedded carbon in imports. Critics in the global South see the CBAM as a barrier to their economic growth. Ajay Seth, India's economic affairs secretary, has argued that CBAM would force higher costs on the Indian economy: "With income levels which are one-twentieth of the income levels in Europe, can we afford a higher price? No, we can't." To many developing countries, the CBAM, and the complex and burdensome emissions reporting it mandates, looks more like a wealthy part of the world using a carbon tariff to impose its values and regulatory system on developing countries that need access to global markets to grow their economies.

Policy asymmetries are apparent in emissions targets: China, India, Saudi Arabia, and Nigeria account for almost 45% of energy-related greenhouse gas emissions. None of them has a 2050 target for net zero emissions; their targets are 2060 or 2070. Similarly, while investment in new coal-fired power plants continues to decline globally, nearly all of the 75 gigawatts of new coal capacity construction that began in 2023 was in China. India has ambitiously set out to develop 500 gigawatts of renewable energy capacity by 2030, up from the 190 gigawatts installed capacity to date (and requiring a massive increase from the 18 gigawatts installed in 2023), but it is also committing US$67 billion to expand its domestic natural gas network between 2024 and 2030, and it plans to increase coal capacity by at least 54 gigawatts by 2032.

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Big shovels

A global economy in transition depends on another transition – a shift from "big oil" to "big shovels". That means much more mining and processing, driven by major new investments and resulting in much-expanded industrial activity. Yet the complexities surrounding mining and critical minerals represent another major constraint on the pace of the energy transition.

The International Energy Agency has projected that global demand for the minerals needed for "clean energy technologies" will quadruple by 2040. At the top of the list are such critical minerals as lithium, cobalt, nickel, and graphite, as well as copper. Between 2017 and 2023 alone, demand for lithium increased by 266%; demand for cobalt rose by 83%; and demand for nickel jumped by 46%. Between 2023 and 2035, S&P expects the demand for lithium to increase by another 286%; cobalt, by 96%; and nickel, by 91%. Electric vehicles require two and a half to three times more copper than an internal combustion engine car; battery storage, offshore and onshore wind systems, solar panels, and data centres all require significant amounts of copper. S&P's analysis of future copper demand found that global copper supply will have to double by the middle of the 2030s to meet current policy ambitions for net zero emissions by 2050. This is extremely unlikely, considering that, based on S&P data that tracked 127 mines that have come online globally since 2002, it takes more than 20 years to develop a major new mine; in the United States, it takes an average of 29 years.

There is another big obstacle: local environmental and social issues and resulting political opposition. Serbia, for example, in July 2024 signed an agreement with the European Union to develop the Jadar Project, which is set to produce 90% of the lithium-ion capacity necessary for Europe's battery value chains and electric vehicles. In August 2024, however, the agreement brought tens of thousands of marchers to the streets of Belgrade; one of the leaders of the opposition called the project "the absolute merger between the green transition and authoritarianism", adding that it could open "new doors to neocolonialism". This opposition united environmentalists and ultranationalists, reinforced by the same kind of disinformation Russia is deploying in European elections. A year earlier, large protests led to the closure of an operating copper mine that represented 5% of Panama's GDP. One of the proponents of the protests celebrated the opposition for thwarting the "gargantuan beast of extractive capital" and pronounced it a role model for protest in other countries. In the United States, the Thacker Pass lithium project in Nevada had initially planned to start production by 2026, following the approval of a US$2.26 billion loan from the US Department of Energy. The project, however, has faced significant opposition on the charge that it could damage water supplies and agricultural land and now is not expected to reach full capacity until 2028.

In short, the push for energy transition minerals is in tension with local environmental, political, cultural, and land use concerns and permitting obstacles. The energy transition will need to find a way to come to grips with this inherent tension.

The complications of competition

Geopolitical competition presents another complicating factor. The energy transition is increasingly intertwined with the great power rivalry between the United States and China. That is true not just when it comes to implementing targets, but also when it comes to the "green supply chain".

China already has a dominant position in mining and a predominant position in the processing of minerals into metals essential for renewable energy infrastructure. It accounts for over 60% of the world's rare-earth mining production (compared with nine percent for the United States) and more than 90% of the processing and refining of rare earths. It produces 77% of it, and processes over 70% of the world's lithium and cobalt and almost half the copper.

The complications of competition continued

Beijing aims to extend this dominance to what it calls the "global new energy industrial chain". with its commanding position in batteries, solar panels, and electric vehicles, as well as in deploying massive amounts of capital toward energy infrastructure in the developing world. With China's huge scale and low costs, Beijing describes this effort as an extensive and integrated approach to developing and dominating the renewable energy sector. From 2000 to 2022, it issued US$225 billion in loans for energy projects in 65 strategically significant nations, with about 75% of that directed toward coal, oil, and gas development. Between 2016 and 2022, China provided more energy project financing around the world than any major Western-backed multilateral development bank, including the World Bank.

The United States, intent on protecting its own green supply chains, has responded with unprecedented industrial policy initiatives and large investments, as well as tariffs on imports of exactly the items for which China is the leading producer: electric vehicles, solar panels, and batteries. In December 2024, China retaliated against those restrictions and controls on semiconductors by banning the export of rare earths to the United States on the grounds of "dual use" – the same language the United States uses to justify export controls to China – because they are used in renewable technologies, as well as by defence industries. The Trump administration is likely planning further tariffs on China. The growing tensions will likely slow the deployment of clean energy technologies, add costs, and constrain the pace of the energy transition. Governments are now mobilising to "diversify" and "de-risk" supply chains. But in practice this is proving very difficult because of costs, infrastructure constraints, time required, and the substantial roadblocks to getting projects permitted.

Electrical surge

Over the last year, a new challenge for the energy transition has emerged: assuring adequate electricity supplies in the face of dramatically increased worldwide demand. This is the result of a quadruple piling on: a coming surge in consumption arising from "energy transition demand" (for example, for electric vehicles); reshoring and advanced manufacturing (for example, of semiconductors); crypto mining; and the insatiable energy appetite of data centres powering the AI revolution. Some estimates have suggested that data centres alone could consume almost 10%of U.S. electricity generation annually by 2030; one large tech company is opening a new data centre every three days.

Electrification trends suggest that power demand in the United States will double between now and 2050. Electricity consumption is already outpacing recent demand forecasts. PJM, which manages electricity transmission from Illinois to New Jersey, almost doubled its growth projection between 2022 and 2023 and is warning of the danger of shortfalls in electricity before the end of the decade. All this means that the goal of achieving zero-carbon electricity in the United States by 2035 will be more challenging than it appeared during the slack years of the COVID-19 shutdown.

Indeed, it has become apparent that, in addition to batteries, natural gas will play a larger role in electricity generation than was forecast even two or three years ago. Utility-scale electricity generation from natural gas emits about 60% less carbon dioxide than coal per kilowatt hour of electricity produced. And reliance on natural gas has grown rapidly. In 2008, coal represented 49% of US electricity generation and natural gas 21%. Today, those figures have been reversed, with coal at 16% and natural gas at almost 45%.

Gas pressure valve at Savannah's Stubb Creek Facility, Nigeria

"A new challenge for the energy transition has emerged: assuring adequate electricity supplies in the face of a dramatically increased worldwide demand."

In California, which is at the forefront of efforts in the United States to promote renewable energy, wind and solar represent 27% of in-state electricity generation today, while 48% is generated with natural gas. Even as renewable energy generation grows, natural gas will play a larger role for a longer period to help meet the growing demand for electricity.

Transition trade-offs

In recent years, a number of major initiatives to advance the energy transition have taken shape – from the Inflation Reduction Act in the United States and the Green Deal in Europe to the COP28 Dubai Consensus, which called for "transitioning away from fossil fuels in a just, orderly, and equitable manner". It is increasingly clear, however, that governments and the private sector will need to navigate the energy transition while balancing energy access, security, and affordability. Investors, decision-makers, and policymakers outside the United States will be doing so in an environment in which White House priorities have markedly changed, from renewables to conventional energy.

The first step is to be clear about the nature of the trade-offs and the challenges and, as the economist John Maynard Keynes warned, not to "rebuke the lines for not keeping straight". In this case, the line will not be straight, so better to recognise than to rebuke.

One of these trade-offs relates to global trade at a time of rising protectionism and an effort by governments to “de-risk” supply chains by bringing them home or closer to home. The restructuring of energy demand and flows in the coming years creates difficult choices between lower costs, on the one hand, and diversification and the protection of domestic industries, on the other. Building the supply chains necessary to support both the energy transition and energy security will demand co-ordination among governments and with the private sector to improve logistics and infrastructure, permitting processes, technology flows, finance, and worker training. As these supply chains are reconfigured in the future, it is important that they be diverse rather than geographically concentrated. For example, in addition to reshoring energy manufacturing domestically, the United States and the European Union should also partner with Asian allies. A major benefit of diversification will be the ability to support the ambitions of the global South, as developing countries can leverage the same supply chains domestically and embed themselves as critical hubs in these new global links.

Another trade-off has to do with the mining and processing essential to clean energy technologies. Today’s lengthy permitting and regulatory approval processes threaten the supply of minerals necessary for the energy transition. Investments in new mines often fail to meet the variety of ESG criteria used by private investors and multilateral development banks, thus curtailing capital flows and creating further bottlenecks. Consistent criteria must address environmental concerns while accelerating investments in new mines for needed minerals.

Any path to emissions reductions will have to go through the global South, because that is where substantial growth in energy demand will be. Yet its nations face particularly daunting challenges in attracting the capital necessary to move away from cheap, coal-based sources of energy (or from wood and waste) in large part because renewable energy projects often entail high upfront capital costs, long-term investment horizons, and policy and regulatory uncertainties while natural gas projects are rejected on ESG grounds. A combination of multilateral grant funding and more private investment is necessary to increase the flow of money to the global South.

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Ever since Abraham Darby switched to coal from wood more than three centuries ago, technological innovation has been central to every evolution in energy production. Investments in and research, development, and deployment of clean energy technologies have driven significant declines in cost for solar and wind. Yet new low- and zero-emissions technologies are needed for end uses other than electricity. In the United States, the Bipartisan Infrastructure Law, the CHIPS and Science Act, and the Inflation Reduction Act together are intended to accelerate growth in renewables, electric vehicle deployment, and energy innovation, including making technologies such as carbon capture and sequestration, hydrogen, and large-scale electricity storage commercially viable. But it is still too early to ascertain to what degree those programs will be reduced and reshaped under the Trump administration. What is striking today is renewed support for the role of nuclear energy, for both existing and advanced technologies, as a necessity for transition strategies and reliability. That is reflected in the growth of public and private investments in nuclear fission and fusion technologies. But also required is investment in new technologies that today may be only a gleam in some researcher’s eye.

Today’s energy transition is meant to be fundamentally distinct from every previous energy transition: it is meant to be transformative rather than an additive. But so far it is “addition”, not replacement. The scale and variety of the challenges associated with the transition mean that it will not proceed as many expect or in a linear way: it will be multidimensional, proceeding at different rates with a different mix of technologies and different priorities in different regions. That reflects the complexities of the energy system at the foundation of today’s global economy. It also makes clear that the process will unfold over a long period and that continuing investment in conventional energy will be a necessary part of the energy transition. A linear transition is not possible; instead, the transition will involve significant trade-offs. The importance of also addressing economic growth, energy security, and energy access underscores the need to pursue a more pragmatic path.

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