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panorama

Hurricanes, Tornadoes and Earthquakes, Oh My:

Astrophysicist Neil deGrasse Tyson tackles renewable energy's future

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It would probably not surprise anyone that when Dr. Neil deGrasse Tyson considers the question of renewable energy and its place in our future, he speaks most passionately about the potential of solar energy in all of its permutations.

After all, as America's most well-known astrophysicist, he's spent a career – and then some – looking up at the sky and imagining its possibilities.

But when the host of public television's *Nova scienceNOW* – an offshoot of his "day job" as principal staff member of the Hayden Planetarium at New York's Museum of Natural History – begins to talk of harvesting the power of hurricanes, tornadoes, earthquakes and volcanoes, one quickly sits up and takes notice.

"These four extraordinary sources of energy are things we run away from, and I think we are long overdue for these to be sources of energy that we tap," he says.

"I'm looking forward to the day when a hurricane is building in the gulf, and then just before it hits land, we capture its energy to drive the city that would otherwise have been destroyed if the hurricane's power had been left untapped," he explains. "Imagine what kind of world that is – and the power over weather systems that represents.

"Or imagine a volcano is about to blow; tap it," Tyson continues. "We can tap a keg, let's tap the volcano. Here is all this energy in there, waiting to kill the city; why not take advantage of it to meet the energy needs of the city instead?"

"That's I how I see this," he says. "In the absence of these approaches, I see us as feeble, helpless creatures, running away from the very forces of nature that we should be harnessing."

Scientific acumen recognized early

Born in New York City, Tyson became consumed by astronomy as a child and actually began lecturing on the subject while still a teenager attending the Bronx (New York) High School of Science.

So well-known did these lectures become that astronomer Carl Sagan, then a faculty member at Cornell University and later to gain fame himself as an author and host of the television program *Cosmos*, personally tried to recruit him to Cornell for undergraduate studies.

Although Tyson would later describe the late Sagan as "very inspirational" and "a most powerful influence," the aspiring scientist instead chose to attend Harvard, where he majored in physics, before moving on to the University of Texas at Austin where he earned his Master's Degree in Astronomy.

He began a doctoral program at the University of Texas, but transferred to Columbia University (from which he earned a Ph.D degree in astrophysics) after UT dissolved his committee.

Professionally, Tyson has been writing on science and related topics since the mid-1990s, and began his television career in 2004 with a program called *Origins: Fourteen Billion Years of Cosmic Evolution*. He's had two presidential appointments, serving first at President George W. Bush's request, as a member of the US Commission on the Future of the United States Aerospace Industry, and later, on the President's Commission on Implementation of the United States Space Exploration Policy, later known as the "Moon, Mars and Beyond" commission.

For his efforts he was awarded the NASA Distinguished Public Service Medal, the highest civilian honor bestowed by the US space agency.

Most notoriously, he was among the first to buck tradition by questioning whether Pluto was indeed the ninth planet in the solar system. In 2006, the International Astronomical Union confirmed his assessment, changing – some would later say, reducing – Pluto to "dwarf planet" status.

His books include *Death by Black Hole: And Other Cosmic Quandaries*; *The Pluto Files: The Rise and Fall of America's Favorite*; and *The Sky Is Not The Limit: Adventures of an Urban Astrophysicist*.

No shortage of energy in the universe

"Anyone who has studied the universe knows that there is no shortage of sources of energy in the universe, and that there is no shortage of energy sources on Earth," he tells *Renewable Energy Magazine*.

“And yet, here we are, crawling on the surface of this dot we call Earth, extracting caloric content that’s buried in the soil, and when you look at that, you can’t help but reflect on how primitive that behavior is.”

Tyson chuckles.

“What concerns me is that we live in an era where energy consumption has become demonized and where people forget, as I said, that there is no shortage of energy,” he says. “The only issue is when your energy source has other, secondary and tertiary, effects on the environment that are detrimental to your long term health and longevity.

“So if you can find energy sources that have no such side effects, then, who cares how much energy you use? Hell, heat up the highway, so the snow melts!” he laughs. “You could just do anything, right? There’s no limit. Energy is what drives civilization. The exploitation of energy sources has distinguished what all the cultures that we have identified as civilized versus those that are not.”

Tyson is equally bothered by what he perceives as a kind of amnesia among the general public about the role physics played in the industrial revolution and continues to play in the development of new technologies, including renewable energy.

“What people forget is that the industrial revolution was enabled because physics came to fully understand the concept of energy,” he says. “Energy was not really known or talked about as an entity, as a quantity to calculate, at the time of Isaac Newton, for example.

“And it would take many, many more decades – the better part of the next century – before the concept of energy became an idea to calculate and to fold into our understanding of the laws of physics. Once you do that, you can now make machines that convert one kind of energy into another.

“That’s the entire industrial revolution,” he says, his voice rising. “People think, ‘Oh, they had clever machines.’ [No], they understood the physics of the energy.”

With that Tyson, ever the natural teacher, is describing how the steam engine was powered by energy contained in wood or coal that heated water that drove a piston that turned a wheel.

“So you’re turning chemical energy into mechanical energy,” he says. “That’s the entire point of the industrial revolution. So I think people need to think more broadly about what energy is and how we use it and how to get it and what the by-products are.”

It all comes back to the sun

Ultimately – leaving aside, for the moment, earthquakes and volcanoes – Tyson says the pre-eminent source of energy on the planet and in our solar system is the sun.

“In fact, it’s the primary source of energy for anything we would ever do,” he says. “The sun was the source of the energy for the coal and the oil that we are pulling out of the ground. It’s just mismatched in time.”

“All that is, is solar energy captured in matter that got laid down millions of years ago – I forget the exact number… but it was during the carboniferous era – and it was stuck there until we discovered that it is a remarkable source of energy that was just waiting for us to yank it out of the ground,” he continues.

“Now, of course, a hurricane, tornadoes – even wind power, which stems from the uneven heating of the surface of the Earth – all of these things are solar-powered; So it hydro-electric power. The sun is driving it. It’s a nearby source of essentially unlimited energy,” he says.

But if it sounds like Tyson is waiting for another leap of science in the solar sector comparable to that which ushered in the industrial revolution, the assumption proves slightly off the mark.

“What we need are engineering innovations,” he explains. “Your capacity to build or to manipulate nature in whatever ways that serves the needs of your survival is a function of the tools you have available to you.

“What I am describing is what in recent times has been referred to geo-engineering,” he says. “The land/water/atmosphere system is extremely complex. But in a geo-engineering future, you understand that complexity well enough to manipulate what goes on inside that system.

“For instance, it’s not raining where you need the rain, so let’s make it rain. That would be geo-engineering,” he continues. “Oh, that earthquake is about to shake out the city; OK, let’s diffuse the tension that’s going on under that earthquake and take that pent-up energy and drive a turbine to run a city. That’s geo-engineering.”

A most grounded out-of-this-world vision

What’s surprising, given his area of expertise, is how grounded – or of this world – Tyson’s views on renewable energy appear to be. For instance, he doesn’t mention – until asked about them – proposals like those considered by the Japanese to put big solar panels in space and sending the captured energy back to the Earth in the form of microwaves.

“A lot has been written on space-based solar power, whole books, in fact,” he says. “But here’s what will always be your challenge if you’re an advocate for this approach: There are large swaths of the Earth’s surface where it hardly ever rains – meaning there are no clouds – and where the sun shines bright during the day and no one lives there.

“So the trade-off here is, are you going to collect sunlight on Earth’s surface by just laying out so solar collectors? Or, are you going to launch something into space in an effort that’s never been done before – beaming sunlight down via microwaves, hoping an airplane doesn’t fly through the beam -- and collect it in one spot?

“So, yeah, maybe that’s the right thing to do, but is it cheaper than putting solar panels in the desert? I don’t think so. I don’t think that it’s cheaper, and it is economics that is going to drive this,” he continues. “Now, you might say, ‘But [with the space array] you get 24-hour sunlight.’ OK, so on Earth, where you get half as much sun in any one place, just put twice as many panels out.

“However big that it is that you can make it in space, you can make it twice as big on Earth’s surface just by building a road out to where you need to lay out the panels. And it is expensive to work in space. People are forgetting that fact” Tyson says.

“I don’t have a problem thinking about space-based solar power, but given that there are plenty of places on the Earth’s surface where nobody lives and which get plenty of sunlight, it seems to me that’s the first place we should look if we are going to collect sunlight in major quantities to drive what’s going on here on Earth,” he adds.

Tyson’s thinking is in line with those who suggest that the most effective use of a region like the Sahara desert would be to cover it with solar panels that can be used – once appropriate energy storage and transmission is achieved – to light Europe at night.

“For example!” he says enthusiastically. “There’s ain’t nothing else happening in the Sahara! Give me a break.

“You can’t have effective solar power in England, for example, because it is too cloudy too much of the time. It really only works in desert climates,” Tyson says. “Seattle (Wash., in the US), as green as that city tries to be, they try to put out solar panels, but the sun just isn’t out enough. It’s more for show.

“It’s like, ‘Look, I’m Green!’ Ok, fine,” he says, laughing.

An engineering issue

Returning to the idea of meeting the civilization’s future energy needs, Tyson acknowledged that something like two billion people on the planet are not currently on the electric grid and that the world will likely need terawatts of additional energy if society as we know it is to continue.

He also acknowledged that the pace of science may be too slow, in some instances, to help meet some of these needs.

“But again, these are engineering problems that we are talking about,” he says. “These aren’t science problems. Now, of course, it is a science problem since we don’t know how to make a controlled thermo-nuclear fusion reactor; there’s some science that is involved in [achieving] that goal.

“But other than that, the rest is engineering; it really is,” he insists. “Energy comes from the sun. I hand it to you. It’s a photon. Work with it.”

Tyson laughs.

“I already understand how the sun makes energy, how it gets here, what effect it has moving through the atmosphere and what it does when it hits the Earth’s surface. The science of that is understood,” he continues.

“Now, in the geo-engineering realm, there’s still the science of the atmosphere that we don’t understand well enough to pull this off, or the science of volcanoes, so those are a little harder. But to make efficient use of sunlight? Directly? As opposed to some of these indirect ways? That’s engineering,” he says.

But Tyson says as clear as it is that engineering solutions are what’s needed to help renewable energy proliferate – and here he applies the need for continued engineering innovation to the realms of wind and tidal energy as well as solar – he says that there’s a significant catch, and one that “people hardly ever talk about”.

“It’s not that people are lazy – although they may be, but that’s not the main reason for this – and it’s not that people aren’t smart; it’s that hardly any of these other sources of energy cost less than pulling oil out of the ground. Period. That’s what it comes down to,” he says. “People react according to their pocketbooks.”

With that, Tyson recalls a scene from the 2007 post-apocalyptic science fiction movie *I Am Legend*, which starred the actor Will Smith.

“There’s a scene where he is refilling his gas tank at a gas station. The field of view is from ground level, looking up. And since there is no electricity in this future, he has to pump it by hand,” Tyson says. “So, he starts pumping the gas, and from the angle you’re shown you see the final price of gas before everything went wrong – it’s something like $19 a gallon.

“That will never happen. It can never happen. It can’t just keep going up. And do you know why?” Tyson says, the excitement in his voice rising. “Because eventually, people will switch to something else. That’s the whole point, okay?”

Economic will slow proliferation of hybrid vehicles

It is economics that Tyson also believes will blunt the proliferation of hybrid cars for the foreseeable future.

“If you do the math, it just doesn’t pay off,” he says. “If you look at the incremental cost of a hybrid, and the minimal extra gas mileage you get for it, and calculate that over the life of the vehicle, or rather, the period that you plan to drive it, you are not really saving money.

“Now, you may be saving the environment, right? But you are not saving money by going green, and most people will only be happy to go green if the act of going green will save them money,” he adds. “In that case, you’ve got a double incentive. If the savings are appreciable and significant, then the change will happen overnight. There will be nothing holding it back from proceeding.”

So taken is Tyson with this point that he actually begins doing the math, his numbers based on the assumption that a hybrid vehicle costs $5,000 to $10,000 more than a traditional, gas-powered vehicle, a fuel price of $4-a-gallon, and an anticipated difference of 15 miles-per-gallon between the two types of vehicles by today’s industry standards.

By his reckoning, it would take the hybrid owner at least five years to recoup the difference in price between the two vehicles – a longer period than most buyers of high-end cars typically hold onto them.

“Now that brings to mind a whole other issue, which is that the difference in miles per gallon between a hybrid and a traditional vehicle is not as much as I think it should be,” Tyson says. “You should be getting at least 100 miles to the gallon with these cars, which you are not.”

“Given the negligible difference in gas millage, anyone who is out of a job or just trying to survive is going to go with the cheapest option that is available to them. Period,” he says. “Until these hybrids are getting 150 to 200 miles per gallon, I don’t see them taking over. I just don’t.”

“You need to provide that economic incentive. Until then, the only people who will buy them are those rich enough to care about the environment,” he adds.

Tyson believes – and in fact, has presented a television segment on the proposition – that the most effective way to end the world’s reliance on the combustion engine would be to find all the possible alternative ways creating electricity, tying them together with an intelligent grid, and then making all vehicles electric.

“The virtue of the intelligent grid is that your connection to it can choose, opportunistically and economically, what the cheapest way is to provide energy when you need it,” he says. “Your connection might think, ‘Oh, there’s wind that blows during the evening hours in this county, let’s tap that energy right now.’ ‘Okay, it’s a bright sunny day, let’s go to the solar panels and bring that energy in.’

“An intelligent grid will be getting energy from the most effective and efficient sources during the day and that’s what you use to charge your car,” he continues. “Once you get to that point, that’s when we have to get the engineers back in the loop to say, ‘Why can’t you charge a car in the time it takes to get a tank of gas?’ That’s the problem with electric cars today; the batteries are too heavy to just swap batteries at the filling station. So I continue to say that it is an engineering problem.”

“Once you start approaching that point, the oil has to compete in terms of price, and if the oil starts pricing itself out because we are running out of it, then it dies on the vine,” he suggests.

Competition for scare dollars and the value of physics

By this point, it becomes impossible not to play devil's advocate, impossible not to suggest that perhaps, going forward, it might be more important to spend education dollars educating future engineers as opposed to future scientists.

"Well, what you don't know is whether there is a new scientific discovery that will enable another entire branch of engineering to unfold," Tyson responds. "So, I would never tell you to fund one and not the other. They all happen together.

"What I would say is that among those people who are becoming engineers, there's a lot of money to be made when oil prices go high, and that can attract a lot of entrepreneurial/inventor types," he says.

Getting more deeply into the subject of education, Tyson said he strongly believes that more young people should take physics as a fundamental part of their science curriculum.

"The earlier our students are exposed to physics the better," he says. "And less there be any doubt, there is no understanding of chemistry without the laws of physics, and there is no understanding of biology without chemistry.

"Biology is the most complex form of chemistry we know, and there are people who go through school and never take physics, so on that level, the chemistry and biology they 'learn' is just stuff they've memorized," Tyson says. "There is no foundation to how to think creatively about the physical world. That comes from physics.

"Now, you might say that I am biased because I'm trained in physics, but consider perhaps, that the MRI in a hospital is based on a physical principles discovered by an astrophysicist who did not have the goal of an MRI as a result of his efforts.

"It's based on nuclear magnetic resonances, and it would later be applied to the medical community – and this is true of every single machine with an on-off switch in the hospital. It is based on a principle of physics, not discovered by a medical researcher, and then it took the medical engineer to invoke that law of physics in a way that could serve humanity in lucrative ways."

"What we're talking about, really, is this philosophical schism that exists in education today: The choice between, do you teach people practical things, or do you teach them foundational science?" Tyson says.

"Personally, I'm leaning toward teaching them foundational science," he says. "That allows them to think in new ways about any new thing they see. Whereas if you teach them applied science, then when they see something they've never seen, they say, 'Well, I wasn't trained in that.' That would be the common response.

"That's the difference between two kinds of office workers: One gets a task they've never seen before and says, 'Well, I'm not trained to do that.' And another person, who was never really trained to do anything, but trained to understand how things work, when they get a new task they say, 'Oh wow, a new task; I'll figure out how to make that work.' Two completely different attitudes toward the same goal," he says.

But advances of education – not to mention research – are often highly dependent on funding, much of which comes from the public sector – funding that has becoming increasingly scarce as governments around the world have had to contend first with a deep financial crisis and then, in many cases, a sluggish economic recovery.

Is he seeing funding for pure science being curtailed as more and more countries put a premium on the development of renewable energy and new technologies?

“No, I wouldn’t say so,” Tyson says. “See, you only have to fund science that nobody has figured out how to use yet; anything else would be the R &D of an energy company, because it has direct financial consequences. Government money is not really necessary to fund engineering solutions to financially lucrative problems. That’s the free market. That’s what we are all into here as Americans.

“It’s the frontier of science that requires the government support, because the capital markets can’t value it,” he adds.” They don’t know how to value it. Or rather they do, but the return on that investment is so far in the future that it can’t attract any real money. That’s why the government does.”

For additional information:

Dr. Neil deGrasse Tyson’s Web site