The Institution of Electronics and Telecommunication Engineers

IETE Bengaluru Magazine

VOLUME12 SEPT - NOV 2021

From the President's Desk

Bangalore is one of the IETE's Centers that publishes its magazine regularly. I feel proud in congratulating IETE Bangalore Centre for releasing its Vol 12 of the Magazine. IETE Bangalore Centre is flourishing high by expanding the vision and Mission of the IETE. It has established a Center of Excellence in the domain of Internet of Things (IoT) through which it is imparting skill training to the students and the young professionals.

This is a bitter fact that the country presently faces a dual challenge of severe paucity of highly-trained, quality engineers, as well as non-employability of large sections of the educated workforce that possess little or no job skills. Huge gaps exist between the industry requirements and the level of skills of engineers due to varied reasons including inadequate training infrastructures, inappropriate mix of skills and education, limited industry interfaces, etc. These gaps need to be filled by providing appropriate market driven skill training to the young professionals. As part of its National Skill Development Mission, the Government has established the National Skill Development Corporation in the Public Private Partnership mode to facilitate setting up of large and high quality vocational institutions.

Professional bodies like IETE can play a very vital role in accomplishing the National Skill Development Mission under the National Skills Qualifications Framework (NSQF). We are proud to spread the message to the Central and State Skill Development Ministries and the corporate world that IETE has already aligned itself to the National Skill Development Mission. Our major Centres like Bangalore, Mumbai, Delhi, Chennai, Kolkata, Hyderabad, Chandigarh, Pune and Ranchi have either established or are establishing the Centers of Excellences in the emerging domains of Electronics & Telecommunication and IT such as Internet of Things, Block Chain, Cyber Security, Artificial Intelligence and Machine Learning.

I extend my best wishes to IETE Bangalore Centre for enhancing their capabilities in Skill and Vocational Training and releasing the 12th Volume of its Magazine that depicts the stories of their accomplished projects and future planning.

Jai Hind

Prof P Prabhakar
President IETE

From the Chairman

Dear IETEians,

I am extremely happy that this edition of our Magazine is being released on IETE Foundation Day. On this day we honour distinction in promotion of Science and Technology, and show our respect to contributions of our members present and past.

The magazine pages reflect our modest achievements and plans. The Centre has been conducting training programmes with the available infrastructure, which we want to develop. We intend to collaborate with the public and private sectors for this purpose. We recently conducted a webinar with two other IETE centres and are planning to do similar activities in the near future too. We wish to expand our ISF network and showcase students' activities. We are also planning an International Conference shortly. We are committed to making our Centre a bigger and better one. I seek the involvement of all in these efforts.

Our magazine is regularly uploaded to our website www.ietebangalore.org and will be emailed to IETE members and anyone who requests for it. I appeal to you to go through the issues critically and send us your feedback.

With the best wishes
C Satyanandan
Chairman, IETE Bangalore

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IETE BENGALURU

From Hon. Secretary

It is my immense pleasure that we are back with the 12th issue of the IETE Bengaluru Magazine. This edition is being released on a special day - The IETE Foundation Day 2021.

In modern times, nations which have rich engineering and technology domains are flourishing economically and are providing better lives to their people. We have excellent potential to grow in diversified areas and excel in Engineering and technological fields. Nurturing creativity and inspiring innovation are two of the key elements of a successful education and IETE Bangalore strives in providing quality education in the various areas of emerging technologies. With the motto of striving for excellence by providing the quality training to all the stake holders the center is planning to collaborate with various Industries and strengthen the IOT lab with new tools.

I would appeal all the ISF coordinators and all members of IETE Bangalore to provide your suggestions in all our activities being conducted and making the Bengaluru Centre more proactive and accomplish the vision of the Centre.

Dr. S G Shivaprasad Yadav
Honarary Secretary
IETE Bangalore

Welcome to Twelfth Issue of *IETE Bengaluru Magazine*! We are releasing this issue of *IETEBM* on IETE Foundation Day Program. We are immensely proud and happy to release our 12th Issue of ieteBM on this very important day.

The Institution of Electronics and Telecommunication Engineers (IETE) was founded on 02 Nov 1953 and we celebrate this day as its Foundation Day every year. We also organize Seminar on a theme of National importance. This year, the IETE has adopted the theme:

"Advancing Skill Development to the Next Level - A Paradigm Shift to Amalgamate Skills & Academics with Seamless Transitions"

The country presently faces a dual challenge of severe paucity of highly-trained, quality engineers, as well as non-employability of large sections of the educated workforce that possess little job skills. Huge gaps exist between the industry requirements and the level of skills of engineers. There is a disconnect between the formal education system and work requirements. The need is about how formal, non-formal and informal learning can be combined and recognised by industry, employers, training providers and individuals. Skills and knowledge are the driving forces of economic growth and social development for any country.

IETE, a premier professional society dedicated to the dissemination of Knowledge in the ICT domain is supporting Govt of India in its mission of Skill Development and bridging the gap between the Informal vocational training and formal Technical University Academic Higher Education and bridge the pathway to transition between the two seamlessly.

iete Bengaluru Magazine would also like to congratulate Prof P Prabhakar on taking over as the IETE President for the year 2021-22. We have included IETE President's IETE Foundation Day message.

This issue covers all the major activities organized by IETEB which includes Engineer's Day Program, Panel Discussion, Ayudha Puja Celebration Training Programs, Workshops, etc. under able stewardship of Chairman Sri Satyanandan and his team, technical articles, Tech Trends etc.

We had requested Dr Prasad Shastry, Dept of Electrical & Computer Science, Bradley University USA to provide us a technical article for IETEBM. He has kindly obliged us and we have included a very interesting technical article on "Wireless Energy Harvesting" by Dr Prasad Shastry in this issue. We are highly thankful to him for sending this article.

We would like to thank IETEB Chairperson Mr Satyanandan, Dr Shiva Prasad, Hon Secretary and the entire IETEB team for their immense support in bringing out this issue of the magazine. Our thanks are always due to Prof Prabhakar, President IETE, for his message, constant support & blessings, Prof Prasad Shastry for his technical article and IETE Bengaluru & IETE HQ staff for their support. Thanks to all members of IETEB Magazine Editorial Board for their contributions in bringing out this issue.

Please send your views, suggestions and be part of the magazine by contributing articles, news clips etc. Thanks for your continued support and encouragement.

Thank You
Dr M H Kori
On behalf of *iete Bengaluru Magazine* Editorial Board

President's Message on IETE's 68th Foundation Day 2021

Advancing Skill Development to the Next Level
- A Paradigm Shift to Amalgamate Skills & Academics with Seamless Transitions

The country presently faces a dual challenge of severe paucity of highly-trained, quality engineers, as well as non-employability of large sections of the educated workforce that possess little or no job skills. Huge gaps exist between the industry requirements and the level of skills of engineers due to varied reasons including inadequate training infrastructures, inappropriate mix of skills and education, limited industry interfaces, etc. There isa disconnect between the formal education system and work requirements, compounding the challenges related to the skill gap. A concerted action is required to ensure sustained employability of the Indian youth.

The skill development ecosystem in India is complex, large and diverse, providing varied levels of skills across an extremely heterogeneous population. Skill development in India can be broadly segmented into Education and Vocational Training. The need is about how formal, non-formal and informal learning can be combined to deliver workforce skills and also look at how such combinations could be used and recognised by industry, employers, training providers and individuals.

Skills and knowledge are the driving forces of economic growth and social development for any country. Government of India, taking note of the requirement for skill development among students launched National Skills Qualifications Framework (NSQF).

NSQF is a nationally integrated education and competency-based framework that enables persons to acquire desired competency levels. The National Skills Qualifications Framework (NSQF) organizes qualifications according to a series of levels of knowledge, skills and aptitude. These levels, graded from one to ten, are defined in terms of learning outcomes which the learner must possess regardless of whether they were acquired through formal, non-formal or informal learning. It is, therefore, a nationally integrated education and competency-based skill and quality assurance framework that will provide for multiple pathways, horizontal as well as vertical, including vocational education, vocational training, general education and technical education, thus linking one level of learning to another higher level. This will enable a person to acquire desired competency levels, transit to the job market and at an opportune time, return for acquiring additional skills to further upgrade their competencies.

I ETE, a premier professional society dedicated to the dissemination of Knowledge in the ICT domain is supporting Govt of India in its mission of Skill Development and bridging the gap between the Informal vocational training and formal Technical University Academic Higher Education and bridge the pathway to transition between the two seamlessly.

It is the right times for all the IETE Centres to grab the opportunity of Nation's Skill Development Mission in getting themselves enter into new horizons for their techno-economic sustainability. I, on behalf of all governing Council Members, extend my warmest greetings on this occasion and encourage all Centres to celebrate this auspicious day with great fervour and passion involving all students, faculty, ISF's, Corporate Members and spread aims and objectives of IETE aligning with the Nation Building towards Atmanirbhar Bharat. Together we can, Together we will raise to new heights.

Jai Hind

Prof P Prabhakar

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AN EVENTFUL QUARTER

1. **15th Sept 2021:** Engineers' Day was celebrated at IETE Bangalore online. (Report in this Issue)

2. **30th Sept 2021:** State Level paper poster presentation by Dept. of ECE, Sapthagiri College of Engineering, Bengaluru under ISF Activity. Mr. Satyanandan, Chairman was the Chief Guest and Prof. C Murali, former Vice President IETE was Guest of Honour. Students presented various projects.

3. **3rd Oct. 2021:** A panel discussion was jointly organized by IETE Trivandrum, Kochi, and Bengaluru Centres on 'Enhancing the Employability of Engineering Graduates'.

Dr K C Raveendranathan, Chairman, IETE Trivandrum welcomed the panellists and invitees. Dr Rajesh MV, Vice Chairman IETE Kochi was the Moderator. Wg. Cmdr. Prabhakar, President IETE presided over the function and greeted the Chairmen and Members of the participating Centres. He appreciated the efforts of the Centres and complimented the Panellists. President also participated in the lively discussion on the topic.

Five panellists were chosen by the three Centres. Mr. G Ramesh, Governing Council Member and Dr. CV Ravishankar, Vice Chairman IETE Bangalore felicitated the panellists Dr Jiji, Dr Sasi, Dr Manoj, Mr Namboodiripad and Mr Rajkiran. Mr C Satyanandan, Chairman, IETE Bangalore extended the Vote of Thanks.

4. **5th Oct. 2021:** IETE at Reva University- Chairman IETE Bangalore along with Mr. Vinay Avanchi, EC Member met Dr. Rajashekhar C Biradar, Director, School of ECE and his team of Professors. They discussed the possibility of starting University Training Programs in collaboration with Industry under the aegis of IETE.

5. **13th Oct. 2021:** Beyond Technology- Ayudha Puje was celebrated at IETE Bangalore on 13th October 2021. Wg. Cmdr. (Retd.) Parthasarathi Ex Governing Council Member IETE performed the rituals. Chairman Mr. Satyanandan, Members and Staff attended.

6. **21st Oct. 2021:** A meeting of ISF Coordinators was held at 6.30 pm. Programs that can be conducted by ISF colleges and celebration of IETE Foundation Day were discussed. Dr. CV Ravishankar, Vice Chairman and Convener, welcomed the participants. Chairman Mr Satyanandan, Hon. Secretary Dr Shivaprasad Yadav and EC Member Prof Murali spoke. ISF Coordinators discussed various issues and decided upon activities to be conducted for Foundation Day.

Engineers' Day 2021

Engineers Day was celebrated at IETE Bangalore on 15th Sept 2021 at 6.30 pm.

Ms Rashmi of MSRIT sang the invocation. Dr. Shivaprasad Yadav Hon.Secretary welcomed the Guests and invitees.

Dr. MH Kori, Vice President IETE spoke about the mission and activities of IETE. He also narrated the launch of 'iete Bengaluru Magazine' on Engineers Day in 2018 and its continued publication since.

Dr. GK Venkatesh the anchor of the program then invited Dr. CV Ravishankar Vice Chairman IETE Bangalore to speak about Engineers Day.

Dr. Ravishankar talked about the contributions of Sir MV whose 160th birth anniversary was being celebrated. He shared photographs of the legendary engineer and administrator. He also mentioned the observance of the day in many countries.

Mr. CP Dwivedi, Vice Chairman IETE Bangalore then introduced the Chief Guest of the evening. Mr. Dwivedi read out the profile of Prof. KR Venugopal Vice Chancellor Bangalore University and requested him to give his address.

Prof. Venugopal expressed his happiness at being invited by IETE Bangalore to take part in the celebrations of the day that is the birth anniversary of Sir M Visveswaraya. He said he was part of the University Visweswaraiah College of Engineering Bangalore for the last forty seven years. He was participating in the event from his room in the UVCE from where he has been working for four decades. The College named after Sir MV after his death and the Bangalore University were founded by Sir MV who continues to inspire him and countless others. Prof Venugopal announced that the college would be declared as a deemed University in a few days by the Govt. of Karnataka.

Dr. Ravishankar then introduced the Guest of Honour Ms Leena Bokil. He read out her profile and invited her to make her presentation.

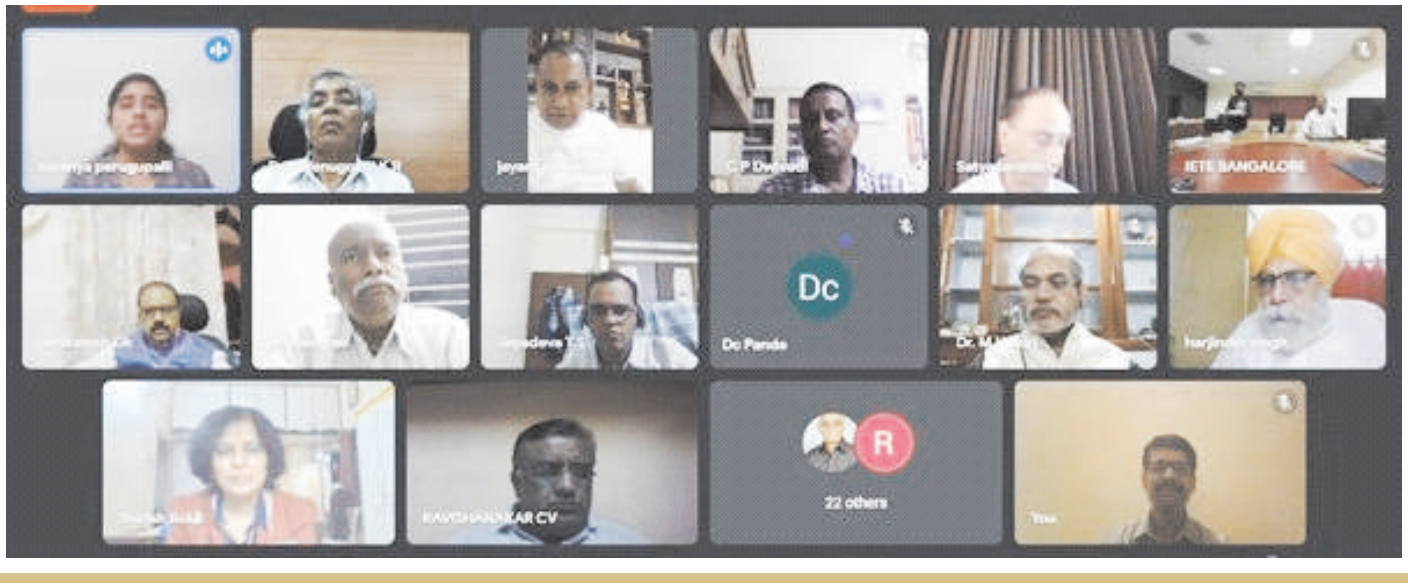
Ms Bokil who hails from Belgaum said she is a global Indian, who had her education and training in India and abroad. She talked about her association with IETE and shared the screen to make her presentation on 'the future in space engineering'. She shared videos and photos about her experiences at NASA and acquaintances with Astronauts who undertook space missions. She described the achievements made by ISRO and the future missions it was planning. She talked about Gaganyan, Asteroid Mining etc. The concept of artificial moon developed by China was interesting. She dwelt on Career Opportunities for young graduates in Space Engineering and how she motivated many of them. She also talked about business opportunities in the field, Space Tourism and the Space Players. The Space Educator said her message to youngsters on Engineers Day was to dream big and think big.

The Chairman IETE Bangalore then spoke to felicitate Mr. P Radhakrishna, Director, LRDE Bangalore on his receiving an Honorary Doctorate from Gitam University. He complimented Mr. Radhakrishna, eminent engineer- scientist and Fellow of IETE, and requested the Hon. Secretary to do the honours in person at LRDE. Mr. Radhakrishna was garlanded and honoured with a shawl and memento. He spoke from the venue thanking IETE Bangalore for the gesture and narrating his association with IETE. He also thanked his colleagues at LRDE who helped him in attaining such laurels. Members in the audience including former LRDE Scientists Dr. DC Pande and Prof. Bhatia too congratulated Mr Radhakrishna.

Chairman then called upon Dr. YVS Lakshmi, Senior Executive of C-DoT Bangalore to speak on the future plans of C- DoT. Dr. Lakshmi talked about their training programmes and the proposed MoU with IETE Bangalore.

In his Presidential Remarks Mr. Satyanandan said it was a very satisfying day with so many eminent personalities gracing the occasion. He thanked IETE members and all invitees and participants.

Hon. Secretary Dr. Shivaprasad Yadav proposed the Vote of Thanks.



ISF Coordinators


Dr. S G Shivaprasad Yadav
MSRIT


Dr. Madhavi
PESIT, Shimoga

Dr. Mamatha
Brindavan College

Dr. K Palaniswamy
Dr.TTIT, Kolar


Prof. Vinay Kumar
RL JIT

Dr. R C Biradar
Reva University

Dr. C V Ravishankar
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Sir MVIT

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SVP Academic Programs

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Message from a Senior IETEian

Mr. Nori Venkateswarlu (000940F) Fellow of Bengaluru Centre turned 95 on 30th Sep. 2021. Mr. Venkateswarlu BSc.(Hons.) DIISc.(Electrical Communication Engineering) retired as Chief Engineer, Doordarshan Headquarters, New Delhi in 1984. He was Consultant to Asia Pacific Institute for Broadcasting Development (AIBD), Kualalumpur and conducted Radio and TV training programmes in Malaysia, Bangladesh, Nepal, Thailand and Papua New Guinea. He has vast Research experience in studies on Effective Mass media planning methods for developmental communication, Cable and Satellite TV, Distance Education via satellite and Satellite transponder demand forecasting for the Asia Pacific region.

His message on the 68th Foundation Day of IETE is reproduced below:

Dear Mr. Satyanandan,

I note with pleasure that you are actively involved in IETE and will be celebrating the Foundation Day on 7 Nov.

I am afraid that due to failing memory I do not recall many details but I do remember that my association with IETE is more than 42-43 years old, I became a Fellow in 1979 prior to my retirement in 1984. It has been a long time and I cherish the association with the institution and its members for so many years. Till about a year ago, I used to get the magazine by post and enjoyed reading the articles on various technical topics. The younger generation will do well to contribute and get knowledge by reading about the latest developments in electrical and electronics engineering.

WIRELESS ENERGY HARVESTING

Dr. Prasad Shastry, Professor, Department of Electrical and Computer Engineering,
Bradley University, Peoria, Illinois, U.S.A.

In this article, an overview of Wireless Energy Harvesting and Wireless Power Transfer is presented.

I. Introduction

A. Ambient Energy Sources

There are several forms of ambient energy currently harvested as shown in Fig. 1. The "thermal" in Fig. 1 refers to the thermo-electric energy. The mechanical energy is of two types: vibration and motion. Bio energy refers to conversion of human sweat into electricity in order to power or charge wearable electronic devices [1]. The mechanical energy harvesting is of two types: a) Piezoelectric harvesting of vibration energy, b) Induction harvesting of the kinetic energy of a magnet moving in a coil. The focus of this article is on the radio frequency (RF) energy harvesting [2].

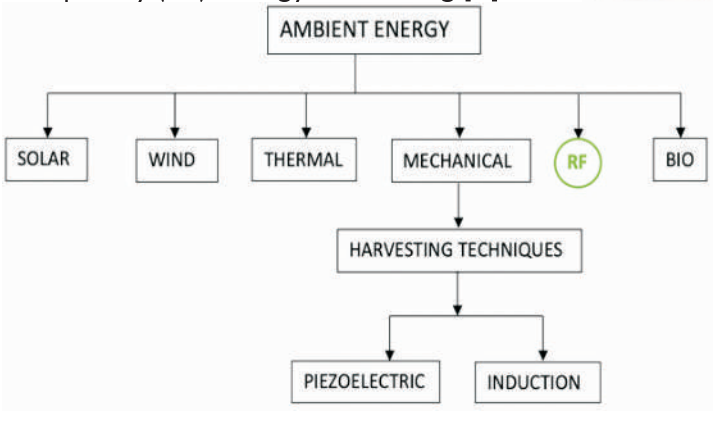


Fig.1 Ambient Energy Classification

The solar energy density in the environment is very high, about 100 mW per centimeter squared, as compared to RF energy density of about a μW per centimeter squared. But the solar energy is intermittent, whereas, the RF Energy is available all the time even though the energy density varies from region to region.

B. typical energy harvesting and powering system

The system block diagram of a typical energy harvesting and powering of sensors is shown in Fig. 2. Irrespective of the type of energy source, the harvested energy is stored in a device such as a battery or a capacitor, and it is used either to power or charge electronic devices such as sensors. Sensor platforms have a microcontroller, and a transceiver for communicating.

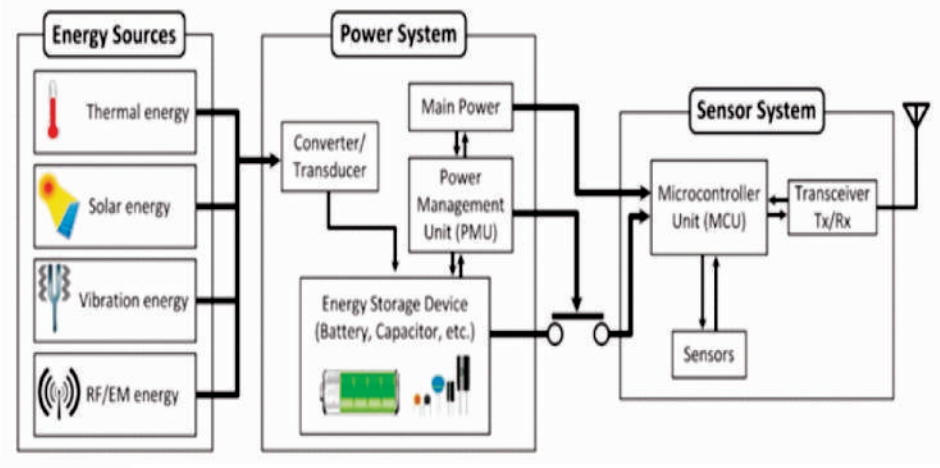


Fig. 2 A Typical Energy Harvesting and Powering System [3]

C. Applications of Wireless Energy harvesting

There are three primary applications: 1) for powering or charging remotely located or inaccessible electronic devices and sensors. There could be sensors in remote mines, for example, or in toxic environments where it is prohibitive to go and change the batteries. Therefore, one should be able to power them or charge them remotely.

2) for powering or charging wearable electronic devices, biosensors, and medical devices [4]; 3) for powering or charging electronic devices inside buildings.

II. WIRELESS POWER TRANSFER AND WIRELESS ENERGY HARVESTING

There are two techniques to power or charge sensors or devices: 1) Wireless Power Transfer (WPT), 2) Wireless Energy Harvesting (WEH). In

WPT, the radio frequency (RF) energy is intentionally created and transferred. The transfer can be over long distances (far-field powering/charging), or over small distances (near-field powering/charging). In WEH, the ambient RF energy already present in the environment is acquired or harvested.

1) Wireless Power Transfer

A. Far-Field WPT

Fig. 3 depicts the architecture of a far-field WPT system. The RF power is generated and transmitted by the transmitter. At the transmitter the DC power is converted into RF power. There is a propagation channel. The RF energy is harvested or acquired at the receiver by an antenna. The critical part of the harvester is the Rectifier or sometimes known as Rectenna, because it is integrated with the antenna. The Rectenna is followed by a DC-DC converter and a storage unit which constitute the power management unit (PMU).

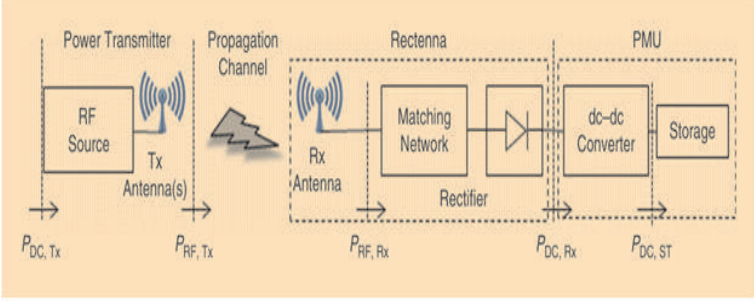


Fig. 3 A Block Diagram of a Far-Field WPT System [5]

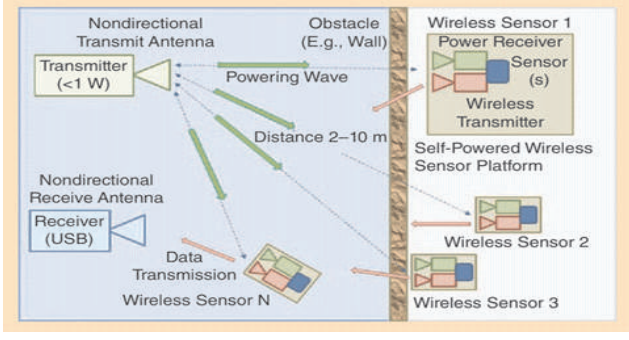
B. Efficiency

In a WPT system shown in Fig.3, the DC power supplied to the transmitter (Tx) is converted into RF power, and again the RF power is converted into DC power at the receiver (Rx). There are two efficiencies to be considered.. One is the overall system efficiency starting from the DC power supplied to the transmitter to the converted DC power at the receiver. This efficiency includes the efficiencies of all components in between. Then, there is the efficiency of only the rectifier, the RF to DC converter. In a WPT, DC to RF efficiency on the transmitter side can be optimized. The channel characteristics are known, therefore, one can also optimize the RF to RF efficiency. The RF to DC converter efficiency can be optimized as well.

The transmitter in WPT system could be designed to serve like a base station or a beacon, transmitting power continuously or intermittently or on demand. One can have a directional rotating antenna or beam steering phased array antenna sending out RF energy in different directions or a fixed omni-directional antenna.

A WPT system may have a feedback communication channel between the receiver and transmitter. The feedback channel can be used for the following purposes: 1) for demanding RF power, 2) for optimizing the whole system efficiency or controlling the output power of the transmitter based on the channel characteristics. Such a system is called an adaptive WPT system.

C. WPT inside a Building



In Fig. 4 a WPT system inside a building is shown. Here, a transmitter is sending out electromagnetic energy in different directions. It is collected by different sensors as shown in the figure. One may have any wireless device to be powered or charged instead of a sensor. Each sensor or device must have a receiver to harvest the power.

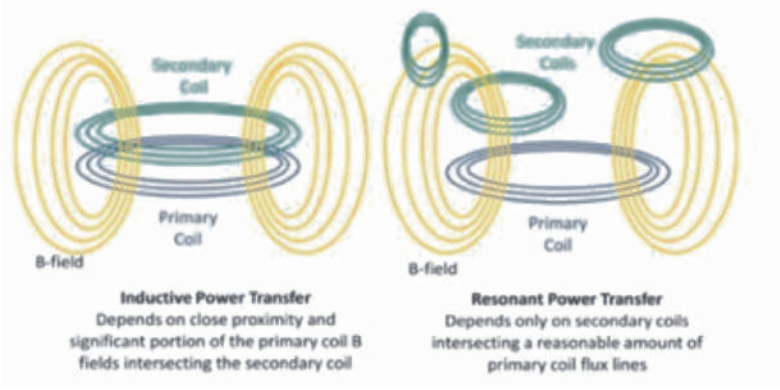
Fig. 4 An illustration of WPT inside a building [6]

Just like a Wi Fi system inside a building, one can have a WPT system inside a building. In the future, it is likely that the Wi Fi routers will contain WPT transmitters.

D. Near-Field WPT

The Near-Field energy harvesting are of two types as shown in Fig 5. In the inductive WPT (Fig.5(a)) there are two coils - primary and secondary coils - in proximity of each other, and the coupling between the two coils is due to the magnetic field. But, this method of coupling has some disadvantages, because the amount of coupling

depends on both the distance between the coils and the orientations of the coils.



There is a second type of Near-Field charging called Resonant Power Transfer (Fig. 5(b)). Here, the coil inductances are resonated with external capacitors, hence they are designed as resonators. Therefore, in this case, as long as there is a reasonable amount of magnetic field coupling, it works very well. The orientation of the coils is not very critical. Therefore, this is the most popular way of near-field charging. A near-field WPT system is shown in Fig. 6.

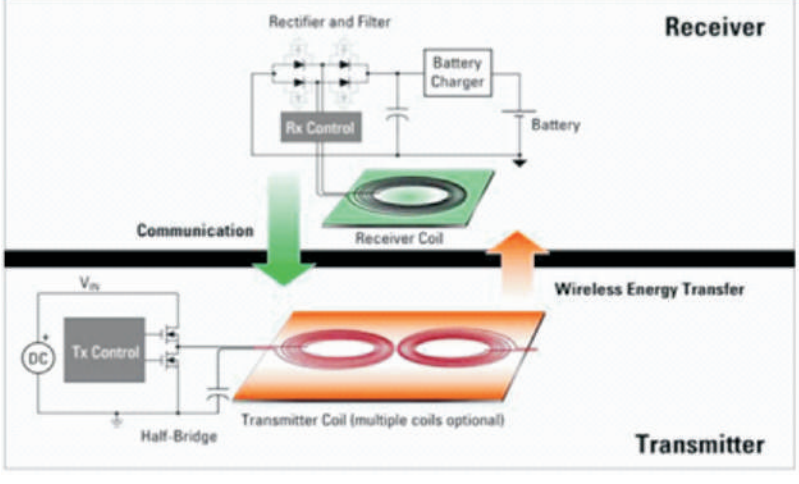


Fig. 5 Magnetic field coupling between coils in Near-Field WPT [7]

Fig. 6 Near-Field WPT System [8]

(a) (b)

Fig. 7 Near-Field WPT to power a TV and charging a Smartphone [9]

In Fig. 7 two examples of application of near-field WPT are shown. In Fig. 7(a) a LCD television is being operated by powering it with about 250 watts. The TV could be powered up to a distance of 2 meters [9].

In Fig. 7(b), what is shown is a smartphone being charged wirelessly near a charger. About five watts is being supplied to this smartphone [9]. Also being developed are wireless chargers for cars, both hybrid and electric cars [9]. Here, a coil is created in a mat in a garage and the car is just driven onto that mat and left there for a length of time for the batteries to get charged. Wireless chargers for medical devices have also been developed [9].

2) Wireless Energy Harvesting

In WEH, the RF energy already present in the environment is harvested. The ambient RF energy is due to the cellular networks, Wi Fi hotspots, and TV and radio broadcasts. In a WEH system, the ambient RF energy is predetermined by the transmitting sources and the channel. Therefore, one can neither optimize the transmitter efficiency nor the RF to RF efficiency which is channel dependent. The only efficiency that can be optimized is the RF to DC conversion efficiency.

In Fig.8, a WEH system for harvesting RF energy in a TV broadcast signal is illustrated [10]. In this system, the harvested energy was used to power an embedded microcontroller unit. There is an antenna. There is a RF to DC converter, which is called a RF to DC charge pump. There is an impedance matching network between the charge pump and the antenna. The charge storage device is a capacitor.

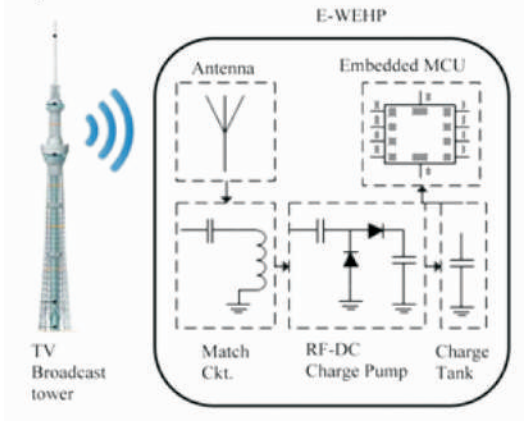


Fig. 8 Components in a typical WEH sensor platform [10]

The charge pump consists of diodes and capacitors. A five stage charge pump was used in this system. About two volts was created which was enough to power the microcontroller. The system efficiency was about 30% and a high value capacitor was used to store the harvested energy.

A. WEH in the Future

In the future the proliferation of 5G networks, the Internet of Things (IoT), and autonomous vehicles will create a tremendous amount of RF energy in the environment. This is pictorially depicted in Fig.9. Therefore, in the future, a great demand for WEH systems is expected.

Fig. 9 The future wireless world – proliferation of wireless devices and systems [11]

III. RF-DC CONVERTER

For RF to DC conversion, circuits have been developed using CMOS technology which has some advantages. Apart from the harvester, one can also, using the same technology, have digital circuitry built into the sensor platform.

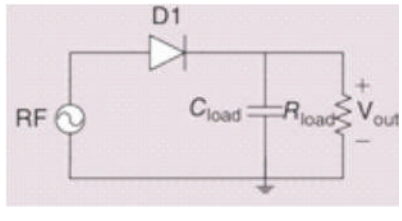
The other technology utilizes Schottky diodes. Schottky diodes are available with very low threshold voltage (0.02 V). This is very critical because in RF energy harvesting, the available power density is very small. Therefore, the turn-on voltage of the diode has to be small, and a small turn-on voltage also improves the efficiency of the converter.

Also, Schottky diodes have very low capacitance so their switching speed is high and their operating frequency range is large. In fact, there are more RF to DC converters using Schottky diodes than CMOS. But, there are some challenges in their design. Since a diode is extremely nonlinear, one has to deal with the harmonics generated in the converter, and one must make sure that the harmonics are not radiated into the environment through the antenna. Impedance matching also poses a challenge because of non-linearity.

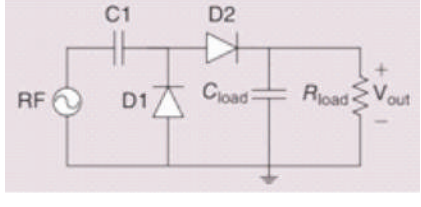
Three classical energy harvesting circuit topologies are shown in Fig. 10. The classical topologies are: 1) the half-wave rectifier, 2) the full-wave rectifier (also known as a voltage multiplier), 3) a charge pump. A charge pump not only acts as a rectifier, but also helps in stepping up the rectified voltage. The Dickson charge pump topology is very popular.

There are two types of efficiencies one has to consider as mentioned before. One is the overall system efficiency and the other is the RF to DC converter efficiency. It has been shown that the efficiency of a rectifier peaks at a particular input power and the maximum efficiency is obtained when the DC voltage is about half the breakdown voltage of the diode.

The maximum efficiency occurs at higher input powers as the number of diodes in the RF to DC converter is increased. It should be noted that at low power levels, typically -10 dBm, encountered in energy harvesting systems, one must use small number of diodes. Increasing the number of diodes does not help. In fact, a one diode converter has a higher efficiency than a two diode converter and a four diode converter! Further, if the number of diodes is increased in order to increase the DC voltage, the peak efficiency occurs at a higher input power!

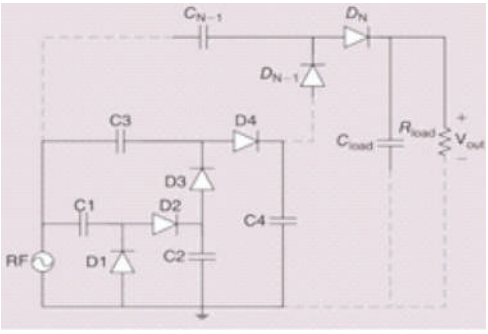


(a) Half-wave Rectifier



b) Full-wave Rectifier

,



(c) Dickson RF-DC Charge Pump

Fig. 10 RF-DC Converter Topologies [12]

IV. CONCLUDING REMARKS

With the worldwide full deployment of 5G wireless systems, Internet of Things, and autonomous vehicles, there will be tremendous increase in the ambient RF energy. Therefore, WEH will become ubiquitous. WPT on-demand systems for charging wireless devices inside buildings, WPT hot spots outside the buildings, and WPT beacons for remotely powering or charging electronic devices and sensors will proliferate in the future. WPT and WEH on demand, for wearable electronic devices, biosensors, and medical devices will become a common feature. There are opportunities for: a) research and development in the area of wireless energy harvesting, b) entrepreneurship to develop wireless energy harvesting products.

ACKNOWLEDGEMENT

The author acknowledges with gratitude the sources of the illustrations in this article. The sources have been referenced.

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OBITUARY

We miss you
Sri Sridhar Murthy

Human brain and it's memory size

Prof C Murali

There are about 100 billion (1011) neurons in the human brain, each of which can fire 200 times per second (5ms update rate) and each neuron is connected to about 1000 others, resulting in a computation speed of 20*1015 floating-point operations per second (flops) which for binary operation will require a data rate of 20,000 Tbps.

Human Brain flops (Computation Speed)
= 100 billion (1011) neurons * 200 flop/sec * 103/neuron = 20 * 1015 flop/sec = 20 peta flops/sec*1 bit/flop= 20,000 Tbps.

Each neuron has write access to 1000 bytes resulting in a memory size of the human brain of 100 Terabytes.
Storage = 1011 neurons * 103 bytes/neuron= 1014 bytes = 100 TB.

Future wireless generations (6G or 7G) are likely to allocate up to 10 GHz RF channels for each user in the THz regime, and by assuming that each user is able to exploit 10 bits/symbol modulation methods and 1000 times increase in channel capacity using yet-to-be-invented concepts, data rates of 100 Terabytes/sec can be achieved.

R = 10GHz channel*10 bits/(sec • Hz)*103 = 100 Tbps

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Tech Trends

Compiled by Dr M H Kori

Lithium-metal batteries

Electric vehicles come with a tough sales pitch; they're relatively expensive, and you can drive them only a few hundred miles before they need to recharge—which takes far longer than stopping for gas. All these drawbacks have to do with the limitations of lithium-ion batteries. A well-funded Silicon Valley startup now says it has a battery that will make electric vehicles far more palatable for the mass consumer.

It's called a lithium-metal battery and is being developed by QuantumScape. According to early test results, the battery could boost the range of an EV by 80% and can be rapidly recharged. The startup has a deal with VW, which says it will be selling EVs with the new type of battery by 2025.

The battery is still just a prototype that's much smaller than one needed for a car. But if QuantumScape and others working on lithium-metal batteries succeed, it could finally make EVs attractive to millions of consumers.

Data trusts

Technology companies have proven to be poor stewards of our personal data. Our information has been leaked, hacked, and sold and resold more times than most of us can count. Maybe the problem isn't with us, but with the model of privacy to which we've long adhered—one in which we, as individuals, are primarily responsible for managing and protecting our own privacy.

Data trusts offer one alternative approach that some governments are starting to explore. A data trust is a legal entity that collects and manages people's personal data on their behalf. Though the structure and function of these trusts are still being defined, and many questions remain, data trusts are notable for offering a potential solution to long-standing problems in privacy and security.

Green hydrogen

As nations do the hard math on how to meet their climate goals, green hydrogen increasingly appears essential.

Hydrogen has always been an intriguing possible replacement for fossil fuels. It burns cleanly, emitting no carbon dioxide; it's energy dense, so it's a good way to store power from on-and-off renewable sources; and you can make liquid synthetic fuels that are drop-in replacements for gasoline or diesel. But most hydrogen up to now has been made from natural gas; the process is dirty and energy intensive.

The rapidly dropping cost of solar and wind power means green hydrogen is now cheap enough to be practical. Simply zap water with electricity, and presto, you've got hydrogen. Europe is leading the way, beginning to build the needed infrastructure. Such projects are just a first step to an envisioned global network of electrolysis plants that run on solar and wind power, churning out clean hydrogen.

Digital contact tracing

As the coronavirus began to spread around the world, it felt at first as if digital contact tracing might help us. Smartphone apps could use GPS or Bluetooth to create a log of people who had recently crossed paths. If one of them later tested positive for covid, that person could enter the result into the app, and it would alert others who might have been exposed.

But digital contact tracing largely failed to make much impact on the virus's spread. Apple and Google quickly pushed out features like exposure notifications to many smartphones, but public health officials struggled to persuade residents to use them. The lessons we learn from this pandemic could not only help us prepare for the next pandemic but also carry over to other areas of health care. These studies explore why digital contact tracing failed to slow covid-19 and offers ways we can do better next time.

Hyper-accurate positioning

We all use GPS every day; it has transformed our lives and many of our businesses. But while today's GPS is accurate to within 5 to 10 meters, new hyper-accurate positioning technologies have accuracies within a few centimeters or millimeters. That's opening up new possibilities, from landslide warnings to delivery robots and self-driving cars that can safely navigate streets.

China's BeiDou (Big Dipper) global navigation system was completed in June 2020 and is part of what's making all this possible. It provides positioning accuracy of 1.5 to two meters to anyone in the world. Using ground-based augmentation, it can get down to millimeter-level accuracy. Meanwhile, GPS, which has been around since the early 1990s, is getting an upgrade: four new satellites for GPS III launched in November and more are expected in orbit by 2023.

Remote everything

The covid pandemic forced the world to go remote. Getting that shift right has been especially critical in health care and education. Some places around the world have done a particularly good job at getting remote services in these two areas to work well for people.

Snapask, an online tutoring company, has more than 3.5 million users in nine Asian countries, and Byju's, a learning app based in India, has seen the number of its users soar to nearly 70 million. Unfortunately, students in many other countries are still floundering with their online classes.

Meanwhile, telehealth efforts in Uganda and several other African countries have extended health care to millions during the pandemic. In a part of the world with a chronic lack of doctors, remote health care has been a life saver.

Multi-skilled AI

Despite the immense progress in artificial intelligence in recent years, AI and robots are still dumb in many ways, especially when it comes to solving new problems or navigating unfamiliar environments. They lack the human ability, found even in young children, to learn how the world works and apply that general knowledge to new situations.

One promising approach to improving the skills of AI is to expand its senses; currently AI with computer vision or audio recognition can sense things but cannot "talk" about what it sees and hears using natural-language algorithms. But what if you combined these abilities in a single AI system? Might these systems begin to gain human-like intelligence? Might a robot that can see, feel, hear, and communicate be a more productive human assistant?

Artificial Intelligence everywhere

"Smart" really just used to mean connected – smartphones, smart TVs, and the plethora of other smart devices were really just the same old toys but connected to the internet. Today, "smart" increasingly means powered by artificial intelligence (AI) – generally machine learning algorithms – and capable of helping us in increasingly innovative ways. Smart cars use facial recognition algorithms to detect whether we are paying attention to the road and alert us if

we're getting tired. Smartphones use AI algorithms to do everything from maintain call quality to help us take better pictures, and of course, they are packed with apps that use AI to help us do just about anything. Even smart toilets are on their way – capable of helping to diagnose gastrointestinal issues by using computer vision to analyze stool samples!

AI has permeated the tools we use to carry out everyday work – from the ubiquitous voice assistants to language translation and tools that allow us to extract structured data from pictures, whiteboard scribblings, and hand-written notes. It also powers much of the robotic process automation that has enabled workloads to be lightened in admin, logistics, accounting, and HR departments. Whatever your industry or job function, you're likely to find there's an AI-powered solution designed to make your life easier.

This broad trend encompasses AI, the internet of things (IoT), and newly emerging super-fast networks like 5G, all of which are coming together to augment us with capabilities we didn't have just a few years ago. This highlights the fact that on a longer timescale than the one we are specifically looking at here, the most impactful trend of all will be convergence. Growing data volumes, faster network and processor speeds, and the "democratization" of data (more on this below) are coming together and will affect society in a way that is much more than the sum of their parts.

Everything-as-a-service and the no-code revolution

Another increasingly powerful driver will be the ongoing democratization of data and technology. In recent years an entire industry has emerged which aims to put the skills and tools necessary for tech-led innovation in the hands of as large a proportion of society as possible, regardless of their expertise or experience. Cloud solutions for storage, network and processing mean costs, and risks of setting up expensive infrastructure in order to try out new ideas are heavily mitigated. Hybrid solutions – for when public cloud services aren't entirely appropriate, for example when dealing with very private or valuable data – have matured to the point where a "best of both worlds" solution is often viable.

Innovation has been curtailed in some areas by the skills crisis, which sounds like a problem but has been a driver behind the explosion of self-service and "do-it-yourself" solutions. Not every company needs to hire an army of computer geniuses to build their own "digital brain" when they can simply lease one for the work they need doing. Ready-built AI solutions exist for everything from marketing to HR, project management, and planning and design of production processes. In 2022 we will continue to see companies deploying AI and IoT infrastructure without owning a single server or proprietary piece of cognitive code.

No-code interfaces will become more popular as a lack of programming knowledge, or a detailed understanding of statistics and data structures, will cease to become a barrier to bringing a world-changing idea into reality. OpenAI – a research group founded by Elon Musk and funded by, among others, Microsoft, recently unveiled Codex, a programming model that can generate code from natural, spoken human language. As technology like this matures – which we will start to see in 2022 – and converges with the possibilities offered by cloud infrastructure, our innovation and imagination will less frequently be held back by a lack of either resources or technical skills.

Digitization, datafication and virtualization

During 2020 and 2021, many of us experienced the virtualization of our offices and workplaces, as remote working arrangements were swiftly put in place. This was just a crisis-driven surge of a much longer-term trend. In 2022, we will become increasingly familiar with the concept of a "metaverse" – persistent digital worlds that exist in parallel with the physical world we live in. Inside these metaverses – such as the one proposed recently by Facebook founder Mark Zuckerberg – we will carry out many of the functions we're used to doing in the real world, including working, playing, and socializing. As the rate of digitization increases, these metaverses will model and simulate the real world with growing accuracy, allowing us to have more immersive, convincing,

and ultimately valuable experiences within the digital realm. While many of us have experienced somewhat immersive virtual realities through headsets, a range of new devices coming to the market will soon greatly improve the experience offering tactile feedback and even smells. Ericsson, which provided VR headsets to employees working from home during the pandemic, and is developing what it calls an "internet of senses," has predicted that by 2030 virtual experiences will be available that will be indistinguishable from reality. That might be looking a little further ahead than we are interested in for this article. But, along with a new Matrix movie, 2022 will undoubtedly take us a step closer to entering the matrix for ourselves.

Transparency, governance and accountability

For technology to work, we humans need to be able to trust it. We already (rightly) see strong pushbacks against many ways that technology is currently being used that are seen as obtrusive, dangerous, or irresponsible. AI, in particular, is sometimes portrayed as a "black box" – meaning we can't see inside it to understand how it works. This is often due to its complexity rather than any malevolent scheme to limit our understanding, however, the effect is the same. This means that incidents where AI is shown to be damaging – for example, when Facebook recently appeared to label images of black people as "primates" – are extremely alarming. This is particularly true in a society that is starting to look towards AI for decision-making that affects lives, such as hiring and firing.

The idea of transparent and explainable AI has been growing in popularity over recent years, as it has become clear that there are segments of society that distrust it – clearly with good reason! Governments, too, clearly understand that there is a need for a regulatory framework, as evidenced by the existence of the EU's proposed Artificial Intelligence Act. The proposed act prohibits authorities from using AI to create social scoring systems, as well as from using facial recognition tools in public places. There is also a list of potentially dangerous effects, including "exploiting vulnerabilities" and "causing physical or psychological harm," that AI solutions providers will have to demonstrate their systems will not cause, before they can be offered for sale. Some, however, claim that it doesn't go far enough as, in its current state, it doesn't contain any stipulation that people should be informed when they become the subjects of AI-driven decision-making processes. Google CEO Sundar Pichai has said that while he recognizes regulation of AI is necessary, "there is a balance to be had" to ensure innovation isn't stifled. This balancing act is likely to become an increasingly prominent subject of discussion during 2022 as more people become aware of the potential positive and negative effects on society that AI and other technology trends will have.

Sustainable energy solutions

During the pandemic, renewable energy was the only form of energy that saw usage increase. In the US, renewable energy use increased by 40% during the first ten weeks of lockdown. Worldwide, all non-renewable energy usage decreased as industries shut down and people stayed at home, leading to an overall reduction in emissions of 8%. This has led to an expectation that increasing investment will be put into generating energy from renewable resources in coming years.

The International Energy Agency (IEA) estimates that 40% more renewable energy was generated and used during 2020 compared to the previous year and forecasts that this growth with continue throughout 2022. Overall, the cost of generating renewable energy from various sources, including onshore and offshore wind, solar and tidal, fell by between seven and 16%. This will be a huge help for countries and businesses trying to hit emissions targets, such as becoming carbon neutral or even carbon negative. Additionally, exciting new emerging energy sources such as biofuels, liquid hydrogen, and even nuclear fusion are becoming more viable, even if it may be a little after 2022 when their full impact of some of them will be felt. However, breakthroughs in all of these areas are likely to make headlines. Helion Energy – a pioneer in the field of fusion energy, which replicates the process used to create energy in the

sun – expects their latest prototype fusion generator to come online during 2022. Practical applications are also expected to emerge in the field of "green hydrogen" energy. Unlike the established processes for creating energy from hydrogen, which involve using large amounts of "dirty" fossil fuel energy to create electrolysis, separating hydrogen and oxygen without emitting carbon, this involves using renewable energy, dampening the overall environmental impact.

Generative Artificial Intelligence (AI)

One of the most visible and powerful AI techniques coming to market is generative AI – machine learning methods that learn about content or objects from their data, and use it to generate brand-new, completely original, realistic artifacts.

Generative AI can be used for a range of activities such as creating software code, facilitating drug development and targeted marketing, but also misused for scams, fraud, political disinformation, forged identities and more. By 2025, Gartner expects generative AI to account for 10% of all data produced, up from less than 1% today.

Data Fabric

The number of data and application silos has surged in the last decade, while the number of skilled personnel in data and analytics (D&A) teams has either stayed constant or even dropped. Data fabrics – a flexible, resilient integration of data across platforms and business users – have emerged to simplify an organization's data integration infrastructure and create a scalable architecture that reduces the technical debt seen in most D&A teams due to the rising integration challenges.

A data fabric's real value is its ability to dynamically improve data usage with its inbuilt analytics, cutting data management efforts by up to 70% and accelerating time to value.

Distributed Enterprise

With the rise in remote and hybrid working patterns, traditional office-centric organizations are evolving into distributed enterprises comprised of geographically dispersed workers.

"This requires CIOs to make major technical and service changes to deliver frictionless work experiences, but there is another side to this coin: the impact on business models," said Groombridge. "For every organization, from retail to education, their delivery model has to be reconfigured to embrace distributed services. The world didn't think they'd be trying on clothes in a digital dressing room two years ago."

Gartner expects that by 2023, 75% of organizations that exploit distributed enterprise benefits will realize revenue growth 25% faster than competitors.

Cloud-Native Platforms (CNPs)

To truly deliver digital capabilities anywhere and everywhere, enterprises must turn away from the familiar "lift and shift" migrations and toward CNPs. CNPs use the core capabilities of cloud computing to provide scalable and elastic IT-related capabilities "as a service" to technology creators using internet technologies, delivering faster time to value and reduced costs.

For this reason, Gartner predicts that cloud-native platforms will serve as the foundation for more than 95% of new digital initiatives by 2025 — up from less than 40% in 2021.

Autonomic Systems

As enterprises grow, traditional programming or simple automation will not scale. Autonomic systems are self-managing physical or software systems that learn from their environments. Unlike automated or even autonomous systems, autonomic systems can dynamically modify their own algorithms without an external software update, enabling them to rapidly adapt to new conditions in the field, much like humans can.

"Autonomic behavior has already made itself known through recent deployments in complex security environments, but in the longer term, will become common in physical systems such as robots, drones, manufacturing machines and smart spaces," said Groombridge.