

Ray Sacks 10:16 AM

Will the slides be sent out to us after the seminar? Ray

Banerjee, Debjyoti 10:24 AM

Do you think nationalization of oil and gas infrastructure a plausible route to reducing US national carbon footprint (as proposed by the Sunrise Movement)? FYI - <https://www.yahoo.com/huffpost/oil-prices-nationalize-oil-companies-094500247.html>

kavya 10:24 AM

From slide 8, Energy efficiency is only 32.7% . is there room to improve this number and thus reduce carbon output?

maq 10:37 AM

What is done with CO₂ after it may be successfully captured for example, in cement or steel manufacture, if it's emission back to the atmosphere is precluded?

Tengfei Luo 10:40 AM

To Prof. Majumdar: What is the status of H₂ storage for non-transportation uses? Will that be a major technical challenge or you see the need of co-production/co-location with other industrial process (e.g., steel plants)?

Yogendra Joshi 10:41 AM

High temperature heat pipes are available, e.g. in nuclear reactors etc, with liquid metals as working fluids.

Rohit Vedhara 10:42 AM

Hello and thanks for this. A couple of us have been working on dimethyl ether for a while and we think that this could be a good refrigerant. Has it been explored before in any material way?

Anonymous Attendee 10:45 AM

is there interest in thermochemical transmission of 'cold'? imagine a central refrigeration unit and a distributed cold energy transmission for air conditioning, refrigeration and industrial chilling. Industrial interest lies in LNG gasification cold energy which can be utilized if it can be transmitted to end user.

Muhammad Taha Manzoor 10:46 AM

Are there any thermal switches available right now, commercially or even at lab scale ?

Anonymous Attendee 10:47 AM

Conditioning of building space requires both temperature and humidity control. How much heating in the summer is a result of humidity control. Is moderating humidity without reheat an important technology challenge?

Anonymous Attendee 10:48 AM

How effective is the use of conventional energy resources coupled with simultaneous carbon capture at the source?

Dr. Riley Hanus, Georgia Tech 10:48 AM

In regions with significant wind and/or solar energy, the price of electricity has been known to go negative periodically. 2 questions: 1) How do you see this impacting the adoption of wind and solar? 2) Are there any energy/hydrogen/water/etc. related technologies that could leverage this periodic negative price of electricity.

Philippe Ben-Abdallah 10:49 AM

Thank you for your nice talk. You have mainly discussed different strategies or research directions to essentially avoid releasing carbon into the atmosphere but what's about potential technologies to effectively collect carbon?

Ajinkya Sarode 10:49 AM

What are the challenges in using phase change materials for heating and cooling of buildings?

Harish Chandrasekar 10:49 AM

Wrt to the moving enthalpy slide, is the temperature kept a constant for a changing enthalpy so that there isn't a great temperature difference in the transportation? Besides in the heating and cooling slide, there must always be an internal issue in the building to attain an equilibrium, right? It is impossible to have just heating and cooling right?

Anonymous Attendee 10:50 AM

Covid -19 has forced the world to stay indoors. As a result the world is consuming less, flying less but a recent report showed that the total carbon output has only reduced by 5.5%! Isn't this concerning? We might not be able to achieve global climate change goals

Anonymous Attendee 10:51 AM

Thank you very much for giving this webinar. We are contributing to CO2 reduction by not taking flights to attend cool seminars like this. This is wonderful.

Nick Crnkovich 10:52 AM

How do you see the new concentrated solar technology playing in with the production of steel and cement?

user1 10:52 AM

What role can one expect nuclear energy to play in resolving the future energy related challenges?

Anonymous Attendee 10:52 AM

How much could we rely on the electric cars to reduce the GHG emissions, taking the full-life-cycle CO2 emissions and the effort to make the electric power source (battery system) work for the cars into consideration? Is it really beneficial to put lots of energy into the battery development compare to just

using conventional fossil fuels in terms of the GHG emissions? Also, the after-life toxic of the batteries?
Thanks.

Joseph Heremans 10:53 AM

Isn't burning fossil fuel plus carbon sequestration the same thing as heat transmission by dissociative chemical reaction, based on $C+O_2 = CO_2$.

Seiji H Engelkemier 10:54 AM

In the next year, wouldn't the largest impact to be electing pro-climate officials to the US government? Much more so than most R&D? What's the role of scientists and engineers in this?

Earis, Philip J. (ELS-LOW) 10:54 AM

What do you view as the near-term "low hanging fruit" in terms of decarbonizing the industrial sector?
Philip Earis (Editor, Joule)

Mohamed Nabil Sabry 10:54 AM

How about energy expenditure to exchange/store/process information? This is an activity that will increase exponentially. Efficiency should be an important challenge

Andrew Bouma 10:54 AM

I'm curious about the panelist's thoughts on Energy Vault technology and how physical energy storage fits in to the picture with thermal or chemical energy storage.

Nachiket 10:55 AM

Q about high energy density storage: what about nuclear energy as a sustainable option?

Melanie Tetreault-Friend, Prof. 10:55 AM

Hi, thank you for the inspiring talk. My name is Melanie Tetreault-Friend, professor at McGill University. All these energy technologies have different risks associated with them, some more serious than others. As engineers, we understand the risks. But how critical is public acceptance in your opinion, and what is our role as engineers in educating the general public to improve public acceptance?

Anonymous Attendee 10:56 AM

What prevents the high resolution thermal imaging? We already have great thermal cameras available. What is the break through needed?

Syed 10:56 AM

Will the chemical energy shortage explained (for example $AB \rightarrow A + B$), and transporting it in form of fluid will be able to compete with grid transmission, knowing the fact that the current infrastructure needs to be replaced completely.

Stefan 10:56 AM

What can we do, to get political leaders to do more against global warming than they do right now? It seems difficult to convince a number of political leaders (not all of course), that the problem is real and that we have to act now.

Elizabeth Sherwood-Randall 10:56 AM

Thank you, Arun, for a characteristically superb presentation! I have to sign off now to join a CFR climate conversation that begins at 8 am but would like to express my appreciation and take you up on the final challenge you presented: that we should make the most of the opportunity/responsibility of this unprecedented moment. Let's continue the discussion soon. All best and thanks again — Liz

Anonymous 10:57 AM

Anonymous please: who in industry is working on these things? Especially industrial processes from renewable heat?

tomkabat 10:57 AM

To what extent might intentional seasonal cycling of industrial and factory processes work to achieve the equivalent of seasonal energy storage. That is matching the usage and availability of energy in production seasons and storing produced materials for use in other seasons?

Sarthak Nag 10:58 AM

Greeting distinguished professors and researchers, I am Sarthak Nag from Kyushu University, Japan.

What is the importance of case specific decentralized technology for maintaining a balance between costs or impact on environment? Let's say that regions with abundance of sunshine hours can switch

Muhammad Taha Manzoor 10:58 AM

Question from Asegun. He developed liquid metal ceramic pumps recently. What is his opinion on the cost and specially machining/fabrication of ceramics?

Zhibin Gao 10:58 AM

Zhibin Gao (National University of Singapore): Could superconductivity can be used practically to deal with the long-distance transmission of heat? How long do you expect to spend? Thanks!

Alejandro Datas 10:58 AM

I would like to know the panelists opinion on challenges for thermal insulation, especially at very high temperatures. Long term thermal energy storage requires really good thermal insulation systems, which I believe do not exist. What about aerogels or other fancy materials like that?

Milica Grahovac 10:58 AM

What is the first step?

mark johnson 10:58 AM

The chemical sector consumes ~4Quads of energy in the US. Yet the sum of the Gibbs Free Energies of those processes is a net exothermic 0.5Quads. How to utilize that thermal energy?

炳阳 曹 10:58 AM

Q: For Arun, Any comments about what role does the data-driven technique, e.g. AI or ML, play in future energy problems? (Bingyang Cao at Tsinghua University)

Dino Megaridis 10:58 AM

Do we have any idea yet on the extent of temporary green house emission reduction caused by reduced global activities in most of the world during this COVID-19 era? Would this emission slowdown allow nature to catch up a a little and extent the timeline for global warming?

Shigeo Maruyama 10:58 AM

Arun, Great talk. At this moment of COVID-19, we are learning that the CO2 emission is reduced very much. Can you comment how much energy saving effect by remote work, tel-work? The information technology can be compared with energy saving.

Nat 10:58 AM

It was mention that 75% of energy usage is based on heating and cooling of buildings. What are your thoughts on the importance of research focused on efficient small scale systems that incorporate passive conduction techniques to manage thermo circulation control by means of direct solar gains, thermal storage walls, thermo circulation vents, etc.?

Brian 10:59 AM

For all new technologies and processes it would be invaluable if there were centralized (hopefully subsidized) large-scale pilot testing facilities. This scale-up and proving step is critical and often very hard to obtain funding for. It is also poorly undertaken. Arun what mechanism would be best for this?
Brian

Angie Mendbayar 10:59 AM

What is the status of the R&D on using CO2 as a refrigerant? I believe that heat pumps are one of the most efficient ways to transfer heat as it transfers heat from one place to another. Thank you!

jorge.alvarado 10:59 AM

Most of the energy production systems discussed so far, are large in scale (i.e. conventional as in power transmission and hydrogen production). Any thoughts on the viability on refocusing the emphasis towards miniaturization and local/communal power generation and management?

Sarthak Nag 10:59 AM

What is the importance of case specific decentralized technology for maintaining a balance between costs or impact on environment?

Stephen Selkowitz 10:59 AM

Variable conductance is clearly important- how does this compare in importance to very low conductance materials/assemblies, that are durable, long lived, very low cost, low embodied carbon, etc?

Joseph Schaadt 10:59 AM

Which of these five grand challenges is within closest reach?

joelmoxley 11:00 AM

What early stage technology companies are the panel particularly excited about in the industrial sector?

Jake Carter 11:00 AM

Hi this is Jake Carter. Methane known to be a more potent GHG than CO₂, and along with agriculture, thawing permafrost is projected to release large amounts of methane in a sort of warming feedback loop. I know there are efforts for carbon capture, but what are the efforts to capture and possibly make use of all of this methane?

user1 11:00 AM

Solar energy travels tremendous distances very efficiently, even within our atmosphere. Why can't we think about similar means (radiation) to have energy transferred long distance as well?

Eric Michael Fell 11:01 AM

Eric (PhD candidate @Harvard) How can the renewables community engage and work hand-in-hand with the energy storage community to further the development of long term storage (whether it be thermal or electrochemical).

Wilbur Li MIT'20 11:01 AM

Decarbonizing the developing world is overwhelmingly important as they successfully bring many billions of people to a higher standard of living.

What are the biggest barriers for scaling clean technologies like wind/solar/EVs/smart grids to these developing countries within years, and how do we overcome them?

Tsinghua 王宝龙 11:01 AM

What do you think the potential of the heat pump in future heating supply?

Ron Freund (Electric Auto Assoc, and Plug In America) 11:01 AM

What is the current understanding of just how nature splits water molecules in leaves of living plants, to be able extract hydrogen at a zero thermal cost, to get away from steam reformation of methane?

mark johnson 11:02 AM

in the steel industry: Iron Ore to Iron reduction is endothermic and consumes coke. Iron to steel is actually exothermic and already electrified. What are decarbonized approaches to making 'iron', instead of 'making steel'?

Elie BADINE 11:02 AM

I would like to thank you all for this wonderful meeting.

I read some papers about light weight concrete (LWC). Do you think that replacing concrete in buildings with LWC could really reduce the heating loss?

Thank you.

Cody L Jacobucci 11:03 AM

Thank you all for your time and visions of the future. As Professor Majundar mentioned, we only have 20-30 years to bring transformative technology to the market to meet our current CO2 threshold. This will require academia, industry, and political leaders to work on time scales we probably have not seen since the Space Race. How do we replicate this, in terms of practical steps? Will we need to develop/expand programs like Arpa-E? How should young graduate students be spending their time to be ready and aligned for these new opportunities to contribute to the "Climate Race"?

Mohamed Nabil Sabry 11:04 AM

A question to organizers: Would we get feedback about impact of this meeting worldwide: No. of participants, no. of poll answers, questions ...?

Joseph Heremans 11:05 AM

Managing the heat in industrial processes has been done for a long time. In steel production, most yield improvements in blast furnaces, e.g., were by adding regenerators and use the heat from the iron oxide reduction to reheat the blast air. Most industrial processes already manage heat very effectively, driven by cost and efficiency needs.

Anonymous Attendee 11:05 AM

how renewable energy penetration will impact the use of thermal storage application in building cooling sector? because before renewables use the prime effort of using storage units was to shift the loads to off-peak hours and operate the cooling equipment at low ambient temperatures to improve the efficiency of the cooling equipment. but when it comes to use renewable energy source, people may avoid using storage units to save the cost of storage units and utilize the storage installation area for solar installation in particular

mark johnson 11:05 AM

A large of the 'waste heat' is actually below 230C (450F, sorry). Is the efficient utilization of this heat actually a problem of heat transfer at the heat sink (Tlow), not a problem of the science of high temperature (Thigh)?

Xiulin Ruan 11:06 AM

Many thanks for sharing your views of the grand challenges. Thermal science has a long history. What do you think are the best opportunities in discovering new fundamental thermal sciences to address these challenges?

Anonymous Attendee 11:07 AM

What technology are you most optimistic about for balancing a renewables-heavy grid? Gas-CCS, nuclear, hydrogen, other long-duration storage, others?

Wei Li 11:08 AM

long distance heat transmission is interesting. But the cost and efficiency are big issues for this process.

using water to do long distance heat transmission may be much easier and cheaper instead of putting so much effort into it. Wei Li from Zhejiang U.

Joseph Schaadt 11:08 AM

Why has the focus for so long been sharply on energy generation as opposed to reducing energy consumption (energy efficiency)?

Alexander Limia 11:09 AM

What role can thermal solutions play in decarbonizing the transportation industry?

Mario Mata 11:09 AM

Since you mentioned about the use of "HYDROGEN", do you think that at some point, the US will implement hydrogen fuel cells for their energy production? Thank you and stay safe!

Stefan 11:10 AM

A lot of the emissions are a result of our economic concepts, behaviors and models connected to constant economic growth. Is constant economic growth sustainable in the light of global warming?

Mohamed Nabil Sabry 11:10 AM

For decades, we were focused on efficiency.

Anonymous Attendee 11:12 AM

Whats your advice for students: How should we think about making an impact in this issue? Especially if we do not have a background in engineering topics discussed today. Are there alternatives to academia & RnD

Mohamed Nabil Sabry 11:14 AM

An opinion not a question: For decades we were focused on efficiency. After Covid-19, we should also care for resilience and sustainability. This should be a social paradigm shift: efficiency AND sustainability, not one against the other

Anonymous Attendee 11:14 AM

For process industries in developing countries like India, which of the following options is preferable? (1) Leap frog to the latest technologies with least carbon footprint or (2) transition through technologies with progressively lower carbon footprint?

Mahmoud Elzouka 11:14 AM

How do you view the impact of localized energy production using efficient, cheap, simple to manufacture mechanical engines, that can run on waste heat?

Anonymous Attendee 11:15 AM

Since we have so little time left to accomplish the goal of decarbonization and given how much time research takes to make advances isn't it time to focus mainly on existing solutions (e.g. Nuclear) and perhaps significant austerity to accomplish the necessary goals. In other words, I am concerned if the "Can do" attitude of scientists is misleading the public as to what we can really be accomplished in a short time frame in terms of innovating out of the mess we find ourselves in.

HUAN WU 11:15 AM

Since we have efficient long-distance electricity transport, why we need long distance heat thermal energy transport?

srajagopalan 11:18 AM

What are your thoughts on the status of inorganic PCMs use for thermal management applications on large scale applications?

Anonymous Attendee 11:18 AM

In the examples of the atomic bomb, space race, national interstate system, and other essential tech and infrastructure development, there was a critical large government presence. What should we expect for climate change given the lack of government's role in large infra projects for decades?

Anonymous Attendee 11:21 AM

could you comment on the role/opportunities of nanoscale heat transfer on these challenges

Anonymous Attendee 11:21 AM

Instead of depending on high temperature materials development and limitations, why not lower the cold side of the Carnot cycle so that the delta T is still the same? Would this be a lower cost approach - Anonymous?

Anonymous Attendee 11:21 AM

What opportunities in energy/resource savings do you see in the needed future pandemic proofing of different industries. (supply chains, commercial/residential spaces, etc.). For example, CO₂ is currently in short supply for the food industry due to a drop in ethanol production, are there ways of flexibly generating resources in an efficient, cheap manner?

Diego Ceotto 11:21 AM

..perhaps the best way to insulate is using fastly the heat. Diego Ceotto from Italy.

Bo Zhao 11:22 AM

Whether the thermal management of electronic devices a thing, since we have billions of them around the world if not more?

Stefan 11:22 AM

Do you see a significant future for thermoelectric technologies?

Administrator 11:24 AM

Thank you all. May I know if this meeting video can be playback online?

Reza 11:25 AM

What about the carbon emission from data centers? Reza from NVIDIA

Hagen, Chris 11:25 AM

What is the future of thermal fluid science education? For example, how do we compete with tech careers for talent? Put differently, how do we competitively market TFS education and careers?

Greg 11:27 AM

Could you please send around slides?

Hagen, Chris 11:28 AM

Highlight available FOA's when mentioning challenges

Mahmoud Elzouka 11:28 AM

Feedback:

Prof. S K Das 11:28 AM

It's not working but I enjoyed it thoroughly

Anonymous Attendee 11:29 AM

Can you mention at the beginning or end, how many people took chance to dial in?

Anonymous Attendee 11:29 AM

Please consider a later start time so it's not so early in the morning for certain time zones in the US and abroad. Thanks for this valuable experience, though!

Shubo Fei 11:29 AM

Very nice presentation. Thank you very much!

Mahmoud Elzouka 11:29 AM

Can you post transcript for these talks? it would make it quickly navigate the 1 hour event.

Ze ZHANG 11:29 AM

Maybe include some speakers from the industry in the future, to see what kind of problems they are interested and what is the biggest challenges they are facing. Is there any gap between that with what academia see.

user1 11:29 AM

Chris: you did a great job moderating the panel! I wish you will continue doing it during the next colloquia.

Vivien Lecoustre 11:29 AM

Great initiative! Looking forward to more great talks. Thank you for organizing.

Cheng Shao 11:29 AM

It is a very nice event, we can learn things from different fields and hope we can have it more often.

Earis, Philip J. (ELS-LOW) 11:31 AM

Really great and stimulating session - timely and insightful analysis and insights. Thanks so much to speaker Arun, panelists Ravi and Asegun, and also to the excellent and efficient Chair, Chris (and all MIT organizers). Zoom platform worked well for me. Really looking forward to next week's session. Great work everyone, and thanks again. Philip Earis (Editor, Joule)

Fan Yang 11:31 AM

Thank you very much for organizing this wonderful colloquia.

Philippe Ben-Abdallah 11:31 AM

Thanks for this nice initiative. To make this event more interactive it would be great to make the answer a little bit more short and to consider a bit more questions.

Shigeo Maruyama 11:31 AM

Congratulations. It is quite useful. Very nice presentations and discussion. Very nice chair, Chris.

simon 11:31 AM

Thank you to the organizers! It was great!

Angie Mendbayar 11:31 AM

Thank You! I am attending from Alaska, but 6 am is not very convenient time for me... I may watch the recording from now on...

Angie Mendbayar 11:31 AM

Thank you again!

Iman Reksowardojo 11:31 AM

It was very inspire for me. I will joint for the next time,

Xuanjie Wang 11:31 AM

Thank you

Amy Marconnet 11:31 AM

Thanks for organizing this. I think it is great to bring the community together. Please let me know if you need any help organizing future sessions - Amy Marconnet (marconnet@purdue.edu)

Nishant 11:31 AM

Thank you so much for organizing this.

tomkabat 11:31 AM

Excellent discussion! Thank you.

Administrator 11:32 AM

that would be good. where and when it will be uploaded?

Hirofumi Daiguji 11:32 AM

Great event!

Aravindh Rajan 11:32 AM

Hypothetically, what technological advancements would make society and policy makers see nuclear energy differently?

user1 11:32 AM

I would suggest limiting the core presentation to 30 min max, making it (ppt slides) available to attendees before the event; have more time for panel discussion and Q&A.

Anonymous Attendee 11:32 AM

Thank you for organizing it. Very timely and helps shape future R&D

Administrator 11:32 AM

thank you all.

Hermann Tribukait 11:32 AM

Fantastic event. Congrats to all, and special congratulations to Arun for becoming a member of the NAS!
Cheers

Suggestion: add # of participants in your polls. Well done!

Iman Reksowardojo 11:32 AM

Iman K. Reksowardojo (Institut Teknologi Bandung), Indonesia

Stefan 11:32 AM

Great format! Great speakers! Thanks for organizing! Would be nice to mix faculty and student contributions and facilitate interdisciplinary discussions.

Wyatt Hodges 11:32 AM

This seminar was fantastic, I can't thank you all enough for organizing it. It was very inspiring, both in content and in seeing so many great minds in our field all in one place and discussing big picture issues. Can't say thank you enough

Abdulaziz 11:32 AM

Thank you very much from Saudi Arabia from KFUPM.

Jensen Zhang 11:32 AM

Thank you very much for a stimulating session!

Joseph Heremans 11:32 AM

Feedback: fantastic initiative, impeccable implementation. This has the potential to become the leading conference on the topic.

kavya 11:33 AM

Feedback: please have a summary or take-away slide at the end. Great things discussed but it would be easy to remember with a summary slide. Which might have to be created during the session (real-time) by the organizers

Anonymous Attendee 11:33 AM

Feedback: great initiative! very timely and much needed inspiration for a thermal science researcher wanting to do something for the environment.

Anonymous Attendee 11:33 AM

excellent talk. One note on Ravi's point on turbine efficiency--it now reaches 63%
<https://www.ge.com/power/about/insights/articles/2018/03/nishi-nagoya-efficiency-record>

ankur 11:33 AM

How can we overcome the heat pipe working limits for high energy applications?

Tom Cooper 11:33 AM

Feedback: inspiring talk, useful discussions, and timely forum overall. I found the polls particularly useful as a way to engage the audience and for us to learn from each other.

user1 11:33 AM

Thank you to those organizing and participating on it! It was really great.

Shuhuai Yao 11:34 AM

What's your view on solid state cooling technologies such as caloric cooling? What are the critical problems and challenges for these alternative technologies to become practical solutions to energy problems?

Cody L Jacobucci 11:34 AM

I would love to hear more about the intersection of development economics and technology transfer in Low and Middle Income Countries. How do we bring our innovations to these countries that will be transforming in the next century in a way that will help them grow and provide equitable access to energy and clean water, while ensuring they are sustainable and cost effective?

Anonymous Attendee 11:34 AM

What your view on the urgency of thermal in electronics cooling considering the current developments in CPU/GPU and the increasing needs of electronics devices?

Julia Nee 11:35 AM

Getting to know the crux of different industry challenges is an important breadth consideration. This is often limited by trade secrets and IP concerns. What have you found to be the best way to learn and work on the real technical challenges faced in various industries.

Daniel Hwai-En Hsieh 11:35 AM

I think this is helpful. Thanks.

Shealy 11:35 AM

Thank you all professors! (As a student whose major is not related to thermal science but is going to do some research about nanoscale thermal science as a PhD student, these kinda colloquiums really helps. However, it's better for the professors to speak slow when answering the questions) Thanks again!

198b95bc 11:35 AM

It was a very nice session full of innovative ideas shared by prof Arun Majumdar. please include my email in attendee list and inform me through email for such knowledge building sessions. I'm thankful to Dr. mahabir bhandari from ornl for recommending this webinar

shawn putnam 11:35 AM

Thanks!!!

198b95bc 11:36 AM

and one more suggestion, please try to answer the question during panel discussion instead of post session

Kyle Gluesenkamp

When Arun showed the number 1 in the quiz slide, I thought he was going to say "we have 1 Earth". This ties in the beginning of the presentation with the end.

Adam A. Wilson, US Army Research Laboratory

Not able to see polling...

Van Baxter

I did not see the poll ? at all

S Jeter

nothing visible on my screen so I cannot respond to poll. The audio is OK

Kyle Gluesenkamp

I joined via the browser option, and don't seem to have access to the polls. Just for future reference.

Van Baxter

My personal choices are 1) thermal storage, 2) refrigerants, and 3) variable conductance envelopes, all buildings relater

Shankar Narayanan

A swiss startup called Vault is exploring the use of concrete blocks for energy storage via potential energy. How does this strategy compare with thermal energy storage (mostly in terms of overall efficiency and costs)

Birendra

at what scale we can produce hydrogen gas from crop residues