

# ANNUAL REPORT | 2019



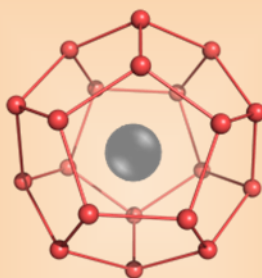
CCS



Cooling



Energy Storage



Water Purification



Energy Recovery

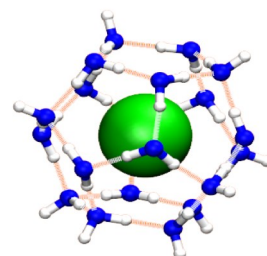
**Linga Lab@NUS**

*Department of Chemical and  
Biomolecular Engineering*



**NUS**  
National University  
of Singapore

**Engineering**



**Linga Lab**

# ABOUT US

Linga Lab@NUS Annual Report

2019

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[www.gashydrates.chbe.nus.edu.sg](http://www.gashydrates.chbe.nus.edu.sg)

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## Praveen Linga

Praveen Linga is a Dean's Chair Associate Professor in the Department of Chemical and Biomolecular Engineering at NUS. He is the co-lead for natural gas research in the centre for energy research & technology (CERT) at the Faculty of Engineering, NUS. He serves as a subject editor in Applied Energy and as an associate editor in the Journal of Natural Gas Science and Engineering. He also serves in the Editorial Boards of Energy & Fuels and Fluid Phase Equilibria journals. He is also a visiting professor with Guangzhou Institute of Energy Conversion (GEIC), Chinese Academy of Sciences (CAS) and Harbin Engineering University, China.

The vision of my lab, "Linga Lab", is to advance hydrate technology as an effective, and feasible solution for the critical needs of clean and safe water, cleaner energy, and environmental stewardship. Our targeted applications are seawater desalination, gas storage, data center cooling and carbon capture & storage. The specific focus of our research is to develop methods and to innovate on experimental process design targeted at improving the kinetics of hydrate formation. A part of our research is also focused on energy recovery from natural gas hydrates, pertaining to developing efficient production methods and tools. Up to date, we have published more than 110 research articles and Prof. Linga has delivered more than 100 keynote/invited talks and seminars.



# OUR PEOPLE

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2019



**Dr Ponnivalavan BABU**  
Research Fellow



**Dr Hari Prakash VELUSWAMY**  
Research Fellow



**Dr Zheng Rong CHONG**  
Research Fellow



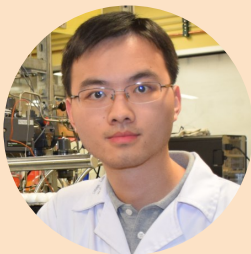
**Dr Maninder KHURANA**  
Research Fellow



**Dr Jun Lin TOO**  
Research Fellow



**Dr Gaurav BHATTACHARJEE**  
Research Fellow



**Dr Junjie ZHENG**  
Research Fellow



**Dr Fahed Aziz QURESHI**  
Research Fellow



**Mr Abhishek NAMBIAR**  
Research Engineer



**Mr Zhenyuan YIN**  
PhD Student



**Mr Marcus Neale GOH**  
Zheng Jie  
M.Eng. Student



**Mr Himanshu KHANDELWAL**  
M.Eng. Student



**Mr Niranjana Kumar LOGANATHAN**  
M.Eng. Student



**Dr Li HUANG**  
Visiting Scientist



**Mr Katipot INKONG**  
Visiting Student



**Mr Akash Govind KUTTIKAD**  
Visiting Student



**Ms Qingcui WAN**  
Visiting Student



**Mr Bingbing CHEN**  
Visiting Student



**Mdm Ai Peng TEO**  
Senior Lab Technologist



**Mr Henry SELVARAJ**  
Lab Technologist

# What's in

**Research Highlights**



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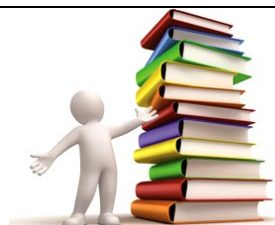
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# ENERGY STORAGE

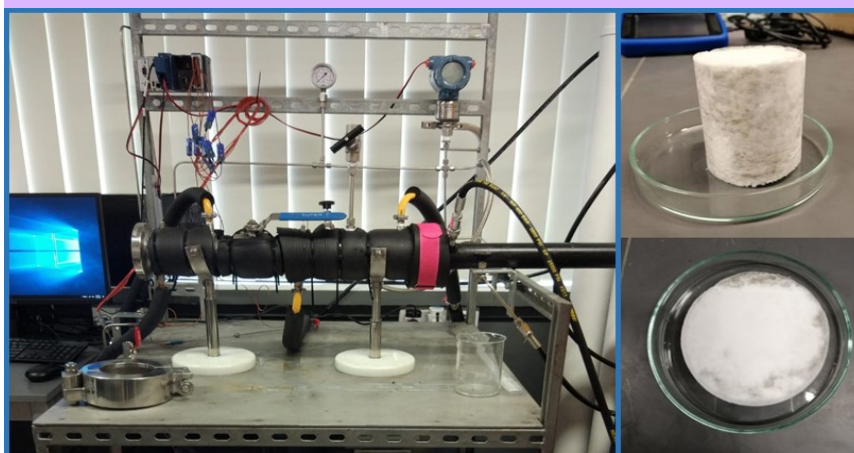
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## Solidified Natural Gas (SNG) Technology

SNG technology provides a viable alternative to store natural gas (NG) in molecular form by locking them in clathrate cages formed by water. A paradigm shift to move away from sl hydrates is needed to realize the potential of SNG (Solidified Natural Gas) technology for large scale natural gas storage. The presence of a promoter that can enhance both thermodynamic and kinetic performance will enable the development of a low cost, energy efficient SNG technology based on clathrate hydrates for natural gas storage. Moreover, SNG offers the added benefit of being the safest mode of NG storage compared to any of the available conventional options for the same. It is also easy to recover the natural gas, with practically zero energy loss during storage and recovery using SNG technology.

In the past year, we have reported rapid kinetics of SNG hydrate formation at ambient temperature conditions, which significantly enhances the economic and operational feasibility of the process. Efforts have also been made towards scaling up of the technology with two bench scale SNG prototypes designed and commissioned in our laboratories. On the downstream side of things, sustained stability of synthesized SNG hydrate pellets has been observed for a period of more than 18 months. Most recently, we have concentrated our efforts on recognizing environmentally friendly additives to rapidly form SNG hydrates at moderate thermodynamic conditions. A total of 6 publications have been originated from our work and 4 conference presentations were made last year.



**Bench-scale SNG Prototype commissioned at Linga Lab along with synthesised high volume cylindrical SNG pellet**

**Dr. Gaurav  
BHATTACHARJEE**  
Research Fellow



Specializes in gas hydrate kinetic studies and energy recovery from hydrates



**Dr. Maninder  
KHURANA**  
Research Fellow

Specializes in process design & systems integration

**Dr. Hari  
Prakash  
VELUSWAMY**  
Research Fellow

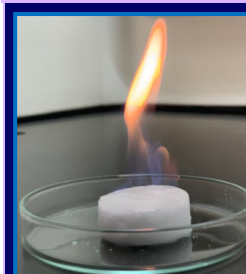


Specializes in experimental studies on the kinetics and morphology of gas hydrates



**Mr. Marcus  
Neale GOH**  
M.Eng. Student

Specializes in experimental studies on the kinetics of gas hydrates



**Burning  
SNG pellet  
synthesized at  
Linga Lab**

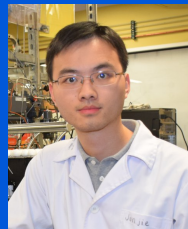
# CO<sub>2</sub> SEQUESTRATION

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## Deep Ocean CO<sub>2</sub> Storage Using Gas Hydrates

The atmospheric dosage of CO<sub>2</sub> has considerably increased due to the combustion of fossil fuels, the rise in global population and infrastructure expansion. The rise in the dosage of CO<sub>2</sub> upsurges the greenhouse effect and causes the rise in Earth's temperature and global mean sea level. These atmospheric changes can lead to issues like flooding, loss of land, coastal erosion and health related diseases. Oceanic sequestration of CO<sub>2</sub> offers huge carbon storage capacity owing to its great abundance of volume. One attractive option to store CO<sub>2</sub> in the ocean is to store in the form of clathrate hydrates. CO<sub>2</sub> hydrates can be formed under the high hydrostatic pressure and low temperature below certain ocean depth. In this project, we explore the dynamic interaction between CO<sub>2</sub> gas, seawater, and the deep sea sediments to develop safe and reliable CO<sub>2</sub> formation and storage strategies.



**Dr. Junjie ZHENG**  
Research Fellow

Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process, Raman and DSC measurement



**Dr. Fahed QURESHI**  
Research Fellow

Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process. Computational molecular models and simulations



**Mr. Himanshu KHANDEWAL**  
M.Eng. Student

Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process. CO<sub>2</sub> hydrate kinetic studies with promoters



**Dr. Junjie Zheng**, was awarded **ExxonMobil Emerging Energy Research Fellow Award** for this project and the entire research team was highly appreciated at a special luncheon arranged by ExxonMobil.



Experimentally observed CO<sub>2</sub> gas hydrate formation across the sediments in deep ocean conditions.

# GAS SEPARATION

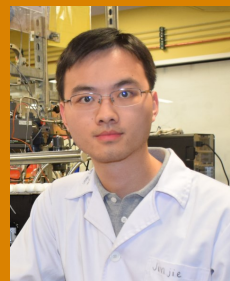
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## Hydrate Based Gas Separation (HBGS)

Natural gas is the cleanest conventional fossil fuel and its share in primary energy consumption has increased by 25% compared to last decade. Many natural gas reserves are still dormant and stranded due to the presence of high levels of contamination like  $\text{CO}_2$  and  $\text{N}_2$ .

With our extensive experience on hydrate based gas separation for  $\text{CO}_2$  capture from flue gas and fuel gas, we have extended its application for purifying the  $\text{CO}_2$  or  $\text{N}_2$  contaminated natural gas. Thermodynamic and kinetic promoters were employed synergistically to enhance the hydrate formation kinetics. Efforts were made to shift the operating condition towards ambient temperature. A hybrid hydrate formation approach involving a short period of stirring for nucleation followed by unstirred hydrate growth was developed. The simplicity of this process and enhanced kinetics at room temperature could lead to an overall cost reduction, making it feasible to develop an economical method to purify natural gas and meanwhile offer the opportunity to store and transport natural gas in the form of hydrates.



Dr. Junjie ZHENG

Research Fellow

Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process, Raman and DSC measurement



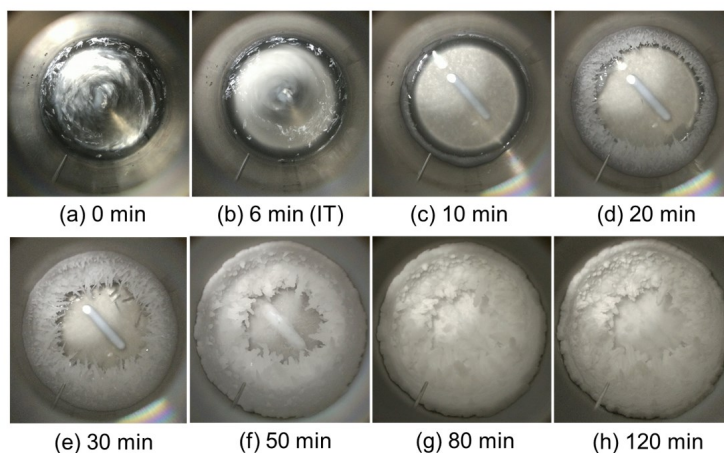
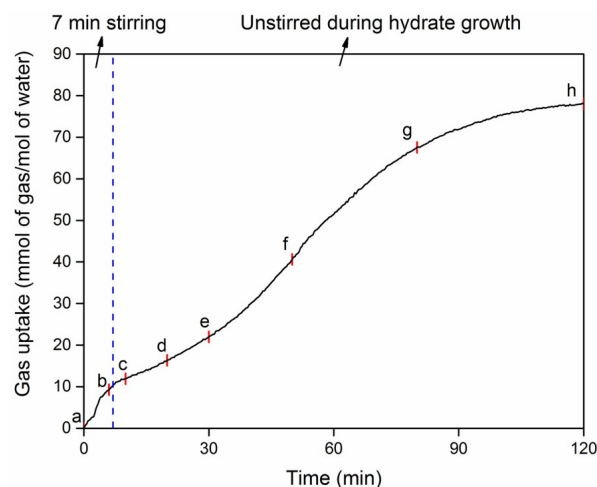
Mr. Niranjan

Kumar

LOGANATHAN

M.Eng. Student

Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process



Hydrate formation from  $\text{CO}_2/\text{CH}_4$  mixture in presence of 5.56mol% THF and 100 ppm SDS at 298.2 K and 9.1 MPa using a hybrid formation method (stirring + unstirred).

DOI: 10.1016/j.apenergy.2019.04.118



# ENERGY RECOVERY

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## Energy Recovery from Natural Gas Hydrate

Natural gas hydrates (NGH) has been considered as the future source of energy because of its large resource volume worldwide and high energy storage capacity. To recover energy from hydrate-bearing sediments (HBS) effectively and safely below seafloor requires a fundamental understanding of the dynamic behaviour of hydrates in sandy media.

The studies in our lab include the following aspects: (a) the state-of-the-art experimental design investigating the fundamental kinetic behaviour of HBS and the associated fluid production using novel production technologies; (b) the numerical simulation codes for the solution of complex problems of transport through porous media, accounting for coupled flow, thermal, and chemical processes; and (c) the global optimization algorithms that coupled with the numerical model in history-matching the experimental and field production results.

Fig. A below shows the newly setup  $V = 3.0$  L high-pressure reactor used in the investigation of fluid production from HBS. Fig. B below shows the graphical abstract of our recent study on the effect of pressure drawdown rate on the fluid production from aqueous-rich HBS using the newly setup reactor [1].

[1]. Z. Yin; Q. Wan; Q. Gao; P. Linga, Effect of pressure drawdown rate on the fluid production behaviour from methane hydrate-bearing sediments. *Applied Energy*, DOI: [10.1016/j.apenergy.2020.115195](https://doi.org/10.1016/j.apenergy.2020.115195)



**Dr. Zhenyuan YIN**  
Research Fellow

Specializes in experimental studies and numerical modelling of fluid production from gas hydrates in sandy medium



**Dr. Li HUANG**  
Visiting Scientist

Specializes in reservoir-scale numerical modelling of gas production from hydrate-bearing sediments at geological media



**Qingcui WAN**  
Visiting student

Specializes in experimental studies on energy recovery from natural gas hydrates

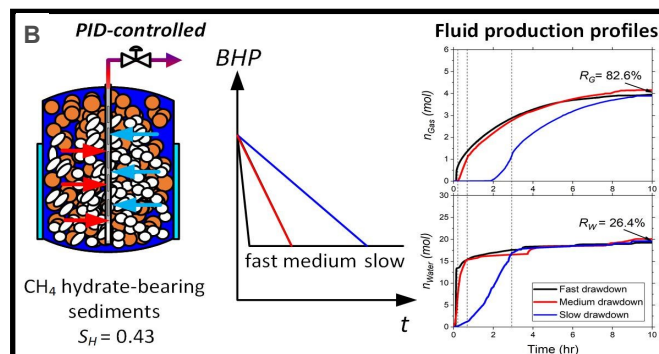
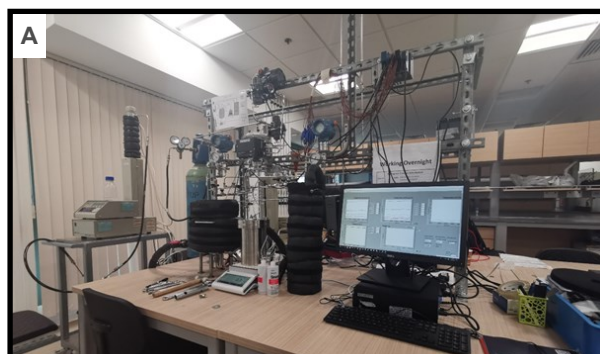


Fig. A. Picture of the  $V = 3.0$ L NGH reactor; Fig. B. Graphical abstract of the pressure drawdown rate on fluid production behavior from hydrate-bearing sediments.



# DATA CENTRE COOLING

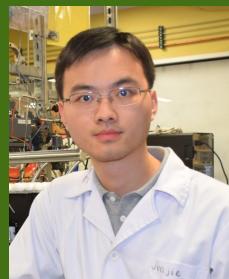
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## Integration of Cold Energy for Sustainable and Energy Efficient Data-Centres (ICE-SEED)

With the rapid expansion of cloud-based services, AI, the Internet of Things and big data analytics, there has been an exponential demand across the globe for data centres. Our team has teamed up with Keppel Data Centres Holdings Pte. Ltd. and Singapore LNG Corporation Pte. Ltd. to develop a novel, energy-efficient and cost-effective cooling technology for data centres.

The large amount of cold energy released during the re-gasification of liquified natural gas (LNG) can be utilized as a high-quality cold source. In this project, we will explore the use of semiclathrate hydrate slurries, which are water-based phase-change fluid, as thermal energy carriers and cooling medium to cool data centres. The thermal density of the semiclathrate hydrate slurry is 2-5 times higher compared with chilled water. Thus, it significantly reduces the amount of water and power required as well as the size of various equipment and distribution lines. However, technical challenges remain in keeping the hydrate slurry flowable and not causing blockage. We will innovate in process design to enable efficient generation of semiclathrate slurries and build a pilot scale prototype to demonstrate the coupling of cold energy with semiclathrates generation system for data centre cooling.



**Dr. Junjie  
ZHENG**

**Research Fellow**

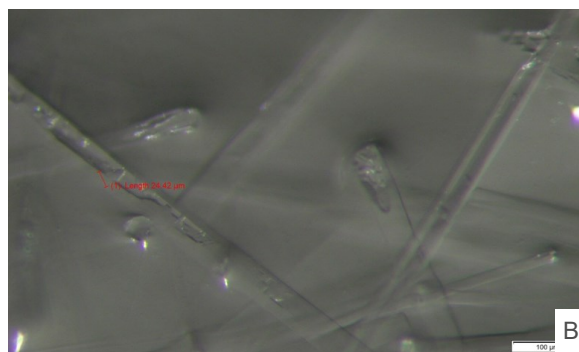
Specializes in experimental studies (both thermodynamics and kinetics) on hydrate process, Raman and DSC measurement



**Dr. Zhenyuan  
YIN**

**Research Fellow**

Specializes in hydrate process modeling and experimental studies on hydrate formation and dissociation



(A) Morphology setup; (B) Needle-shape semiclathrate hydrates observed by microscope

# RECOGNITIONS

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The year 2019 has been a prolific year for us, marked by milestones and achievements.



**Prof Linga** received the Outstanding Asian Researcher and Engineer (OARE) Award from SCEJ (Society of Chemical Engineers, Japan). This prestigious award is presented to the researchers or engineers under the age of 45 who have accomplished outstanding achievements in chemical engineering.

**Prof. Linga** appointed as a Dean's Chair Professor in the Faculty of Engineering at NUS from 01 January 2019. This appointment is in recognition of his outstanding and impactful scholarly accomplishments.

**Prof Linga** listed among the **Top 5** in the world in the field of [clathrate hydrates](#) (10-yr period) by **Microsoft Academic**.



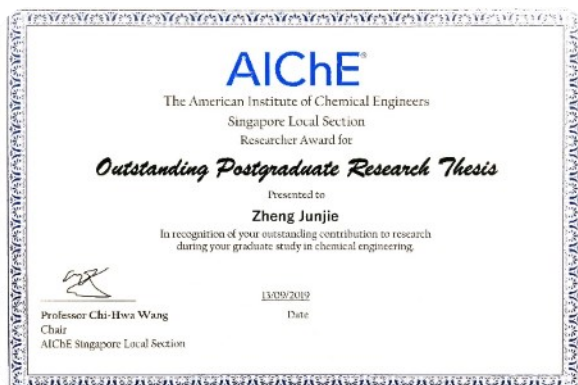
**Prof Linga** elected as Fellow of **Royal Society of Chemistry** (RSC) for his contribution in the field of chemical sciences. The Royal Society of Chemistry is one of the oldest and most reputed professional bodies headquartered in the UK.

**Prof Linga** joined **Harbin Engineering University (HEU)** as a Visiting Guest Professor for three years.

**Prof Linga** joined **Indian Institute of Technology (IIT) Madras** as a Visiting Professor for three years.

**Prof Linga** invited to join **Energy & Fuels** and **Fluid Phase Equilibria** journals as an Editorial Advisory Board Member.





**Dr. Zheng Junjie**, a research fellow at Linga Lab was awarded 'Outstanding Postgraduate Research Thesis' award by AIChE Singapore Local Section.

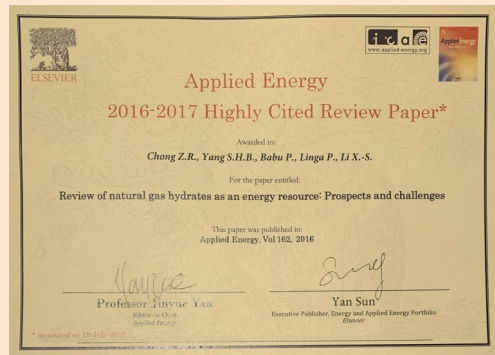


**Dr. Zheng Junjie** was awarded the **ExxonMobil Emerging Energy Research Fellow Award 2019** by Singapore Energy Centre.



Our alumni, **Dr. Hari Prakash Veluswamy** has joined **IIT Roorkee** as an Assistant Professor in the Department of Chemical Engineering.

## Paper Awards



# TECHNOLOGY & GRANTS



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## LNG Cold Energy Utilization to Desalinate Sea Water Employing the Hydrate Based Desalination (HBD) Process

Linga Lab@NUS and Shell Energy Singapore have signed a Research Collaboration Agreement (RCA) for developing a hydrate based desalination technology for seawater desalination utilizing LNG cold energy. Shell Energy Singapore will support research activities to the tune of S\$120,000 for three years.

Dr. Linga has also secured a major research grant to develop a hydrate based desalination technology for producing water from seawater by harvesting LNG cold energy. Energy Market Authority (EMA) has awarded S\$27 million in research grants to 13 industry-partnered projects in the areas of Gas Technology and Smart Grids. [Read More!](#)

## SNG (solidified natural gas) Technology for Natural Gas Storage via Clathrate Hydrates

Linga lab secured a competitive grant to develop SNG (solidified natural gas) technology for natural gas storage via clathrate hydrates. Read more on Energy Market Authority (EMA) [Media release!](#)

Linga Lab@NUS led by Prof. Linga and Lloyd's Register Global Technology Centre Pte Ltd (LR GTC) have signed a Research Collaboration Agreement (RCA) for developing SNG (solidified natural gas) technology for natural gas storage. LR GTC will support research activities to the tune of S\$350,000 for three years.

## Evaluate Stability of CO<sub>2</sub> Hydrates

In collaboration with ExxonMobil, Linga Lab is developing and testing a laboratory-scale prototype that can mimic the deep ocean environments to investigate the stability of CO<sub>2</sub> hydrates for potential long-term storage of CO<sub>2</sub> in deep oceanic sediments.

## Integration of Cold Energy for Sustainable and Energy Efficient Data-Centres (ICE-SEED)

Linga Lab@NUS has secured a major research grant administered by the National Research Foundation (NRF) and Infocomm Media Development Authority (IMDA) aimed at developing semi-clathrate hydrate technology as a sustainable and energy-efficient means for data-centre cooling amidst the backdrop of advancing Singapore's future 5G capability and ever-increasing data traffic. [Read more.](#)



Smart Energy, Sustainable Future



Ministry of Education  
SINGAPORE





# MEDIA REPORT

Linga Lab@NUS Annual Report

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Our innovation (NewGen Gas) is one of the 15 selected deep-tech projects for start-up support under GRIP initiative in NUS. This is based on our SNG (Solidified Natural Gas) technology. The NewGen Gas Pte. Ltd. is championed by Dr. Maninder Khurana, a Research Fellow at Linga Lab.

**NUSnews**[NUS Home](#) [Email](#) [Library](#)[Home](#) [Highlights](#) [Research](#) [Press Releases](#) [News Reports](#) [Press Room](#) [Staff Awards](#)[Home](#) / [Highlights](#) / NUS invests \$1.5m in 15 deep-tech start-ups

## NUS invests \$1.5m in 15 deep-tech start-ups

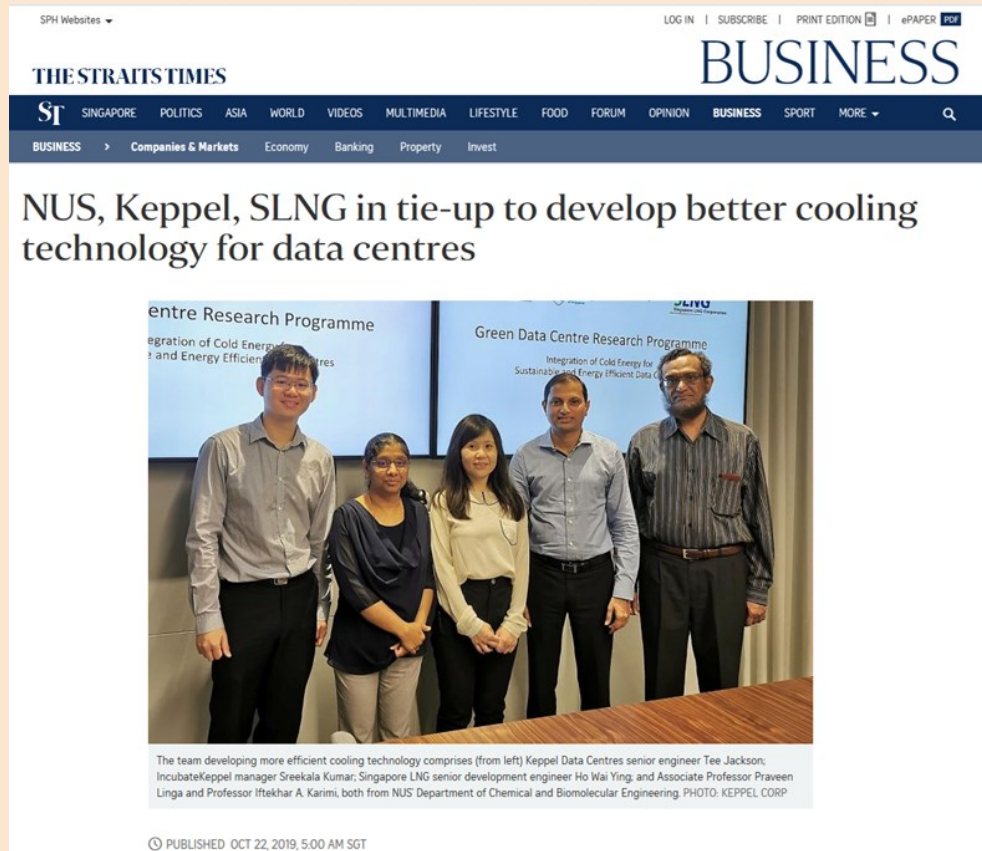
22 January 2019 | Entrepreneurship

Under the engineering track, NewGen Gas, created by Research Fellow Dr Maninder Khurana from NUS Chemical and Biomolecular Engineering, offers a low-cost and safe way of storing natural gas in the form of gas hydrates called solidified natural gas. The hydrates can be stored at zero degree Celsius and at atmospheric pressure, eliminating the need for cryogenic conditions of liquefied natural gas or high pressure risks of compressed natural gas, and potentially reducing storage costs by 50 per cent.



Dr Khurana developed NewGen Gas

We have teamed up with Keppel Data Centres and SLNG to jointly develop a novel, energy-efficient and cost-effective cooling technology based on semiclathrates for data centres. Keppel Data Centres is a leader in Asia-Pacific region in data storage and SLNG manages the regasification terminal in Singapore.



## Maritime Global News

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### Singapore: LNG Terminal to Develop Data Center



**Shailaja A. Lakshmi**

The National University of Singapore's Faculty of Engineering (NUS), Singapore LNG Corporation (SLNG) and Keppel Data Centers Holdings join forces to develop new energy-efficient cooling technology for data centers.

This innovation could further pave the way for more sustainable and compact data centers, said Singaporean conglomerate Keppel Corporation.

With the rapid expansion of cloud-based services, AI, the Internet of Things and big data analytics, there has been an exponential demand across the globe for data centers in recent years. As the leading data center hub of Southeast Asia, Singapore accounted for around 50 per cent of the region's data center capacity in 2015.

## NUS, Keppel, SLNG to build cooling tech for data centres

The new system can improve the power usage effectiveness of data centres by 20%.

The National University of Singapore Faculty of Engineering partnered with Keppel Data Centres and Singapore LNG Corporation to develop an energy- and cost-efficient cooling technology for data centres, according to a press release.

A five-member team from NUS Engineering, Keppel and SLNG will develop a prototype of a new cooling mechanism that will store and carry cold energy from liquefied natural gas (LNG) terminal into various data centres and then circulate that energy within the cooling loop in each data centre.



### Singapore to use its LNG terminal to develop data center cooling technology



The National University of Singapore Engineering collaborated with the Keppel Data Centres Holdings Pte Ltd and Singapore LNG Corporation to develop a technology that can efficiently store and carry cold energy from the Singapore LNG Terminal to various data centres. This solution aims to open the way for more sustainable and compact data centres.

## Trio to develop LNG-based data center cooling technology



Oct 21, 2019

LNG World News



The National University of Singapore's Faculty of Engineering (NUS), Keppel, and Singapore LNG have joined forces to develop a new, LNG-based, cooling technology for data centers.

Singapore is the leading data center hub of Southeast Asia and accounts for around 50 percent of the region's data center capacity in 2015.

## Singapore's LNG Terminal could be used to cool data centers

Keppel is part of a project aiming to reuse cold energy from LNG re-gasification process

October 22, 2019 By: Paul Mah

## NUS, Keppel and SLNG to develop energy-efficient cooling technology for data centres

Published by Nicholas Woodroof, Assistant Editor

Hydrocarbon Engineering, Monday, 21 October 2019 11:00

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## NUS, Keppel and SLNG join forces to develop new energy-efficient cooling technology for data centres

The National University of Singapore's Faculty of Engineering (NUS Engineering), Keppel Data Centres Holdings Pte Ltd (Keppel Data Centres) and Singapore LNG Corporation Pte Ltd (SLNG) have joined forces to develop a novel, energy-efficient and cost-effective cooling technology for data centres.

Published 7 months ago on October 21, 2019

By Keppel Corporation

## FNTalk.com

FNTalk.com – Hot Finance News!!!

★ **BREAKING:** Amazon removes racist messages after they appear on some product listings

Home » Companies » NUS, Keppel, SLNG in tie-up to develop better cooling technology for data centres

## NUS, Keppel, SLNG in tie-up to develop better cooling technology for data centres

October 21, 2019



## Singapore: LNG Terminal to Develop Data Center

Shailaja A. Lakshmi October 21, 2019

TRENDING Tencent set aside \$70bn for cloud and AI data centre campuses

Asia Pacific

Digital Disruptors

## Power Usage Effectiveness Could Be Improved By 20% With New Cooling System

By Antony Sarvas | PUBLISHED: 18:15, 23 October, 2019 | UPDATED: 18:15, 23 October, 2019

## Trio join forces to develop LNG-cooling system for data centres

Published by Will Owen, Assistant Editor

LNG Industry, Monday, 21 October 2019 09:00

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# PUBLICATIONS



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1. Molecular level investigations and stability analysis of mixed methane-tetrahydrofuran hydrates: Implications to energy storage.  
Kumar, A.; Veluswamy, H.P.; Linga, P.; Kumar, R; **Fuel** 2019, 236, 1505-1511  
[DOI: [10.1016/j.fuel.2018.09.126](https://doi.org/10.1016/j.fuel.2018.09.126)] .
2. Direct use of seawater for rapid methane storage via clathrate (sII) hydrates.  
Kumar, A.; Veluswamy, H.P.; Kumar, R; Linga, P.; **Applied Energy** 2019, 235, 21-30.  
[DOI: [10.1016/j.apenergy.2018.10.085](https://doi.org/10.1016/j.apenergy.2018.10.085)] .
3. LNG cold energy utilization: Prospects and challenges.  
He, T.; Chong, Z. R.; Zheng, J.; Ju, Y; Linga, P.; **Energy** 2019, 170, 557-568.  
[DOI: [10.1016/j.energy.2018.12.170](https://doi.org/10.1016/j.energy.2018.12.170)] .
4. Methane hydrates: A future clean energy resource.  
Yin, Z; Linga, P.; **Chinese Journal of Chemical Engineering** 2019 27 (9), 2026-2036.  
[DOI: [10.1016/j.cjche.2019.01.005](https://doi.org/10.1016/j.cjche.2019.01.005)]. (Invited submission for a special issue on gas hydrates)
5. Improved kinetics and water recovery with propane as co-guest gas on the hydrate based desalination (HyDesal) process.  
Nambiar, A.; Babu, P.; Linga, P.; **ChemEngineering** 2019, 3, 31.  
[DOI: [10.3390/chemengineering3010031](https://doi.org/10.3390/chemengineering3010031)]. (Invited submission for Dr Babu for his ChemEngineering travel award)
6. Thermodynamic and kinetic modelling of mixed CH<sub>4</sub>-THF hydrate for methane storage application.  
Khurana, M.; Veluswamy, H. P.; Daraboina, N.; Linga, P.; **Chemical Engineering Journal** 2019, 370, 760-771. [DOI: [10.1016/j.cej.2019.03.172](https://doi.org/10.1016/j.cej.2019.03.172)] .
7. Sodium dodecyl sulfate preferentially promotes enclathration of methane in mixed methane-tetrahydrofuran hydrates.  
Kumar, A.; Kumar, R.; Linga, P.; **iScience** 2019, 14, 136-146.  
[DOI: [10.1016/j.isci.2019.03.020](https://doi.org/10.1016/j.isci.2019.03.020)] .
8. Economic evaluation of energy efficient hydrate based desalination utilizing cold energy from liquefied natural gas (LNG).  
Chong, Z. R.; He, T.; Babu, P.; Zheng, J.; Linga, P.; **Desalination** 2019, 463, 69-80.  
[DOI: [10.1016/j.desal.2019.04.015](https://doi.org/10.1016/j.desal.2019.04.015)] .
9. Techno-economic evaluation of cyclopentane hydrate-based desalination with LNG cold energy utilization.  
He, T.; Chong, Z. R.; Babu, P.; Linga, P.; **Energy Technology** 2019, 190212.  
[DOI: [10.1002/ente.201900212](https://doi.org/10.1002/ente.201900212)]. (Invited submission for a special issue on Methane and Natural Gas Utilization)



10. Clathrate hydrate formation of CO<sub>2</sub>/CH<sub>4</sub> mixture at room temperature: Application to direct transport of CO<sub>2</sub>-containing natural gas.  
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13. Effect of temperature and pressure on the methane hydrate formation with the presence of tetrahydrofuran (THF) as a promoter in an unstirred tank reactor.  
Inkong, K.; Rangsunvigit, P.; Kulprathipanja, S.; Linga, P.; **Fuel** 2019, 255, 115705. [[DOI: 10.1016/j.fuel.2019.115705](https://doi.org/10.1016/j.fuel.2019.115705)] .
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Veluswamy, H. P.; Kumar, A.; Kumar, R.; Linga, P.; **Applied Energy** 2019, 253, 113515. [[DOI: 10.1016/j.apenergy.2019.113515](https://doi.org/10.1016/j.apenergy.2019.113515)] .  
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16. On the importance of phase saturation heterogeneity in the analysis of laboratory studies of hydrate dissociation.  
Yin, Z.; Moridis, G.; Linga, P.; **Applied Energy** 2019, 255, 113861. [[DOI: 10.1016/j.apenergy.2019.113861](https://doi.org/10.1016/j.apenergy.2019.113861)] .
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18. Innovative approach to enhance the methane hydrate formation at near ambient temperature and moderate pressure for gas storage applications.  
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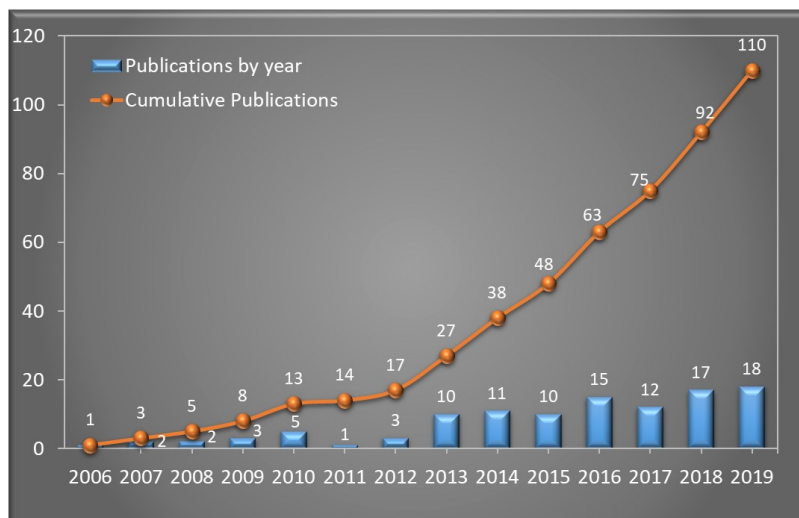
# IMPACT ANALYSIS



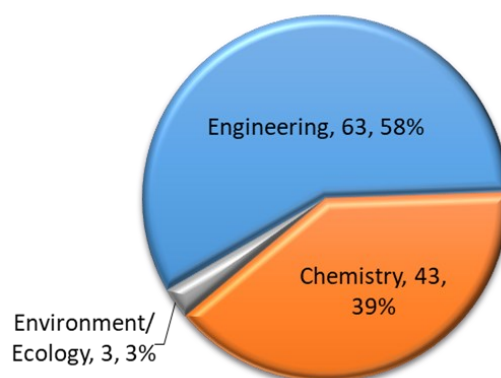
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2019

## Publication Statistics



## Subject Classification (ESI, Clarivate Analytics)



## Citation Statistics

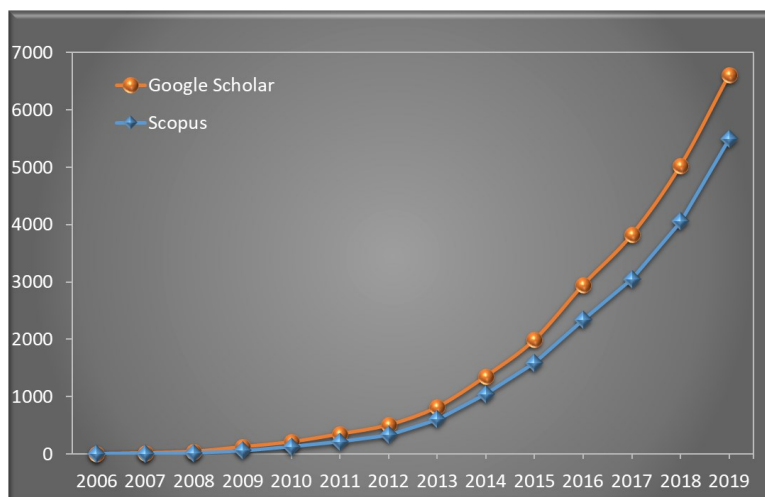
### Essential Science Indicators (ESI) Clarivate Analytics

Highly Cited Papers  
as of 2019

19

Hot Papers as of  
2019

5



	Scopus	Web of Science	Google Scholar
Total Publications (as of 2019)	110	108	110
Total Citations (as of 2019)	5554	5370	6649
Citations per paper	50.5	49.7	60.4
h-index	43	41	45
Field-Weighted Citation Impact (FWCI)*	3.9	-	-

\*FWCI in SciVal (Elsevier) indicates how the number of citations received by an entity's publications compares with the average number of citations received by all other similar publications. An FWCI of 1.0 indicates a scientist's impact is about the global average, a value above 1.0 indicates impact is above global average (i.e. FWCI of 2.11 means, 111% above the global average).

# VISITORS



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**Prof Tianfu XU** from Jilin University, China



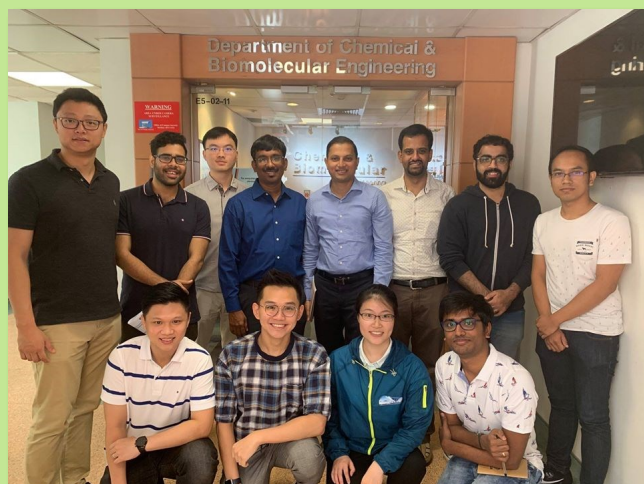
**Prof Mohammed Al-Beiruty & A/Prof. Bamaga** from King Abdulaziz University, Saudi Arabia



**Prof Rajnish Kumar** from IIT Madras, India



**Prof George Moridis** from Lawrence Berkeley National Laboratory, US



**Prof S Suresh** from NIT Tiruchirappalli, India



**Dr. Nayef Alsaifi** from King Fahd University of Petroleum and Minerals, Saudi Arabia



# KEYNOTE/INVITED

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**Plenary Speaker**, International Symposium on Natural Gas Value Chain [ISNG-2019], Chennai, India, Dec 10-11, 2019



**Invited Seminar**, Sun Yat Sen University, Zhuhai, China, Oct 20, 2019



**Invited Seminar**, South China University of Technology, China, Oct 24, 2019



**Institute Seminar**, Guangzhou Institute of Energy Conversion (GIEC), Chinese Academy of Sciences, China, Oct 25, 2019



# KEYNOTE/INVITED

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**Invited Speaker**, PPC PETROMAT symposium at Chulalongkorn University, Thailand  
May 30, 2019



**Guest Lecture**, Vellore Institute of Technology, India  
Dec 12, 2019

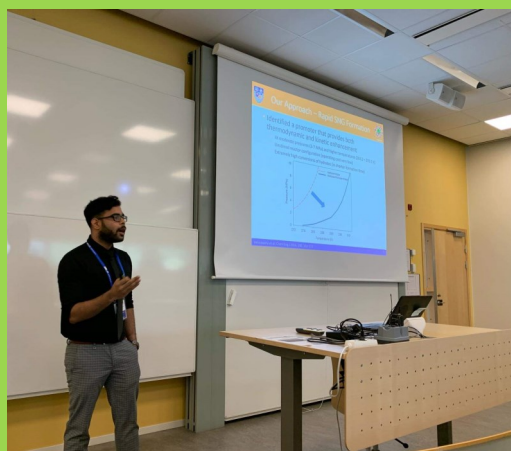
Other Keynote and Invited Seminars include:

- **Keynote Speaker** in International Conference on Unconventional Energy Resources (ICUER 2019), RGIPT, Rae Bareilly, India, February 28-March 01, 2019.
- **Invited Speaker**, Joint workshop on Energy by NUS-UCalgary, Calgary, July 7-9, 2019.
- **Invited Speaker**, 15th International Conference on Properties and Phase Equilibria for Products and Process Design (PPEPPD 2019), Vancouver, Canada May 12-16, 2019.
- **Invited Speaker**, Advances in Gas Hydrate Production Technology, Offshore Technology Conference (OTC2019), Houston, USA, May 6-9, 2019.
- **Invited Seminar**, Centre for Chemical Engineering (SPIN), Ecole des Mines de Saint-Étienne, France, July 18, 2019.
- **Invited Seminar**, Department of Chemical Engineering, Indian Institute of Technology Madras (IIT-M), India, June 20, 2019.
- **Invited Seminar**, China University of Geosciences, Wuhan, China, October 22, 2019
- **Invited Workshop Seminar**, Indian Institute of Technology Madras, Chennai, India, December 9, 2019

# CONFERENCES

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## The 11<sup>th</sup> International Conference on Applied Energy (ICAE2019)

In August 12-15, 2019, Linga Lab Postdoc Dr. Gaurav BHATTACHARJEE presented his study on solidified natural gas (SNG) during the 11th International Conference on Applied Energy (ICAE2019) at Vasteras, Sweden. The oral presentations have received recommendations to be considered in the Applied Energy (IF = 8.426) journal.

## AIChE 2019 Annual Meeting

In November 10-15, 2019, Linga Lab Postdoc Dr. Gaurav BHATTACHARJEE presented his study on solidified natural gas (SNG) during the 2019 AIChE Annual Meeting at Orlando, U.S.A.



## 1<sup>st</sup> ExxonMobil Singapore Energy Centre Fellows and Friends Luncheon



The 1<sup>st</sup> ExxonMobil Singapore Energy Centre Fellows and Friends Luncheon was organized on December 13, 2019. Linga Lab members Himanshu Khandelwal, Dr. Zheng Junjie and Dr. M Fahed Qureshi attended the event and presented their work on carbon sequestration via hydrates. Dr. Zheng Junjie was awarded ExxonMobil Emerging Energy Research Fellow Award during this event.



# GRADUATIONS

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Linga Lab members celebrating with our recently graduated Ph.D Dr. Junjie Zheng in the Commencement Ceremony!  
From left to right: Mr. Akash, Mr. Bingbing Chen, Mr. Zhenyuan Yin, Dr. Junjie Zheng with his parents, Dr. Hari Prakash Veluswamy, Dr. Gaurav Buattacharjee, Dr. Li Huang.



Our undergraduate Final Year Project member Mr. Kaneson MACHAPU celebrating graduation with his family. He graduated from the National University of Singapore with a Bachelor of Technology (Chemical Engineering) with Honours (distinction).



# ACKNOWLEDGMENT

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Smart Energy, Sustainable Future

ExxonMobil

Honeywell  
uop



INFOCOMM  
MEDIA  
DEVELOPMENT  
AUTHORITY

Keppel



NATIONAL  
RESEARCH  
FOUNDATION  
PRIME MINISTER'S OFFICE  
SINGAPORE



## Collaborators



SEOUL  
NATIONAL  
UNIVERSITY



THE UNIVERSITY  
OF BRITISH COLUMBIA

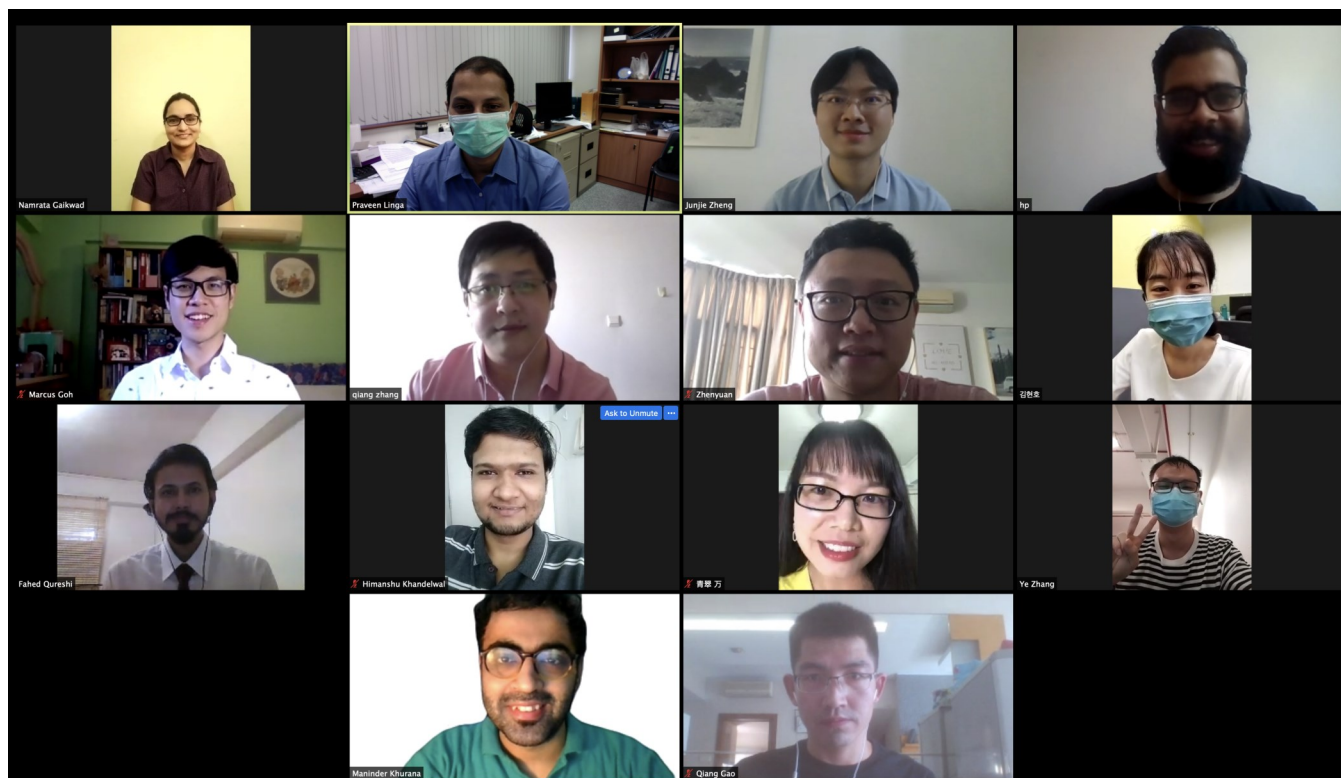


THE UNIVERSITY of  
TULSA



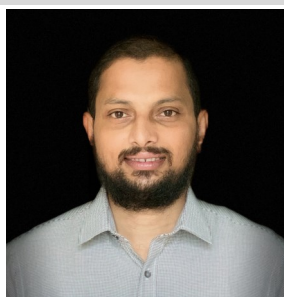
## Our Family



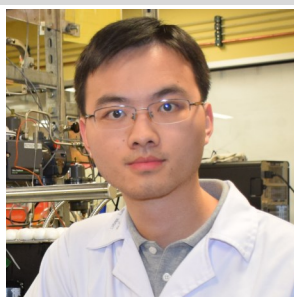


A group photo of Linga Lab taken via ZOOM amidst COVID-19

## Editorial Team



Prof Praveen LINGA



Dr Junjie ZHENG



Dr Fahed Aziz QURESHI



Dr Gaurav BHATTACHARJEE



Dr Zhenyuan YIN



Dr Maninder KHURANA



Mr Marcus Neale GOH



Mr Himanshu KHANDELWAL

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