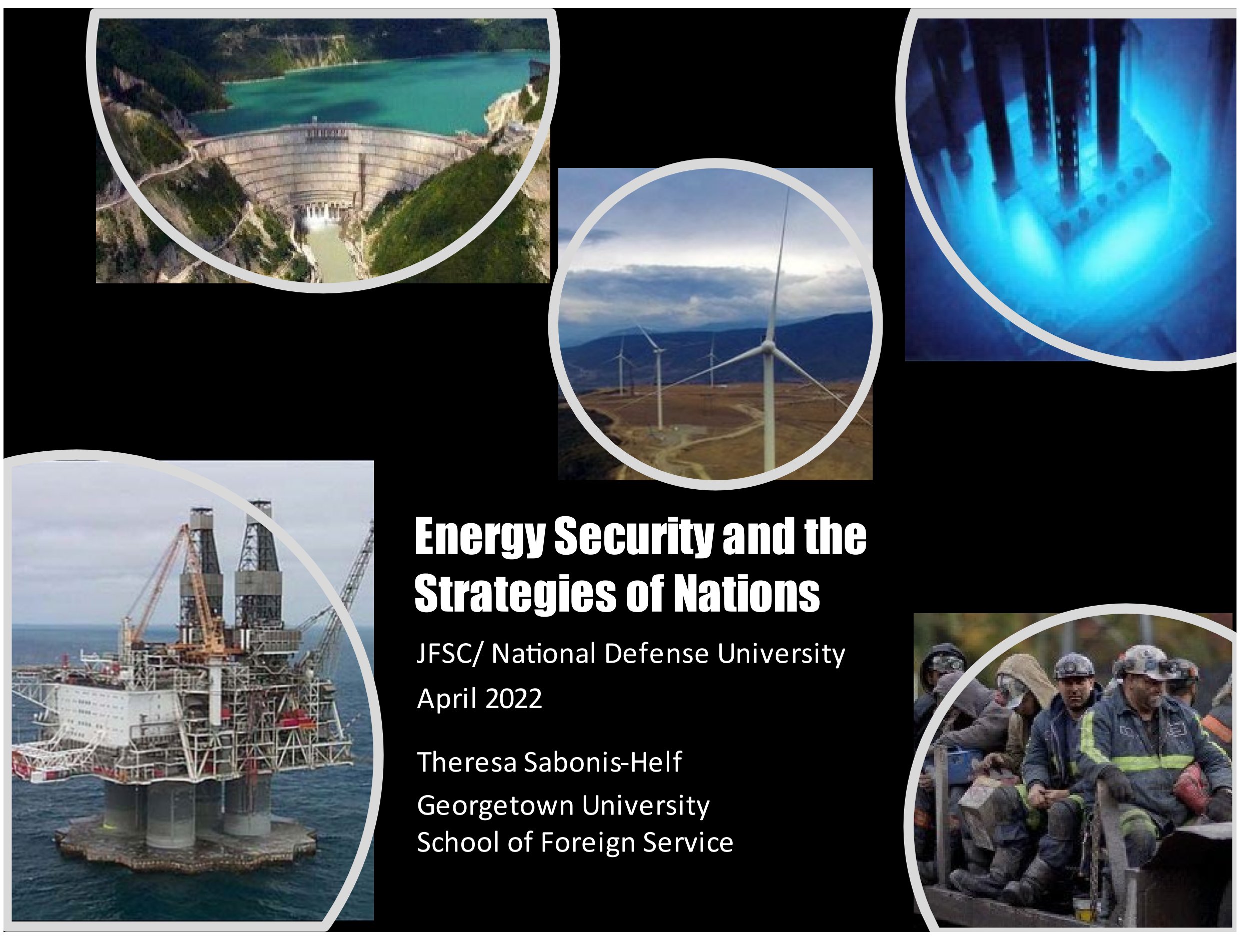
Energy Security and the Strategies of Nations, Part 3

The following article is a transcript from a presentation made to Joint Forces Staff College faculty and students. The Editorial Board initially considered publishing the question and answer portion of the presentation, but decided that the content held significant value and should be published in its entirety. Campaigning *debuted Part 1 in September 2022 and Part 2 appeared in November 2023. In this final installment, Dr. Sabonis-Helf engages in question and answer with attendees. The conversation captured in this transcript is wide-reaching.* Campaigning *inserted keywords to facilitate readers finding questions and responses most pertinent to their interests.*

Presented by [1]
Theresa Sabonis-Helf



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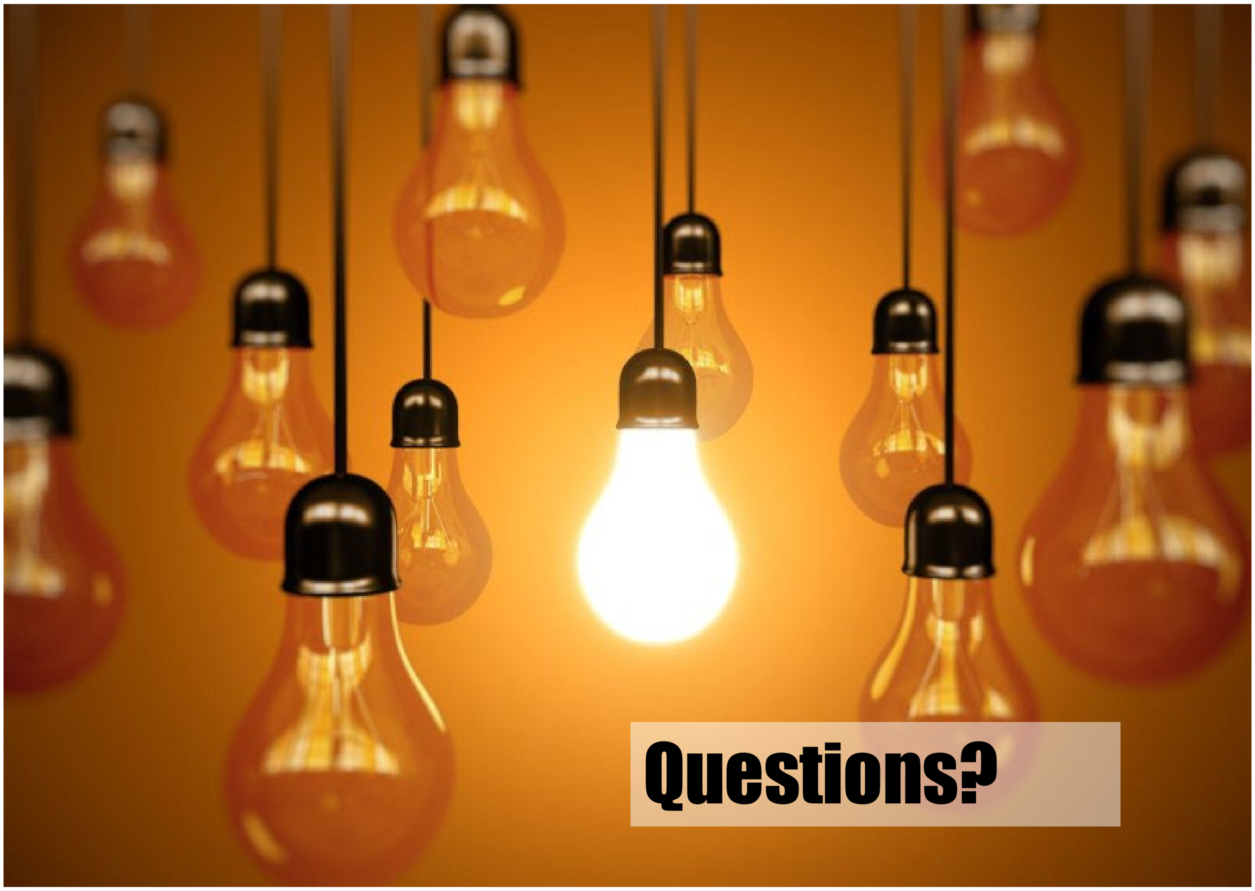

Figure 1: Questions? Source: https://depositphotos.com/11915796/stock-photo-idea-concept.html

Editor's note: Part 3 is the final installment of the Dr Theresa Sabonis-Helf presentation to the JCWS-Hybrid class 22-1 on 15 April 2022, the first time Hybrid program have been back in the JFSC building since COVID. Their questions and exchange with Dr Sabonis-Helf were both incisive and insightful, potentially leading to follow-on articles in *Campaigning.*

Student 1: On average, how much do natural gas proven reserves change each year? Are proven reserves trending upward or downward, is the world using more natural gas than it is finding?
Keywords: proven reserves, natural gas
Keywords: proven reserves, reserve trends, natural gas

Sabonis-Helf: That's a great question, and actually, proven reserves vary with price. "Proven reserves" is a legal category. It means how much do you know is "in there" that you can get out with existing technology at or near the current price. Proven reserves go up not because we're finding more necessarily, but because we can economically recover more of what we know is there. At the present time, proven reserves continue to grow for oil and gas. The only natural resource where proven reserves are in decline is coal. And that's because industrialized society has been using coal for the longest of all of those resources.

Student 2: How do you see the effect of a potential all-electric automobile industry within ten to fifteen years reducing the dependence on oil, and will the net impact on [the U.S.] carbon footprint improve or just shift?
Keywords: electric auto industry, oil dependence, internal combustion, carbon emissions

Sabonis-Helf: Well, it will improve significantly—dependence on oil will decrease. Oil is most important in mobility, so when you're moving stuff around, it's hard to get a better deal with entropy than oil, and so we use it for mobility. (The idea is that the amount of energy for the space required (the energy density) is very favorable.) The U.S. probably will continue to use it for a longer period of time for mobility in the sense of airplanes and heavy vehicles and so on. Moving away [from oil] for automobiles is desirable for a couple of reasons, and this is widely misunderstood, so I want to call your attention to it.

The first reason has to do with local air quality. The more densely populated cities are—and the trend all over the world, including in the U.S., is for cities to be more dense—the harder it is to maintain air quality of an acceptable standard. Automobiles as a point source of emissions are hugely problematic, and shifting them to electricity, regardless of the source of that electricity, dramatically improves urban air quality. Shifting vehicles to electric shifts a significant source of emissions in cities. Vehicles with an internal combustion engine (unless they're hybrid) stuck in traffic and sitting still with the engine running is when the vehicle emits the most. When you shift to electric, that is no longer the case. When you shift to hybrid, that is also no longer the case. Urban local air quality is hugely important. It's not that we're getting more and more aggressive about air quality, it's not that we keep making the standards higher and higher, it's that as our cities get more and more dense, meeting the old standards gets harder and harder.

Second, building a grid that is more stable requires finding either better ways to store electricity or better ways to shift the way we use electricity. At the present day, every grid in America has two challenges, and we can describe these as the 2:00 AM challenge, when nobody's using very much electricity, and the 6:30 PM challenge, when the grid is under strain because everyone is using the most. Shops aren't closed yet. Some industry is still winding down. People are at home preparing dinner, charging their devices. Every grid is under strain at 6:30 PM. What we want is to try to level off that demand a little bit, and there's a couple ways to do that.

One is moving electricity across time zones, because if it's always 6:30 somewhere, then you can stabilize the grid more readily. Another way is to shift demand. If we incentivize people to charge their electric vehicles at night, that actually helps stabilize the grid. Regardless of what the source of electricity is, spreading that demand out a little bit better across time enhances the stability of the grid, reduces the challenge of integrating more renewable energy, and overall makes it easier to do the transformations we need to do with our grids.

Now you might have caught a problem here, and that is if you drive your Tesla home from work and plug it in at 6:30 PM, you're not helping. You're putting the grid under new and additional strain. Shifting the way people charge vehicles as we get more and more vehicles on the grid is going to be important. We can do that either through the way we charge for electricity through timed chargers or through shifts in technology, but essentially one of the things we have to do is transition in some way. To the question about does that have a net impact on our carbon footprint—it does absolutely, and if we do it right, it is pretty significant.

Student 3: Which has more leverage, water or energy, being that water is a basic human need, while energy is a nice to have?
Keywords: water, energy tradeoffs, renewable and combined cycles

Sabonis-Helf: I'd like to say that I've made my career in energy, but water is my hobby because I think in the end, it will be more important. The reason why that's a future and not a present issue is that it's not just about which one's more critical, it's about where do we feel the scarcities, and how do we respond to those scarcities, and the scarcity of usable water, usable for human communities, is now beginning to rise, and it will be increasingly important.

But the other thing about your question is that we talk a lot about the water-energy nexus; water and energy are very profoundly connected. When we have droughts, that has an impact on all of our forms of energy because all of our power plants—well, not all, most of our power plants, with the exception of renewable and combined cycle—use huge amounts of water flowing through the plant in order to convert energy into electricity, so we use water in production of energy. If we're trying to desalinate, we use energy in the production of water, so these two things are very intimately linked, and of course the third link in that chain is food. There is a food-water-energy nexus that is extremely important, and we can come back to that in a moment because I suspect somebody's going to have a question about that.

Student 4: How do you see the rising rate of urbanization affecting the energy dynamics in the future? It is projected that 75% of the world population will be in cities by 2050.
Keywords: energy dynamics, urbanization, energy footprint

Sabonis-Helf: It profoundly affects water dynamics. What we see is that water demand grows currently at the rate of two times the rate of population growth because of urbanization. In terms of energy, it cuts actually more than one way. In some ways, urbanized individuals use more energy per capita than rural, but it also makes it easier to transform systems, so it's a little bit hard to say. I would argue that if you can reimagine your cities, if you build cities with energy efficiency in mind, as China is doing with some of its new cities, urbanization can actually reduce the energy footprint per capita. But if you're adding on to already existing urban areas and you're not rethinking your systems, then you don't gain some of the efficiencies.

Student 5: Where do you see opportunities for new security blocs/new emerging nations based on energy security over the next ten to twenty-five years?
Keywords: energy security, energy futures, renewable energy security, energy transformation, emerging nations

Sabonis-Helf: Great question, but it really depends on the form of energy. Think about Europe. For the countries that are energy poor, shifting to renewable energy is a win-win. It enhances their security. It enables them to try to capture a lead in a high-tech industry that will create more jobs. For a country like Germany, energy transition is a win-win. For a country like Poland, with lots of traditional energy, with lots of coal, with lots of employment in coal, the energy transition is a win-lose. In some respects, it will improve air quality. It will improve quality of life, but they are going to lose industries that have so far been important. What is going to be interesting to see is, how do the countries that see energy transformation as a win-win interface with the countries that see it as win-lose? The European Union is a big experiment in how to do that as equitably as possible and how to reduce the tensions associated with that.

But if we step back from that and ask the question, what are the new emerging blocs? China is very energy hungry, very energy thirsty. China is also trying to lead the world in renewable energy at the same time that it has very strong alliances and relationships with both Russia and the Middle East. The thirst for energy will continue to shape Chinese energy policy for a long time into the future. The same thing will be true of India. Both countries have argued that they should not have to transform their energy sectors until ten years after they see a real transformation among the developed countries. What we're seeing is that because countries are staggering their transition, because the developing world argues that they should do this more slowly than the developed world, you will see energy alliances shift in location before they shift to something new and different.

Regarding new emerging nations and new emerging blocs, I think even as Europe uses less and less oil and gas, China's going to continue for a time to use more and more. The same thing is going to be true of India. In terms of new security blocs, I would argue that though we're used to seeing diffusion of technology as a threat, for example, China's stealing our technology and our intellectual property, in renewable energy or in next-generation energy or energy efficiency, there is a global interest in diffusing those technologies as rapidly as possible as much as possible. This is currently the European narrative. It is not the United States narrative, but I would argue that for emerging nations (including China) to work very closely with developed nations in order to be able to do next-generation energy without having to go through a period of profound dependence is actually an important component of good foreign policy, good security policy for the next decade going forward.

Student 6: Do you see other large countries having longer term energy strategies that bridge time and political parties unlike the United States, which pulled out of the Keystone Pipeline? You don't see this happening with Russia and China.
Keywords: long-term, energy solutions, energy strategy, competition, infrastructure, pipelines, Keystone Pipeline, synthetic fuels

Sabonis-Helf: Okay, let me break that into two parts, because I want to answer your question about long-term strategy, but I want to separate it from the question of the Keystone XL pipeline. In terms of longer-term energy strategy, not only are nations that can see further into the future and plan at an advantage, but nations that are still building out their infrastructure are at an advantage because we're talking about some significant transformations of infrastructure and that poses a challenge to everyone but nations that are expanding and growing can address that differently.

Imagine for a minute the problem that Europe is facing right now. They've already said they want to stop building new natural gas infrastructure. How do they square that with trying to move off of Russian gas? Does that mean they have to use Russian gas until they're done? Does that mean they have to rethink what infrastructure they want and need? What do they have to reconsider? If you've already got infrastructure in place, it's a different question. If you're building it for the first time, it takes you in a fundamentally different direction, but you are right, we need some long-term vision absolutely. But part of the long-term vision problem has to do with how you balance those three factors.

Now to your point on the Keystone Pipeline. Let me raise a couple of things. The Keystone Pipeline got really mired in partisan debates, and people missed a couple of the most important underlying issues about the Keystone XL. First, let's go all the way back to oil sands. Oil sands are a natural resource that is essentially somewhat between oil and coal. You can convert it into oil, but in order to do that, it requires a pretty large infusion of water and natural gas. Synthetic oil, oil-sands oil, is extremely caustic, so it has a lot of sulfur in it. It needs a lot of cleaning. It also is so viscous that in some locations you actually have to warm it before you can move it around to keep it from solidifying. In order to get that product to market, it requires a very high steady price of oil for it to be cost-effective. The way that you could make it cheaper is to move it through pipelines, and those pipelines in some places are heated pipelines to keep it moving because unlike the conventional oil of Alaska, the synthetic oil of Canada is *synthetic*—it requires a lot of intervention and inputs.

Canada is our ally. The U.S. would like them to play an important role in world markets. The U.S. would like to help them. But does the U.S. want to get this product to world markets? That raises some interesting questions. It is attractive to refine the synthetic oil in the Louisiana area because many of those refineries are designed to handle Venezuelan crude, which is also very sulfurous and relatively viscous. But what's the problem here? Well, the problem is actually U.S. law. Under U.S. law, it is illegal for the U.S. government, to include the U.S. military, to use a synthetic fuel that is significantly more polluting than oil. We put that law in the books to keep from doing lots of research into creating fuel out of coal, because South Africa creates jet fuel out of coal. It can be done. It is incredibly polluting. The United States made a decision quite a long time ago not to go there.

Here's the problem. Canadian synfuel is a synthetic fuel that is more polluting than oil, so it is illegal for the U.S. military or the U.S. government to use it. Not illegal to sell it, not illegal to sell it to the world market, but illegal to use in America. Does it serve the U.S. interests to help an ally get a fuel product to market that is more polluting than oil and illegal to use in the United States? That's actually a pretty complicated question; that's not a simple partisan issue. Do our alliances trump the environmental concerns? Does the fact that without the Keystone XL, much of this will never get to the market? Does the fact that the market is currently in transition and this kind of synthetic fuel will be the first to go? How do we think about all these things? The problem in the United States is not just partisanship. It's that we take a complex problem like Keystone XL, and we want to flatten it and simplify it into sound bites, when in fact it is a fairly sophisticated complex problem.

Add to that the final point about Keystone XL. It is much more important than people give it credit for, and that is because the synthetic fuels of Canada are so caustic, the design of the pipeline itself has to be different. Keystone XL is called that because Keystone already exists. Keystone is a pipeline that moves synthetic fuel to market, and that pipeline has experienced repeated melt-throughs because the synthetic fuel is highly caustic. The design of Keystone XL did not take that adequately into account, so the groups that are saying, “what if this pipeline leaks?” are not posing something that is a pointless argument. Keystone is more prone to melt-throughs and leaks than almost any other pipeline. If you're going to build a new one, do you build it the same as Keystone and put a highly caustic fuel through it, or do you have to reimagine it? That's another thing that has to factor into our equation. The Keystone XL pipeline debate is not simply one party says, “let's go,” and one party says, “let's stop.” It is a very complex set of questions about alliances. What forms of energy are acceptable, and how do we think about the future?

The other thing about Keystone XL is that there was a short-lived debate in the United States. Can we shape this pipeline so that the U.S. can get some of the oil from the Bakken into that pipeline? Because the oil in the Bakken is still all in tankers. And the decision of the people who own Keystone XL was no, we're not going to do that, so there's yet another question. If the United States needs more infrastructure to move energy around, do we prioritize conventional energy over unconventional oil? Do we prioritize U.S. oil over Canadian oil? Do we do none of these things? As you can see, this is actually a really sophisticated issue, and we have managed it extremely poorly on both sides.

Student 7: Putin has said recently that Russia should pivot energy exports to Asia. Is that realistic? And what would that mean for Russia-China, Russia-Europe relations?
Keywords: Russia, pivot to Asia/Pacific, Sino-Russian relations

Sabonis-Helf: The pipelines that serve China and Russia already serve China pretty extensively but those pipelines do not connect to the same fields that serve Europe. To redirect, particularly to redirect with natural gas, requires the building of a lot more infrastructure. Probably Russia will have to do that, but that's going to take time, and it's going to be expensive. The pipelines that already exist that serve China are so extensive that it is no cheaper to move gas in pipelines than it is to move gas in sea lanes just because the pipelines are so long.

Europe's a more attractive market. They pay better. They don't negotiate in bulk the same way that China does. The infrastructure to go to China is going to be expensive to build. That probably is the long-term move, but Russia does not have the option to do that with gas. With oil, Russia kind of has the option to do that and kind of doesn't. In order for China to shift all of its imports to Russia right now, China would have to let go of some of the contracts or to decide they're going to use less of the oil that they're buying from the Middle East. And China is trying to cultivate a range of sources to reduce its own vulnerability. Yes, China will take more Russian oil, but no, China does not want to become fully dependent on Russia for its supply. Certainly not after watching what has been unfolding in Europe. There's a set of political questions to make that are a little bit unrealistic, and there's a set of infrastructure questions that make those medium term not immediate term decisions.

Student 8: In the shift to electricity and battery technology, can you elaborate on the immense strain on rare earth metals/minerals?
Keywords: lithium, Salton Sea, California, energy storage infrastructure

Sabonis-Helf: There is a considerable short-term strain; however, we also know that when you find value for a commodity, you begin to pursue it differently. I don't mean to suggest that this will solve all the problems, but I want to give you an example of something fantastic that's happened this year and I want to do that because 2022 has not developed a reputation for being a fantastic year. Out in California, at the Salton Sea—the big salt lake in California—there had been a geothermal facility that was producing electricity using the natural pressure and steam from geothermal. At that facility they had a persistent problem, which was that the stuff that was coming from deep in the earth was very corrosive and contained all kinds of contaminants. What to do with that nasty stuff was a big problem. In the past year they have done the analysis and research. They knew this for a long time, but the extent to which it was true they did not know. They've discovered that "that nasty stuff" that was gunking up the works at the geothermal facility is lithium.

Now think about this. This is coming from deep in the earth. It is a byproduct of producing electricity. What has happened is that geothermal facility has now been removed from the grid and it's going to be devoted entirely to getting that lithium out of those deep earth fissures, and the financing for it has come from the automobile industry in the United States, which is very excited to find a new source of exploitable deep earth lithium.

My point is that a lot of what we've treated as waste or a lot of what we've treated as not cost effective, in fact, can be very important if the price signals change. The same thing is true with horizontal drilling and fracking. A lot of what's getting in the way of what we thought we wanted may end up being useful. I would argue that this new pressure on rare earth elements is actually going to lead to some major breakthroughs in how we mine, what strata of the earth we mine, and what we're doing with those mined products. The lithium mine that's unfolding now in the Salton Sea is sort of next-gen strategic materials, and I think it won't be all of the future but part of the future. The other issue is that we are almost at a point where there's enough lithium in circulation that it's cost-effective to recycle. When we begin recycling lithium, that's going to have a substantial impact.

But you're absolutely correct that the existing mines right now for a number of the important materials are under huge strain, and these are materials we need for windmills. These are materials we need for batteries. These are materials we need for solar panels. What we're seeing is the supply chains—supply chains even for stuff we already consume—are problematic right now. The supply chains for strategic minerals are very problematic right now. I see that not as a huge long-term problem, because what I'm seeing is a lot of substantial innovation.

Student 9: Given potential flashpoints with China in Northeast Asia and the South China Sea, the PLA can potentially block or inhibit sea lines of communication (military exclusion zone or MEZ) in a crisis. How do you assess the likelihood of the PLA potentially controlling strategic choke points in a time of crisis to impact freedom of commerce, trade, and navigation?
Keywords: energy transportation, sea lanes, blockades, energy commodities

Sabonis-Helf: I see China's concerns here as being a little bit at odds with itself because China is so dependent on imports through the South China Sea that to start shutting down lines, they would do at their own peril. I think China is very afraid that the U.S. will shut down sea lanes. It is possible that they could shut down some of the sea lanes, but it would really raise the risk to China enormously. Because of their dependence for oil, for gas, for all kinds of commodities, China, in my estimation, has shown more interest in development of the new sea lanes through the Arctic than they have in the capacity to shut down. There may be some circumstance in which they would find it to their advantage to do so, but the downsides to China would be extraordinary, and I'm not sure why they would want to. I can imagine scenarios in which they might choose to do that, but the implications would be pretty profound.

Student 10: What do you see as the future of nuclear power? Either with conventional light water reactor designs or some of the more modern fourth generation or small modular reactor designs.
Keywords: nuclear energy, nuclear futures, reactors: convention, light water, modular, compact

Sabonis-Helf: I'm really glad you asked that, because I usually talk a lot more about nuclear. I haven't been talking about it as much recently because of all that's unfolding in Russia. But I'm very excited about the fact that it looks like we're very close to getting the first small modular reactors in the United States built in Alaska. I don't think the United States has international credibility in small modular reactors until we're using and showing the capacity to regulate some of them on our own territory. I'm very pleased to see that we're moving in that direction. Small modular reactors have a number of advantages. One of the advantages from the U.S. perspective is that the U.S. grid, as it's currently configured, does not need more, large base load. If you take a 1,000-megawatt power plant and slap it onto our grid, you're not really helping, because the grid is built out enough that we only need power at that 6:30 in the evening peak point when the grid is under strain. Nuclear does not work well for peaking. It's baseload, you have to leave it on at the same level all the time. Small modular reactors are a better fit for a mature grid.

It's taking the U.S. a very long time to implement small modular reactors in part because it requires a different kind of regulation. One of the big challenges that the regulatory agencies have in the United States is that every nuclear power plant in the United States is built along different design specs, and that makes it hard to regulate. The regulatory apparatus only accepts one type of reactor because there's so many variations on that type. Small modular represents a new type and getting the regulatory system spun up to do that has been hard work for the industry and for the regulatory agencies, but I think we're finally getting there.

I'm also very excited about the future prospects for compact nuclear fusion. Some years ago, I believe now it's already seven years, Lockheed Martin opened the Skunkworks, their corporate proprietary research facility, to invite academia and the government in to have a look at their compact fusion reactor, which they said was very close to being ready. And of course they can't use it unless they can bring the regulatory system along. They have an obligation—everyone in the nuclear industry has to bring the government along and make sure that the technologies and the risks are clearly understood. Everybody went to have a look, and in the assessment of DARPA, the reactor was not as close as Lockheed said it was, but it was closer than DARPA expected.

In the years since, we've seen a lot of research unfolding on compact fusion. Now we've been able to do fusion since 1950s, but the reaction releases such an enormous amount of energy all at once that all the energy, the surplus energy, is used to contain that reaction. In other words, it's a very cool science project, but useless in generating energy terms.

Compact fusion is the idea that you can manage the reaction in a way that there's still a lot of surplus energy. If the technology is correct in terms of the specs that we've seen, it would be a profound transformative technology. The reason why I'm optimistic is that in the past year and a half, we've seen a flurry of patents applied for in compact fusion technologies. Who's applying for those patents? MIT, CalTech, the U.S. armed forces—that flurry of patents makes me think that we are now in a moment where we actually are quite close. That doesn't mean we'll instantly use it as a technology near people. It will probably be pioneered as a naval technology, and we'll probably have some space applications for it before we start putting it in a neighborhood near you. But I do think that compact fusion is a very important breakthrough.

You're raising the issue of new scale. And yes, that I think my previous answer got to that. We are moving into a world where small and medium nuclear is going to be important in the UK, possibly in Europe, and may even finally develop in the United States.

Student 11: Russia made progress with a nuclear plant in Turkey, do you see the progress and comfort in "small/medium" size nuclear reactors fighting the environmental concerns? My recent reading on NuScale has shown success with Japan and Kazakhstan partnerships.
Keywords: nuclear, nuclear power plants, scale of nuclear power plants

Sabonis-Helf: My previous answer got to part of that with regard to NuScale. We are moving into a world where small and medium size nuclear reactors is going to be important in the United Kingdom, possibly in Europe and the United States and maybe going forward.

Student 12: Following Russia's invasion of Ukraine, actors across the globe collectively reduced Russian reliance on energy. This is an amazing feat of economic statecraft and a deliberate effort to reorient supply chains away from strategic competitors. Based on these observations, how do you assess China's calculus shifting or impacting their potential decision to engage in a crisis/conflict involving Taiwan?
Keywords: lessons learned, lessons not learned, conflict and energy security, multipolarity, risk, strategic clarity

Sabonis-Helf: I really think that the lesson that China has learned from Russia is that although we are moving into an era of multipolarity, and although there will be some inevitable competitions about whose sphere of influence belongs to whom, I don't think Russia expected either the Ukrainian level of resistance or the extent of European support. I think that China is taking the lesson that moving on Taiwan is higher risk than they might have assessed before the Ukraine conflict. If Russia had won an easy victory in Ukraine, then Taiwan would be much more at risk than it is today.

A lesson I'm afraid China has not yet learned from Russia, and I'm stealing this from a good friend of mine who is actually a China scholar,[2] is that when leaders stay around too long, the information that they get degrades over time. I don't think Xi has learned that yet, but I do think that Xi has been in power in China long enough that the number of people willing to tell him when he's wrong and the quality of intelligence he is receiving has inevitably downgraded. And I do think that is one of the big things that has happened in Russia. It is simply more and more

[2] Edward C. Chow, Testimony Before U.S.-China Economic and Security Review Commission, Hearing on China's Energy Plans and Practices, March 17, 2022, Panel II: China's External Energy Policies. Source: https://www.uscc.gov/sites/default/files/2022-03/Edward_Chow_Testimony.pdf Comprehensive hearing agenda located at https://www.uscc.gov/hearings/chinas-energy-plans-and-practices

difficult to find anyone who will tell truth to power. If the leader has been absolute and has been in place long enough to start getting rid of everyone who disagrees with him—I think we're seeing that going on. It is particularly dangerous because in a period where power is shifting into a more multipolar world, really good information, or good understanding of the risks and signaling the likely consequences of decisions becomes more and more important. Instead, we are at a moment where things are *unclear* and two of the world's most militarily enabled leaders are not getting good information.

Student 13: If the world shifts to electric cars, how do we manage the environmental impact of disposing of millions and millions of batteries in future decades as they wear out?
Keywords: recycling, lithium, infrastructure recycling, risk, risk management, energy efficiency, less use/lower demand

Sabonis-Helf: Part of how we manage that is recycling the lithium. Part of how we manage that is thinking about that entire supply chain. You are not wrong to worry about that. It is an issue that's being built already into how people think about the future. But I don't think that if we were to take that argument and push it in a different way—to say that continuing to mine and burn coal instead of shifting to batteries because we know the environmental risks associated with coal, and we don't yet know what the environmental risks are associated with batteries. It's a problematic argument because we know the risks associated with coal, and they're quite high.

Managing risk is an important thing that we have to go forward and do a better job of. What we didn't do in the past was to think at all about the risk associated with upper atmosphere pollution. The greenhouse gas impacts were simply not incorporated into any of our calculus. When we begin to incorporate those impacts, nuclear becomes more attractive, coal becomes less attractive, figuring out how to manage batteries becomes more necessary. But we simply have to incorporate these things, but we also have to understand that we were not counting at all on something that has become a substantial risk, and we have to think about how we move into this next generation, even if it brings new risks with it.

The only thing in energy that does not bring risk, the only thing that is all good, is efficiency in using less. When we look at what has happened in, let's say, natural gas, one of the reasons why burning natural gas is such a win for the United States—it is still a fossil fuel, the upper atmosphere greenhouse gas pollutants are lower, the local smog level pollutants are dramatically lower, and the efficiency of a state-of-the-art combined cycle gas power plant is so much higher. If you're using an old-style power plant where you're burning a fossil fuel to boil water and using that water to spin a turbine, in many instances, you're only capturing as electricity 30 percent of the energy you are burning. In a combined cycle plant that's well managed, you're capturing up to 65 percent. That is an efficiency that is incredibly important. Efficiency in creating electricity, efficiency in using electricity—we have to get more serious about that very unsexy bit of how do we squeeze more out of everything we use rather than just saying, "okay, let's make more." Find a new way to make more. Let's use better. Let's figure out ways to use better. When the incentives shift, we're very good at that. Think about how lighting in the United States has been completely transformed in the past fifteen years.

Student 14: What is the role of and/or African experience with the changes and challenges?
Keywords: Africa, off-grid energy, urgency, energy transmission

Sabonis-Helf: There's actually some really great stuff going on about African electricity right now. I recommend taking a look at what the UN is doing. There was a period when we looked and said, “wow, if we could do perfectly efficient solar energy across a very small square of North Africa, we could power all of Europe.” There were some real problems with that. Concentrating all of our source of energy in one place, using North Africa to light up the rest of Europe before we lit up Africa, supply chains, there were lots of problems with it, but now the analysis and modeling is focused on where in Africa can we put in large-scale movements of power? Where do we need to be off grid? Where do we need to do macro-micro grid interfaces? The good thing about renewable energy is that it depends on local governance, not national, and many of the big ambitious plans in Africa connected to electricity have fallen apart on governance at the national level.

The downside is if you focus on off-grid energy, off-grid electricity. You're never promising twenty-four-hour electricity; you're talking about can we light up the schools, can we light up the clinics? These things represent huge improvements over nothing, but one of the other big problems in the world is the extent to which people burn biomass inefficiently, which can lead to horrible indoor air quality, important impacts on forests, important impacts on the health of communities. Getting electricity, getting renewable energy, getting clean energy to more of the world is an urgent priority. We still have 770 million people who do not have access to electricity and that is the problem we have to solve together with figuring out how to make the energy transition. And that is really ambitious, but it's finally getting a lot of intense focus from the UN in the direction of the investment banks. I think there's a lot of good news in African renewable energy. I think it is really important. Russia is offering to build floating nuclear facilities to connect to Africa. They've had some success with using floating nuclear facilities to supply Arctic towns. What I've seen so far of the floating nuclear capabilities: I don't recommend it. But you should expect to hear a little bit more about that because there are a number of countries that are very interested in that right now.

Student 15: What policy improvements should the United States make for improving electricity production that is reliable, affordable, and environmentally conscious, from exploration and withdrawal to the end user?
Keywords: U.S. policy, energy policy, federated policy, national policy, relocation, BRAC, grid management, infrastructure management, infrastructure responsibility, peak-use, tariffs, energy storage, hydro storage, subsidies (hidden)

Sabonis-Helf: Even though we have coal in the United States, it is really important that we continue to move away from it. My recommendation for towns that are heavily reliant on coal is that we begin to think seriously the way that we do think about BRACing a town.[3] When a town is producing something that just doesn't make sense anymore, it requires some serious assistance to figure out how to move to the next thing. We've done a pretty good job of that through the BRAC program when we move bases away from towns. We have not done a good job with that at all about coal. We need to move away from coal because of the lower atmosphere contaminants, the upper atmosphere contaminants, and also because coal increasingly doesn't

[3] The Department of Defense, when closing bases, uses a methodology called Base Realignment and Closure (BRAC). The process, as a major consideration, weighs the economic impact of closing a base on the neighboring town. In this context, BRAC’ing means to consider the costs of ending energy production in a community and assisting the community in progressing towards the future mode of energy production.

employ people. Although the arguments are profoundly about labor, that's actually not a real issue. Increasingly for coal in America, we're doing mountain top removal. Mountain top removal is technology-intensive, environmentally destructive, and doesn't employ very many people. One thing we need to do is to get serious about our own moving away from coal.

The next thing we need to do in America: our grids are managed on a state-by-state basis, and that's becoming increasingly problematic because to incorporate more renewable energy into the grid, we need to be able to move electricity across state lines. And that's a really serious policy problem. This is one of those situations where from an engineering perspective, it's absolutely logical, and it must be done. From a political perspective, it's going to be very difficult because the vested interests know that they're going to lose. What you need to understand is that the grid in America is going to have to be substantially transformed in the next fifteen years. That's coming, that's already partly under way. We need to make some serious policy decisions about what that grid needs to look like and where our priorities are, and we're not yet doing a very good job of that.

Although there's been a lot of good work and research on what is the grid that we need for 2040, we're still using a grid that would be recognizable to Thomas Edison, even though there are a lot of transformative things we could be doing and must be doing. Focusing on that grid piece on transmission—how do we move electricity around—is really important because we need to redesign that grid to make more room for the wind and the solar, to make more room for efficient use of natural gas. The grid is the big thing that we have to think hard about and devote some policy attention to.

The other thing that I think that we need to do in the United States: we neither use time-of-use tariffs, which means charging people more for electricity during peak of demand than we charge in the middle of the night. We need to start giving discounts late at night because we need people to make the choices to balance out their consumption. We need there to be an incentive to run your dishwasher in the middle of the night instead of right after you finish dinner. Time-of-use tariffs are a standard thing in many parts of the world. We've had a lot of problems doing them effectively in the United States, but it is something that we need to move towards.

We also need to get more involved in pumped hydro storage. The largest facility in the world of pumped hydro storage is in Virginia in Bath County. It sounds crazy, but the way we balance the grid is to move lakes around. Now this is hard on the fish, but what we do is at times when there's surplus electricity in the grid and electricity has to keep moving or it degrades the system, we actually move entire lakes uphill, and then at points when the grid is under strain, we spill them back down as an artificial hydro supplement to the grid. This might sound really inefficient. It's not. It is the most cost-effective means of power storage we have in the world today. It's used on a large scale in Norway, on a fairly large scale in Canada, and in most of the United States we don't use it very extensively. But this system, because water directly turns a turbine rather than us boiling water to turn it into steam to spin a turbine, using hydropower is very highly efficient. Above 90 percent of the energy captured can be converted into electricity. Pumped hydro storage—because again, we're physically moving water—is still about 80 percent efficient, it's still more efficient than combined cycle. That's a little in the technical weeds.

I guess the other thing I would say is we still have enormous amounts of hidden subsidies to coal, oil, and gas. We need to move away from them. We also need to make sure that, when we're fracking, we're still very lax about capturing the natural gas released instead of just releasing it into the atmosphere. When you look at the leakage from our fracking facilities, it's really quite shocking. The United States used to lead the world in innovative technologies to prevent this kind of leakage. Now we're number three or number four in the world for creating that kind of leakage. We got to tighten that up. That's a profound and troubling inefficiency that's new in our systems.

Student 16: Fracking has been linked to cause issues to water supply. In the balance of risk, at what point does a country address its want to produce natural gas/energy prior to causing issues to its water supply?
Keywords: fracking, water quality, water supply, contamination, risk

Sabonis-Helf: The fracking and water intensity issue, you're correct to be concerned about that in that fracking only makes sense in terms of its water intensity in places that are relatively water rich. The level of contamination that we're seeing with water that's been used in fracking makes it problematic for doing out West. We are not yet good at pricing water. We spoke about that earlier. Until we can get more rational about the way we use water and the limits we're willing to put on water, people will continue to use it to trade for oil and gas, which they know they can sell. But there is a problematic link there.

Student 17: Which environmental issue is more devastating to a country? CO2 emissions or poor water quality? And/or which of those issues relies less on the other commodity to fix?
Keywords: carbon emissions, water quality, international emissions

Sabonis-Helf: I think that's a slightly problematic comparison. Water quality is something that you can improve locally. Greenhouse gas emissions is something that's going to take a concerted effort on the part of a small number of countries. China plus the U.S. account for 40 percent of greenhouse gas emissions. China plus the U.S. plus the European Union account for 50 percent of global emissions. Until you get serious work from that group of players, nothing an individual small country does is going to change the trajectory of greenhouse gases, but water quality and water quantity are a local problem that these nations should use as a focus.

Student 18: Can the U.S. grid handle the increase of demand as the switch to electric vehicles moves forward?
Keywords: energy demand, energy consumption, peak demand, infrastructure capacity, incentives

Sabonis-Helf: The speed of adoption suggests that our grid will be able to adopt in time because we're not rushing as full speed toward electric vehicles, but the first thing I'd like to see is having the electric vehicles be charged at night. If we can find ways to incentivize or enforce that, then we can absorb a lot of electric vehicles before it creates challenges to the grid.

Student 19: Beyond solar not producing at nighttime and turbines not producing on windless days, do you see other problems/risk with renewable energy generation and distribution besides its intermittency?
Keywords: renewable energy, renewable risks, energy generation, energy distribution

Sabonis-Helf: Yes, the amount of land demanded, the amount of land you need to generate solar energy is much greater than the amount of land you need for combined cycle. The wind is a very impressive and profound source. The U.S. has focused on onshore wind. We're about to move into offshore wind, and offshore wind has some really profound possibilities. But the real issue is we cannot transform entirely to renewable energy until we get better at electricity storage, which is a puzzle we're still unlocking. Until we get all the way there, hydro and natural gas will continue to be important components, and it may be that doing carbon capture and storage—even though we keep talking about it and not quite doing it—carbon capture and storage may become an important component in all of this. And I think there is no question that nuclear will be an important part in all of this.

Student 20: With electric vehicles taking center stage as a way of reducing U.S. reliance on oil, is hydrogen power generation still being considered as an alternative for powering vehicles?
Keywords: hydrogen power, efficiency, cost effective, energy use, energy application

Sabonis-Helf: With regard to hydrogen, there are a number of things that we use energy for that we simply can't imagine how to electrify, a lot of industrial procedures. Imagine steel production. You need an incredibly intense heat and flame in order to do that. Can you get that through electricity? Not in a cost-effective way. Hydrogen is not a source of energy like natural gas. Hydrogen is a way to move energy around, so it's more like electricity. The idea is we are still going to need hydrogen for industrial applications, possibly for mobility of heavy things like airplanes and big trucks. The question is not, is there a role for hydrogen, the question is, how much hydrogen do we need? Europe is rushing full speed and with great enthusiasm toward trying to see which country can capture the technological lead in producing green hydrogen. Or blue hydrogen. Blue hydrogen is when you use natural gas to produce the hydrogen, but you capture the carbon that is associated with making it. Hydrogen is going to be important. Are we going to use it in vehicles? Some countries will. Some countries will not. I do not know if that's a trajectory that the U.S. will pursue. I believe that electric vehicles and hydrogen vehicles will be competing with each other in a lot of markets.

Student 21: We talked a lot about the nexus of energy and water and as countries look to harness hydroelectric power, they're building infrastructure on rivers—something on the Mekong River and the Nile River are going to impact their neighbors and possibly add strain to food insecurity and water scarcity. What are your thoughts on potential friction points? Is there an opportunity to solve these problems diplomatically between nations? From a combatant commander's perspective, what kind of implications would they have on the military?
Keywords: water-energy nexus, Africa, Southeast Asia, upstream/downstream, dam building, national strategic reserves, petroleum reserves

Sabonis-Helf: That is a great question. It is a whole separate lecture and set of policies, but the reality is that in places where the downstream states are the most powerful, we get relatively resilient treaties and agreements. I do believe that Egypt will be able to shape the situation enough that the downstream riparians below the Grand Renaissance dam will not perish. There's a lot of negotiation. There's a lot of tension there. The bigger problem is when the upstream riparian, the nation that has the ability to capture the water, is the most powerful. I actually worry more about the Mekong, because China will just keep the water and the downstream states will just have to adapt, than I do about the Nile, where the downstream states have more power to negotiate and to consider tradeoffs.

But all over the world, since rainfall patterns are changing significantly and will continue to do so, water is not going to be where we thought it would be. We are seeing a decline in the utility of old hydro and I think that what we're going to see is hydropower will remain important, but the giant hydropower projects are going to become more and more problematic. Literally in the World Bank assessment they're having to incorporate how quickly can this dam pay for itself before water patterns change significantly enough that it makes no more sense. That's a different calculus. In the same way that now we have to ask the question: what are the greenhouse gas implications? That's a different question. Water poses a new risk and remember what we're more likely to see than wars over water is out-migration and local conflict. Yes, water is a new risk, but think about it not in terms of, are these two nations going to fight each other about water. Think about how much tension does that create in local communities, how much localized violence, and how much migration or out-migration, and how quickly are we responding to help transform the agriculture or the means of livelihood of different regions of the world?

I do want to conclude on one thing that we haven't touched on that I was expecting somebody to touch on just because it is the current thing that scares me. In the United States, the administration took two decisions connected to energy in the past two weeks, one of which I think was very smart and one of which I think was very problematic. The one I think was very smart is the release of oil from the strategic petroleum reserves. Under the treaty that the United States belongs to that caused us to create the strategic petroleum reserves, we are required to have ninety days' substitute for all of our imports. The U.S. Strategic Petroleum Reserve (SPR pronounced "sprue") is more than the U.S. needs right now. Now that the U.S. is importing substantially less oil and has all the reserves, we can release at the maximum level. Physically we can release from these reserves at the rate of two million barrels a day into the future for several months. I think that's a great way to bring the price down to calm the markets. I think that was a smart choice. Not all of the U.S. allies can do this, or are willing to do this, because not all of U.S. allies need their SPR as little as the U.S. needs its strategic reserves. The U.S. has surplus because domestic production rose significantly and our treaty obligation is to have reserves sufficient to replace 90 days of imports. That was a good policy decision.

The second one, relaxing the ethanol standards, I believe to be a terrible decision for maybe a reason that you haven't thought of. We know that Ukraine is going to be unable to put in the seasonal planting to the full capability that they usually do. We also know that Russia is not putting in their full planting. Russia and Ukraine are the breadbasket of Europe and North Africa. The last time Russia had major fires that damaged the crops, Russia's first response was to block all exports of grain. This created a massive price spiral in North Africa, and the Arab Spring unfolded in a period of grain prices spiraling out of control. We're already seeing a spiral in grain prices, and although corn is not a perfect substitute for wheat, the United States is the largest producer in the world of corn. We convert corn into ethanol because we have a surplus; 40 percent of the corn that we produce in America, we convert into ethanol as a surplus. The decision to draw down the surplus in a season when we know there will be dramatic world hunger in the fall and winter, I would judge as strategically irresponsible.

I recognize the domestic reasons why we'd like to see our gasoline prices come down. But the United States as the largest producer of surplus corn in the world should be thinking very hard about that market. And I don't want to hear any arguments about free market because ethanol is not a free market. Everything connected to ethanol and corn is a very heavily managed government set of markets that act as subsidies and price supports in the United States, and I firmly believe that we are targeting in the wrong direction here. And that even if the war in Russia, Ukraine fights to an unhappy conclusion before the winter, which I very much hope and I actually believe it will, it's going to be a hungry winter, and the United States should be thinking very hard about that.

Thank you all for the great questions. If you are interested in reading more about some of the discussion points today, here are my suggestions for further readings on energy and climate:

- *The New Map*, Daniel Yergin: Penguin 2020
- *Windfall*, Meghan L. O'Sullivan: Simon & Schuster, 2017
- *The Energy Security Dilemma: U.S. Policy & Practice*, David Bernell and Christopher A. Simon: Routledge Press, 2016
- *The Quest*, Daniel Yergin: Penguin, 2011
- *Hot, Flat, and Crowded*, Thomas Friedman: Farrar, Straus & Girous, 2008
- *Oil on the Brain*, Lisa Margonelli: Broadway Books, 2007/2008