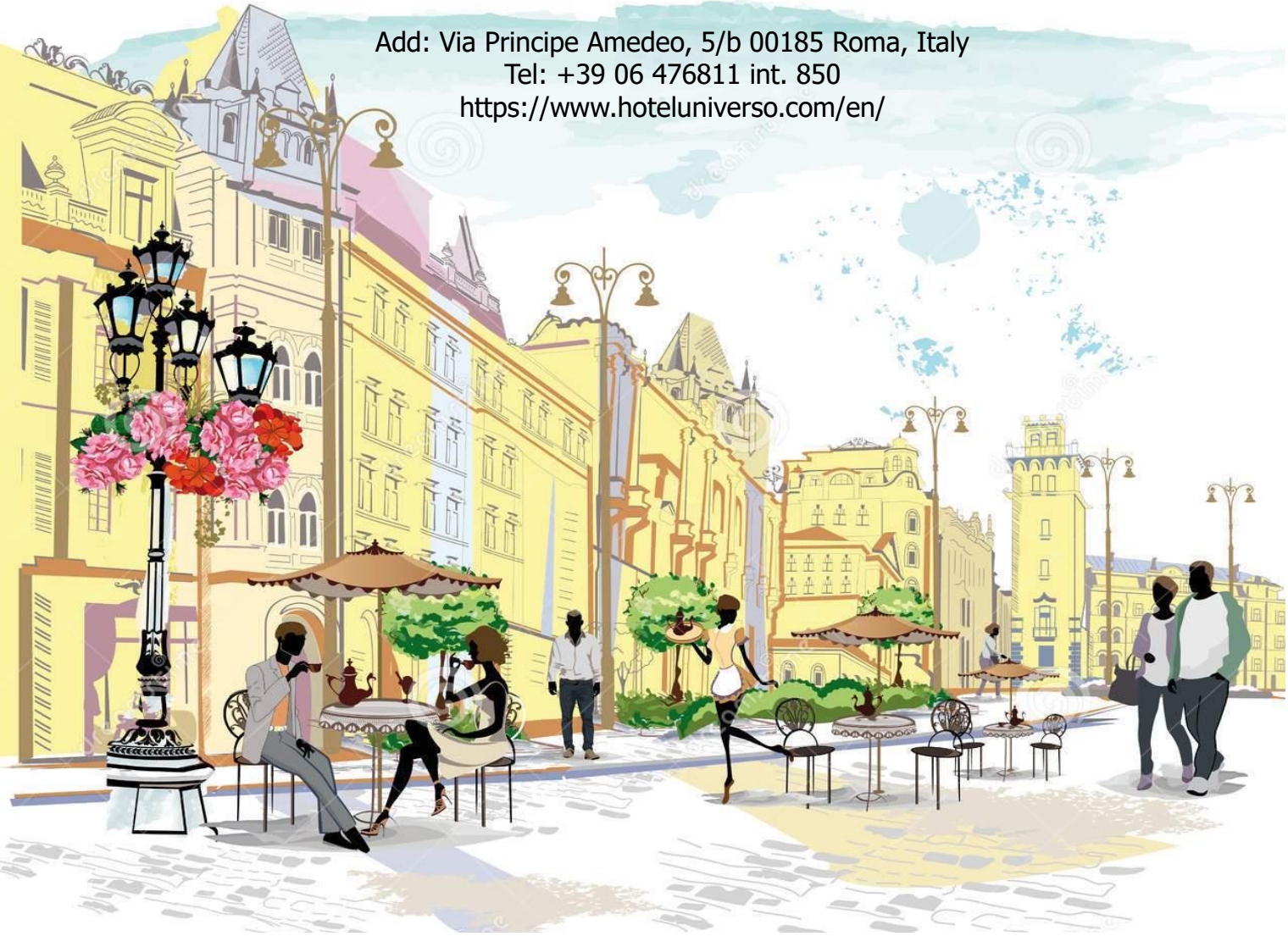
2019 The 2nd International Conference on Electrical Engineering and Green Energy

2019 The 2nd International Conference on Mechanical and Digital Manufacturing

Rome, Italy
June 28-30, 2019

Best Western Plus Hotel Universo

Add: Via Principe Amedeo, 5/b 00185 Roma, Italy
Tel: +39 06 476811 int. 850
https://www.hoteluniverso.com/en/



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Welcome Address

It is great honor to welcome you all to Rome for 2019 The 2nd International Conference on Electrical Engineering and Green Energy (CEEGE 2019) , and 2019 The 2nd International Conference on Mechanical and Digital Manufacturing (ICMDM 2019), to be held at Best Western Plus Hotel Universo, Rome, Italy from June 28 to 30, 2019.

After several rounds of review procedure, the program committee accepted those papers to be published in conference proceedings. We wish to express our sincere appreciation to all the individulas who have contributed to CEEGE 2019 and ICMDM 2019 conferences in various ways. Special thanks are extended to our colleagues in the program committee for their thorough review of all the submissions, which is vital to the success of the conference, and also to the members in the organizing committee and the volunteers who had delicated their time and efforts in planning, promoting, organizing and helping the conference.

This conference program is highlighted by four Keynote Speakers: Prof. C.Y. Chung, University of Saskatchewan, Canada; Prof. Reiner Johannes Schütt, West Coast University of Applied Sciences, Germany; Prof. Eduard Siemens, Anhalt University of Applied Sciences, Germany, Prof. Hassan Bevrani, University of Kurdistan, Iran; One Plenary Speaker: Prof. Mohan Kolhe, University of Agder, Norway.

One best presentation will be selected from each session, evaluated from: originality; applicability; technical Merit; qualities of PPT; English. The best one will be announced at the end of each Session, and awarded the certificate after the finish of sessions.

We wish you a wonderful conference and enjoyable visit in Rome!

Conference Organizing Committee
Rome, Italy

Organizing Committee

Conference Chairs

Hassan Bevrani, University of Kurdistan, Iran
Masayuki Morimoto, Tokai University, Japan

Program Chairs

Mohan Kolhe, University of Agder, Norway
Ing. Reiner SchÜtt, West Coast University of Applied Sciences, Germany

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Abdelghani Chahmi, University of Sciences and Technology, Algeria
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Zhen Hu, State Grid Hunan Electric Power Company Limited Research Institute, China
Gayadhar Panda, National Institute of Technology Meghalaya, India
Matsankov Misho, Technical University of Sofia, Bulgaria
Ranga Babu Peesapati, National Institute of Technology Meghalaya, India

Local Information

Conference Venue: **Best Western Plus Hotel Universo**

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https://www.hoteluniverso.com/en/

Time

UTC/GMT +2

Weather

The Weather Situation of Rome in Italy

Average daily minimum temperature	Average daily highest temperature
15℃	28℃

Money

EUR（€）

Most places in Rome deal with cash, and credit card. Some foreign credit cards are accepted in high-end establishments.

Banks or private money changers offer the best foreign-exchange rates. EUR is the only accepted currency. Most banks charge a commission and duty for each travellers cheque cashed. Current exchange rates are posted at exchange counters.

Getting Around

The most convenient and economic way of getting around Rome is by far the Public Transit Bus service. Buses run 24 hrs. a day and cover the entire city. Bus tickets and subway metro tickets are interchangeable within the time validity of the ticket. Validation begins by punching them into the ticket counter found on both the bus or subway. Keep the ticket with you at all times during your trip because if there should be a check by the controller, you could get a fine ranging from €40 to €70.

Tickets can be purchased in advance at any tobacconists (easily found by the blue sign with a capital T outlined in white found throughout the city) and from vending machines at both the train and metro stations. Tickets are not considered used until they are validated, so you can keep a supply of them.

*Part of the local information above comes from the network.

Instructions for Presentations

Oral presentations

Oral presentations have been allocated 15 minutes of effective presentation time, including Q/A time between Session Chair and speakers.

Authors must prepare their oral presentations to be sure to convey their message in clear and sharp manner, including giving outline of the key principles, facts and results. More detailed discussions can continue during the breaks.

In order to ensure a smooth performance during your session, we kindly ask you to consider the following instructions:

Be at the session room 15 minutes before session starts and introduce yourself to the session chairs.

A video projector and a PC will be available in all conference rooms. Speakers suggested not use their own laptop computer, avoiding useless time breaks in between papers.

Bring your presentation on a USB memory stick in MS-PowerPoint or Adobe PDF formats, and upload it in the Session Room computer no later than 10 minutes prior to your session start! You can also bring it earlier, during the coffee/lunch breaks before your presentation. Please upload your presentation in a right place in order to find it easily at the time of presentation.

Please wear formal clothes or national characteristics of clothing for participation.

In order to avoid any compatibility problems, read carefully the instructions below.

PowerPoint Instructions

For MS-PowerPoint presentations, please use the following versions only: PP 97-2003 (*.ppt) or 2007, 2010 to guarantee that it will be opened successfully on the on-site PC

We recommend to the PPT/PPTX format instead of PPS

All videos or animations in the presentation must run automatically!

Pictures/Videos

We cannot provide support for embedded videos in your presentation; please test your presentation with the on-site PC several hours before your presentation.

In case your video is not inserted in MS-PowerPoint, it is possible to have it in other formats – MPEG 2,4, AVI (codecs: DivX, XviD, h264) or WMV. Suggested bitrate for all mpeg4 based codecs is about 1 Mbps with SD PAL resolution (1024x576pix with square pixels, AR: 16/9).

Fonts

Only fonts that are included in the basic installation of MS-Windows will be available (English version of Windows). Use of other fonts not included in Windows can cause wrong layout/style of your presentation.

Suggested fonts: Arial, Times New Roman.

If you insist on using different fonts, these must be embedded into your presentation by choosing the right option when saving your presentation:

Click on “File”, then “Save As”

Check the “Tools” menu and select “Embed True Type Fonts”

Poster presentations

Suggested Poster with size of 60cm*80cm (width*height), with conference short name and paper ID on right up corner.

Posters are required to be condensed and attractive. The characters should be large enough so that they are visible from 1 meter apart.

During poster session, the author should stand by your poster, explaining and answering doubts or questions.

Program at a Glance

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*Collecting conference materials
*Certificate will be signed and issued after each session.
*Accommodation not provided, and it's suggested to make an early reservation.</td><td>10:00-17:00</td></tr>
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University of Kurdistan, Iran</td><td>9:00-9:05</td></tr>
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'Efficient Uncertainty Modeling for Optimal Planning and Operation of Modern Power Systems'
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	Dinner	18:30-19:30
June 30 Sunday	**Optional One Day Visit**	7:10-19:00

Keynote Speech

Prof. C.Y. Chung

University of Saskatchewan, Canada

Title: Efficient Uncertainty Modeling for Optimal Planning and Operation of Modern Power Systems

Abstract: Power systems with high penetration of intermittent renewable energy resources (RES) must cope with significant uncertainties originated from RES and electricity load prediction error in both transmission and distribution sectors. These uncertainties might adversely affect stability, reliability, security, and optimal operation of the system and lead to wind power curtailment and load shedding events in the system as big challenges. Also, dependence structure (DS) modeling of all uncertainty sources, as an essential task, is another challenge for uncertainty handling in optimal planning and energy and reserve scheduling of power systems containing numerous geographically diverse and correlated RES. Particularly, this is a critical problem in microgrids where the size, the location, and the coordination of distributed generation, energy storage systems, and demand response loads are of high importance for optimal distribution expansion planning goal. This presentation will report the latest research on i) efficient modeling and incorporation of RES uncertainty, ii) advanced artificial intelligence-based prediction approaches such as deep learning, and iii) advanced statistical DS modeling as canonical vine (C-Vine) copula, which can significantly mitigate these challenges specially in high dimensional cases.

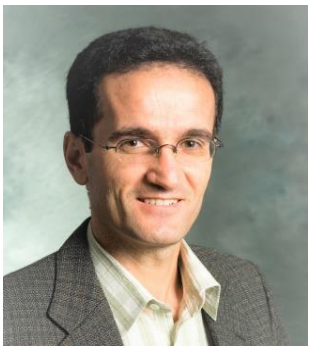
Biography: Dr C.Y. Chung is a Professor, the NSERC/SaskPower Senior Industrial Research Chair in Smart Grid Technologies, and the SaskPower Chair in Power Systems Engineering in the Department of Electrical and Computer Engineering at the University of Saskatchewan, Saskatoon, SK, Canada. He is a prominent leader for advancing academic activities and applied research in power systems engineering development in the province of Saskatchewan. He is now leading a research team, supported by SaskPower and NSERC of Canada, to conduct cutting-edge and long-term smart grid research for SaskPower and address critical technical issues associated with smart grid technologies and their applications to real power systems. He is a Fellow of IEEE and IET. He is also an IEEE PES Distinguished Lecturer and a member of IEEE PES Fellow Evaluation Committee.

Dr Chung received the B.Eng. degree (with First Class Honors) and the Ph.D. degree in electrical engineering from The Hong Kong Polytechnic University, China, in 1995 and 1999, respectively. His research interests include smart grid, renewable energy, power system stability/control, planning and operation, applications of advanced optimization methods, power markets and electric vehicle charging. His research work has not only generated 3 US patents, 2 book chapters and over 130 international journal papers, mostly in well-respected

IEEE transactions and IET journals, but has also resulted in successful transference of two new commercial software packages developed for power system analysis. Software package "Small Signal Analysis Tool (SSAT)" developed by him is now being used by over 80 power companies and nearly 90 universities worldwide. He has provided consultancy services to both government agencies and well-known private companies.

Dr Chung was the Member-at-Large (Smart Grid) and Member-at-Large (Global Outreach) of IEEE PES Governing Board and also the IEEE PES Region 10 North Chapter Representative. He was the Past Chairman of the IEEE Hong Kong Section, IEEE Hong Kong Joint Chapter of PES/IAS/PELS/IES and IET Hong Kong PES. He was the General Chair of IEEE EPEC2017 and IEEE PES APPEEC2014, Co-Chair of IEEE TENCON2015, IEEE PES APPEEC2013 and IEEE ICHQP2012, Vice-Chairman of IET APSCOM 2015 and IET APSCOM2012, Technical Chairman of IET APSCOM2009, and Honorary Secretary of IEEE DRPT2004 and IEEE IAS 2005 Annual Meeting.

Dr Chung is currently an Editor of "IEEE Transactions on Power Systems", "IEEE Transactions on Sustainable Energy", and "IEEE Power Engineering Letters", a Subject Editor of "IET Generation, Transmission & Distribution", and an Editorial Board Member of "Journal of Modern Power Systems and Clean Energy", and "CSEE Journal of Power and Energy Systems".



Prof. Hassan Bevrani

University of Kurdistan, Iran

Title: New Directions in Power Grids Frequency Control

Abstract: Today, power grid frequency control regains research interest due to the coming challenges of increasing renewable energy penetration, changing structure and emerging new distributed generators (DGs), storage systems, controllable loads and power electronics technologies. Recent advances in control, communication and computing technologies accelerate this process. The frequency control in a modern power grid should perform complex multi-objective regulation optimization problems characterized by a high degree of diversification in management policies, and widely distribution in demand and supply sources.

Wide-area measurement systems, integration of DGs/Microgrids, controllable loads (demand response) and performing virtual inertia provide new concerns and opportunities to handle the frequency control in new power grids. This speech addresses an updated review on most important frequency control challenges, modern relevant control possibilities, important achievements, and new research directions.

Biography: Hassan Bevrani received PhD degree in electrical engineering from Osaka University in 2004. He is a full professor, the Program Leader of Micro/Smart Grids Research Center (SMGRC), and Vice Chancellor for Research at the University of Kurdistan. Over years, he has worked with Osaka University (Japan), Kumamoto University (Japan), Queensland University of Technology (Australia), Kyushu Institute of Technology (Japan), Centrale Lille (France), and Technical University of Berlin (Germany). He is the author of 5 international books (including Robust power system frequency control, Springer, 2009; Intelligent automatic generation control, CRC Press, 2011; Power system monitoring and control, IEEE-Wiley, 2014; and Microgrid dynamics and control, Wiley, 2017), 15 book chapters, and more than 300 journal/conference papers. Prof. Bevrani is a senior member of IEEE and he was the gust editor of two volumes of Elsevier Energy Procedia (100 and 147). His current research interests include Smart grid operation and control, power system stability, Microgrid dynamics and control, and Intelligent/robust control applications in power electric industry. More information is available in http://smgrc.uok.ac.ir/.

Prof. Reiner Johannes Schütt

West Coast University of Applied Sciences, Germany

Title: Characteristics, Challenges and Chances of Cellular Power Grids for a Sustainable Energy Supply

Abstract: The power generation, transmission and distribution are in a profound change process. In many regions all over the world the annual production of electrical energy by renewable sources is bigger than the consumption in these areas. For these regions there are very good conditions to install so called smart grids to use the benefits of so called cellular power grids. The dimension of an optimal cell has to be discussed. The power exchange with neighboring cells like regions should be kept as low as possible and considers the correspondingly low demand for line capacities. Especially in northern Germany with its big amount of wind turbines, different regions are trying to make the power supply more sustainable, cost effective and sure with the help of cellular power grids.
This paper describes the main technical characteristics of cellular power grids with the help of examples built up in northern Germany and experiences made there. Discussing the optimal use the examples show, that there are under- and over-balanced energy cells even if they are using different types of storage elements. Due to insufficient local energy balance the cellular power concept need a power transfer between multiple energy cells. The paper shows how the conversion between heat, cooling, gas or fuel and electricity offers good solutions. For a certain time, cellular power grids can act as islanding systems. The paper shows the main challenges to handle this islanding case and the black start capabilities. The paper gives an answer to improve resilience of the energy supply in regions with the help of using cellular power grids.

Biography: Prof. Dr. Reiner Johannes Schütt is the coordinator of focus area “automation of sustainable energy systems” in the “Competence Centre Renewable Energies and Climate Protection Schleswig-Holstein” and member of the “Institute for the Transformation of Energy Systems”. Prof. Schütt received the Diploma degree in Electrical Engineering from the Universtity of Hannover in 1987. Prof. Schütt started his professional career as an R&D engineer in the department of power electronics at the University of Hannover and worked for several years as a technical director at ENERCON Nord Electronic GmbH. In 1998 he joined the West Coast University of Applied Scienes in Schleswig-Holstein as a Professor for Electrical Drives and Control with focus on applications in decentralized sustainable energy systems. He published numerous technical journals and conference proceedings especially in the field of control and automation of decentralized electrical generators. In 2010 he published the “Innovation Study Pellworm”, where he described how to build up a smart grid on a German island. Prof. Schütt is co-author of the book “Understanding Wind Power Technology”, 2014 John Wiley & Sons, Ltd.

Prof. Eduard Siemens

Anhalt University of Applied Sciences, Germany

Title: Industrial IoT for for use in energy-autarkic systems based on renewable sources

Abstract: The transition of energy production towards renewable sources leads inevitably to distributed decentral energy production approaches. Hereby, keeping energy production and consumption globally as well as locally in balance becomes a challenge for the distribution and management systems. The role of a reliable and dependable data network between the energy production, transforming and consumption components becomes key components for the stability of the energy system. Recently approached information technologies like smart sensors, Software Defined Networks and Time Sensitive Networks become a crucial part of network distribution systems.

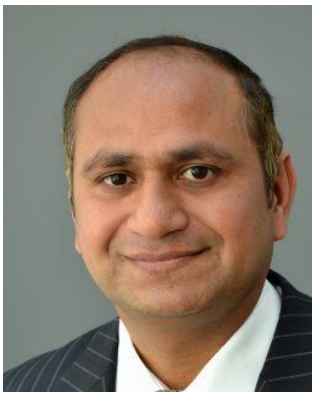
Once integrated into the network management and system components, said technologies enable the realization of cost-efficient autarkic energy islands using solar-, wind- and water power. Especially in rural regions of developing countries such energy systems can have essential impact on the economic and social development of whole regions.

The paper describes, how the use of sensors for real-time sensing of ambient conditions, application of machine learning methods to monitor the state of charge of batteries and for optimization of energy consumption in diverse branches of farming leads to transition of agriculture of countries towards green and sustainable economics.

Examples of implementations in South-East Asia, Central Asia and Siberia are discussed in the paper.

Bioraphy: Personal details: Professor for communication technologies at Anhalt University of applied Sciences since 2010, head of the Future Internet Lab Anhalt (FILA, fila.de); Visiting professor at National Research Tomsk Polytechnic University; ~80 granted patents and patent applications in the field of efficient and fast data transport, IT infrastructures, energy efficiency; Founder of serveral tech startups in the field of energy efficiency and also in Big Data – e.g. SmartLighting, Dexor, Tixel; ~60 papers in journals, peer reviewed proceedings of conferences and monograps. Research focuses: Communication technologies for system control in decentral energy systems and energy efficiency; Linux OS and RT-aspects in automation and in M2M communications and IoT; Efficient big data transport. Research on transport protocols for multi-gigabit data transmission over IP networks, IP infrastructures for Cloud services and M2M communication

Plenary Speech



Prof. Mohan Kolhe

University of Agder, Norway

Title: Micro-Grid Architecture for Increasing Penetration of Solar Photovoltaic System

Abstract: This is the right time to study the impact of Solar PV penetration into the distribution network and to identify appropriate solutions for overcoming related challenges. In the existing system most of the solar PV systems are connected to inject power into the network without giving effective contribution for managing voltage and power flows. Most of these issues can be resolved through designing an innovative smart micro-grid architecture for facilitating PV penetration especially in the distribution network. The focus of this plenary speech will be on integration of solar PV system with other distributed energy sources via intelligent power conditioning devices within the distributed network for making it a smart micro-grid. It will cover overview on impact of micro-grid deployment on future power system networks for the design of smart grid, energy supply and demand scenario, and energy efficiency. The smart micro-grid will employ innovative products and services together with intelligent monitoring and control communications to facilitate secure integration and operation of solar PV systems with other distributed generators while considering demand side management.

Biography: Professor (Dr) Mohan Kolhe is with the University of Agder (Norway) as full professor in electrical power engineering with focus in smart grid and renewable energy. He has also received the offer of Hafslund Professorship in Smart Grid from the Norwegian University of Science and Technology (NTNU). He has more than three decades' academic experience at international level on electrical and renewable energy systems. He is a leading renewable energy technologist and has previously held academic positions at the world's prestigious universities e.g. University College London (UK / Australia), University of Dundee (UK); University of Jyvaskyla (Finland); and Hydrogen Research Institute, QC (Canada).
Prof. Kolhe was a member of the Government of South Australia's Renewable Energy Board (2009-2011) and worked on developing renewable energy policies
Prof. Kolhe's academic work ranges from the smart grid, grid integration of renewable energy systems, home energy management system, integrated renewable energy systems for hydrogen production, techno-economics of energy systems, solar and wind energy engineering, development of business models for distributed generation.

Prof. Kolhe has been successful in winning research funding from prestigious research councils (e.g. EPSRC, BBSRC, EU, NRP, etc.) for his work on sustainable energy systems. He has published extensively in the area of energy systems engineering. He has been invited by many

international organizations for delivering expert lectures / courses / key note addresses. He has also been member of many academic promotional committees as well as expert member of international research councils.

Detailed Program

Oral Presentation- Giorgia Room

Saturday Afternoon, 29 June 2019, 14:00–18:30

Session 1: Electronic System 14:00-16:15	
G1011	Approximation Methods for FO-IMC Controllers for Time Delay Systems
G2018	Feasibility Study on Installation of Rooftop Photovoltaic System in Complied with Thailand Energy Building Code
G1020	Development of Cable Accessories with SiR Insulation for 320kV HVDC Cable
G1021-A	Improving Electrochemical Performance of Si-Based Electrode via Gradient Si Concentration
G1025	Novel Frequency-Doubling Modulation and Control Strategy for Three-Level Full Bridge based Power Electronic Traction Transformers
G1027	Challenges and Research Opportunities of Frequency Control in Low Inertia Systems
G1037	Control Method for Three-Phase Grid-Connected Inverter PV System Employing Unity Power Factor (UPF) strategy in Microgrid
G2007	Path Planning based on an Artificial Vision System and Optical Character Recognition (OCR)
G1041-A	The Use of Serious Games to Change Energy Consumption Behaviours
Coffee Break 16:15-16:45	
Session 2: Mechanical Engineering 16:45-18:30	
G11002	Selection of Optimal Variant of Hybrid System under Conditions of Uncertainty
G11003-A	Kinetic Energy Harvesting From Human Hand Movement Activities Mounting Free/Impact Based Micro Electromagnetic Generator
G1038-A	Action Recognition with Dense SIFT Flow Two Stream CNN
G1039	Making a Case for Local Combined Heat and Power and District Heating Infrastructures Within the United Kingdom Policy Landscape
G2004	Flexible Production Cell Applying Artificial Vision Concepts and Open Source CNCs
G2011	Parameter Prediction using Machine Learning in Robot-Assisted Finishing Process
G2012-A	A Study on the Reduction of the number of Measurements in Degradation Test Using Clustering

Note:

* Please control each presentation time within 15 mins, including Q & A.
* Best Presentation of each session is encouraged to award to student author prior.
* Winner of Best presentation will be announced at the end of each Session, and awarded the certificate at the end of sessions.
* To show the respect to other authors, especially to encourage the student authors, we strongly suggest you attend the whole session.
* The scheduled time for presentations might be changed due to unexpected situations, please arrive meeting room at least 10 Mins before Session starts.
* Session photo will be taken at the end of the session and updated online.

Saturday, 29 June, 14:00–16:15

Session 1: Electronic System

Room: Giorgia Room
Chair: Prof. Hassan Bevrani, University of Kurdistan, Iran

G1011 **(14:00-14:15)**	Approximation Methods for FO-IMC Controllers for Time Delay Systems **Dr. Cristina Muresan**, Isabela Birs, Ovidiu Prodan, Ioan Nascu and Robin De Keyser Technical University of Cluj-Napoca, Romania Fractional Order Internal Model Control (FO-IMC) is among the newest trends in extending fractional calculus to the integer order control. Approximation of the FO-IMC is one of the key problems. Apart from this, when dealing with time delay systems, the time delay needs also to be approximated. All these approximations can alter the closed loop performance of the controller. In this paper, FO-IMC controllers will be tested in terms of the approximation accuracy. The case study is a first order system with time delay. Several scenarios will be considered, aiming for a conclusion regarding the choice of the approximation method as a function of the process characteristics, closed loop performance and FO-IMC fractional order. To approximate the time delay, two extensively used techniques will be considered, such as the series and Pade approximations. These will be compared to a novel approximation technique. An analysis of the test cases presented show that the series approximation proves more suitable in a single scenario, whereas the novel approximation method produces better results for the rest of the test cases.
G1018 **(14:15-14:30)**	Feasibility Study on Installation of Rooftop Photovoltaic System in Complied with Thailand Energy Building Code Pathomthat Chiradeja and **Assoc. Prof. Atthapol Ngaopitakkul** King Mongkut's Institute of Technology Ladkrabang, Thailand Renewable energy especially solar energy has become a significant part in electrical power generation with its advantage in the environmentally friendly and current trend of decrease in installation cost. The photovoltaic (PV) system on a rooftop is one of the power generating system based on renewable energy that can fit building to utilize space efficiently. This paper is analyzing the feasibility of installing a solar PV rooftop on the building using a case study building located in Bangkok, Thailand. The performance will be evaluated in term of both energy and economic perspective. The comparison with Thailand building energy code also been done to show that overall energy consumption with PV system complies with the law. The result has shown that with rooftop photovoltaic system installation, annual energy consumption in the building can be reduced significantly and it can achieve feasibility in term of economic perspective.
G1020 **(14:30-14:45)**	Development of Cable Accessories with SiR Insulation for 320kV HVDC Cable **Dr. Ruoyu Xu**, Mingyu Zhou, Zhengyi Han, Yi Luo, Haitian Wang, Yuzhen Zhou and Tong Yang Global Energy Interconnection Research Institute Europe GmbH, Germany HVDC cable accessories with environment-friendly insulating material and flexible compatibility other than ethylene propylene diene monomer (EPDM) are demanded in the global market. In this paper, the authors present their newly developed silicone rubber (SiR) insulated cable joints and terminations as a potential answer to that call. Simulation models were built in computer programs. Three most venerable spots in the insulator were identified. SiR insulated accessories with optimised conductivity were produced and tested according to Cigre TB 496 and IEC 62895:2017. The test objects

	passed the type test with good success. It proved that with proper design, manufacturing and installation, SiR insulated cable accessories are able to provide good service in the power system networks.
G1021-A **(14:45-15:00)**	Improving Electrochemical Performance of Si-Based Electrode via Gradient Si Concentration **Mr. Zhenbin Guo**, Limin Zhou and Haimin Yao The Hong Kong Polytechnic University, China Silicon (Si) has long been regarded as one of the most promising anode materials for the next-generation lithium-ion batteries (LIBs) due to its exceptional specific capacity and apt working voltage. However, the dramatic volume change of Si during lithiation/delithiation processes leads to the delamination between the current collector and the electrode materials, resulting in the poor stability and degradation of electrochemical performance of the LIB. Inspired by the functional graded design in natural biomaterials, here we propose to solve the interfacial delamination problem by graded electrode in which the Si composition is distributed in a graded way. The prepared graded electrodes especially those after gradient optimization are found quite successful in alleviating the interfacial delamination, resulting in higher capacity and capacity retention, higher coulombic efficiency, higher effective mass loading in comparison to the traditional ones. Such graded electrode can be applied together with other strategies for solving the large volume change problem of Si and can be easily produced by the existing manufacturing facilities of electrode. This work provides a guideline for the design and manufacture of the graded Si-based electrodes for LIBs.
G1025 **(15:00-15:15)**	Novel Frequency-Doubling Modulation and Control Strategy for Three-Level Full Bridge based Power Electronic Traction Transformers **Dr. Hongbo Li**, Wenqing Mei, Ye Yang, Wenguang Luo, Zhixue Zhang and Xiaodi Zang CRRC Zhuzhou Institute Co., Ltd., China Power electronic traction transformers (PETTs) are widely investigated to substitute bulky line frequency transformers in railway traction system presently. This paper adopts the three-level topology for both grid-side cascaded converters and primary-sides of LLC resonant converters. The cascade number is reduced by half as well as isolated transformers compared to the traditional two-level configuration. Less cascade number of modular converters leaves relatively more space for electric insulation implementation, which is beneficial to PETTs in terms of the limited installation space in the train. A frequency-doubling modulation strategy for LLC resonant converters is proposed, which can enable the operating frequency of isolated transformers two times higher than the switching frequency to further reduce the transformer size without increasing the switching loss. Meanwhile the proposed modulation strategy can realize the capacitor voltage balance autonomously as well. Additionally, the control strategy of cascaded rectifiers and key parameter design guideline of LLC resonant converters are also introduced.
G1027 **(15:15-15:30)**	Challenges and Research Opportunities of Frequency Control in Low Inertia Systems Ha Thi Nguyen, **Assoc. Prof. Guangya Yang,** Arne Hejde Nielsen and Peter Højgård Jensen Technical University of Denmark (DTU), Denmark The dominance of converter-based generation in power systems results in a significant reduction of the number of conventional power plants. The transition introduces major challenges of substituting synchronous generators and their ancillary dynamic control services with converter-interfaced generations whose control and interaction with the grid have not been fully understood. This paper presents challenges and research opportunities of frequency control of such low inertia systems. Challenges of frequency control in converter-based systems and a review of power systems facing the challenges caused by low inertia conditions around the world are first investigated. Then, a summary of the solutions that have been proposed for frequency control in low inertia

	systems is analysed. The paper will conclude with research opportunities for frequency control in low inertia systems, which require further investigation for converter-interfaced systems.
G1037 **(15:30-15:45)**	Control Method for Three-Phase Grid-Connected Inverter PV System Employing Unity Power Factor (UPF) strategy in Microgrid **Dr. Amirreza Naderipour**, Zulkurnain Abdul-Malek, Vigna K. Ramachandaramurthy and JosepM. Guerrero Universiti Teknologi Malaysia, Malaysia Microgrids (MGs) are developing owing to the rapidly growing distributed power generation systems. The MG controls the flexibility of the network to ensure the requirements of reliability and power quality are satisfied. A typical MG normally consists of dispersed generation resources, which are connected by power electronic inverters, storages, and non-linear loads. This study deals with a compensation control method of a photovoltaic grid-connected inverter using unity power factor (UPF) strategy in MG. In this case, the proposed control method can provide output currents without distortion and with the UPF. Further, it is able to increase the inverter output current to approximately 19 times of the value obtained conventionally. The proposed control method can be applied to three-phase grid interfaced converters such as DG inverters and can also be easily integrated into the conventional control scheme without installation of extra hardware. A theoretical analysis is presented and the performance of the proposed control method for a grid-connected inverter in a MG is evaluated through simulation results.
G2007 **(15:45-16:00)**	Path Planning based on an Artificial Vision System and Optical Character Recognition (OCR) **Assoc. Prof. Thomas Martin Rudolf**, Julio Ernesto Sanchez Díaz Instituto Tecnológico Autónomo de México ITAM, México The presented paper describes the integration an Artificial Vision System and Artificial Intelligence into a machine tool to find the correct instructions to move chips from an initial state to a goal state. To do so, several technologies such as OCR, graph-search control method and G-Code generation are integrated into one Cyber-Physical Production Systems. The integrated Cyber-Physical Production Systems (CPPS) detects the initial state via a visual system and the user defines the required goal state. Applying the graph-search control method the correct sequence of movements is obtained to find the goal state. Then, the CPPS converts this sequence to G-Code and the machine tool executes by the machine tool. The paper describes the different components to achieve the resumes the results.
G1041-A **(16:00-16:15)**	The Use of Serious Games to Change Energy Consumption Behaviours **Assoc. Prof. Luís Miguel Pires Neves** INESC Coimbra, Portugal Energy behaviors are acknowledged as an important element in promoting end-use energy efficiency. However, energy behaviors are still an underexploited resource due to the lack of adequate approaches to address their complexity. The creative combination of different disciplines is required to develop comprehensive approaches to the understanding of energy behaviors and promotion of end-use energy efficiency in more effective interventions. This paper presents the work developed and the lessons learned during a practice based research project involving several higher education institutions in Portugal. The purpose of the project was to learn about energy consumption behaviors using a mobile application. Students with diverse backgrounds were involved from an early stage throughout the entire process, starting with the characterization of end-users' energy behaviors and energy demand, in order to design the query process and to establish the most effective feedback advices and rewards which were aimed to be used as a way to keep respondents involved, and also to directly induce best practices. Although the inquiry process has not produced yet the results we would have liked to obtain, the

	development of this project provided meaningful insights about the way to reach younger generations and to disseminate general knowledge about a relevant topic as energy efficiency. The use of gamification provided an effective way to grab the attention of students and their competitiveness forced them to explore the field in a way which would be difficult to attain differently. As a final outcome, it is expected that the project not only affects those who tried the mobile application but also induce behavioral transformations on the several students which were involved in the practice-based project, also spilling over to their family context.
	Coffee Break **16:15-16:45**

Saturday, 29 June, 16:45–18:30

Session 2: Mechanical Engineering

Room: Giorgia Room
Chair:

G11002 **(16:45-17:00)**	Selection of Optimal Variant of Hybrid System under Conditions of Uncertainty **Dr. Matsankov Misho** and Ivanova Mihaela Technical University of Sofia, Bulgaria The aim of the study is to select an optimal variant of a hybrid system under conditions of uncertainty according to selected criteria. The problems of the study are the different options for building the hybrid system and choosing an adequate criterion for choosing the optimal variant. The study covers analysis of three variants of building up a hybrid system for supplying of autonomous electric load. The three variants are: introduction of an active user for equalizing the load schedule; introduction of additional generating source for covering the peak portion of the load schedule; covering the peak portion of the load by using an additional generating source and diesel generator. An optimal variant is selected under the conditions of uncertainty according to two criteria: minimum discounted expenses and loss of power. To this effect, the method of Mathematical hierarchical game theory analysis is applied. As a result of the study, the appropriate criteria for choosing an optimal variant for building a hybrid system are obtained. The results obtained allow to set a different degree of significance of the formulated basic criteria in the computational algorithm for decision making for the construction of the hybrid system.
G11003-A **(17:00-17:15)**	Kinetic Energy Harvesting From Human Hand Movement Activities Mounting Free/Impact Based Micro Electromagnetic Generator **Mr. Mohammad Fazlur Rahman Pathan** Kaunas University of Technology-KTU, Lithuania A comprehensive review of design and experimentation is presented in this research paper on sustainable renewal energy scavenging from Human body movement using Micro electromagnetic kinetic energy harvester to powering wearable, portable electronics devices, implantable medical devices, temperature measurement etc. The body location which is chosen as the harvester is human hand between elbow and shoulder. Human body is a big source of energy harvesting in two ways i,e, mechanical energy and thermal energy. Mechanical energy is of two kinds one is static energy and the other one is kinetic energy. Due to motion or displacement or enforcement excitation the kinetic energy is extracted. The electric charges which remains imbalance on the surface or within a material is static energy. Thermal energy is extracted from the dissipation of heat from human body. Human body parts and organs generate energy through two types of activities one is voluntary and the other one is involuntary. The energy which are produced by voluntary activities are high as people intentionally does work by body motion, walk, run. The generated energy by involuntary organs like heart, breathing, artery are smaller compare to voluntary energy harvesting. One process of energy harvesting is by use of micro electromagnetic generator, flexible and stretchable piezoelectric, triboelectric, electromagnetic induction, PVDF mounting on human body. For acquiring greater amount of energy needs to mount gear and generator devices like electromagnetic, magnetostrictive vibrators generator on parts of body. Micro electromagnetic vibration convert the kinetic energy of human hand motion into electricity as an efficient source of power.
	Action Recognition with Dense SIFT Flow Two Stream CNN **Mr. Sang-Kyoo Park**, Dong-Sung Pae, Jun-Ho Chung, and Myo-Taeg Lim Korea University, Republic of Korea

G1038-A **(17:15-17:30)**	Recently, there are many studies in action recognition for ADAS control systems, because pedestrian behavior patterns are more complex than other obstacles. Rather than simply avoiding pedestrians, it is more efficient to set avoidance strategies based on predicted pedestrian behavior. The optical flow based two stream CNN architecture has high performance in action recognition. The optical flow represents the motion information, but it is weak in light changes or complex movement situation. Therefore, we propose the dense SIFT flow based two stream CNN. The dense SIFT flow uses a SIFT flow algorithm and an energy function to create a flow vector representing the movement information of each pixel. Although the performance of the dense SIFT flow is good for representing the motion information, it requires a lot of computing power. To reduce the computational load, we substitute SIFT descriptor with binary descriptor and modify the energy function. The binary descriptor reduces computational time and is more robust with respect to complex movement situation. In the experiment, UCF-101 action recognition dataset is used and the results show that our method is more accurate than the conventional method.
G1039 **(17:30-17:45)**	Making a Case for Local Combined Heat and Power and District Heating Infrastructures Within the United Kingdom Policy Landscape **Prof. Javier Urquizo**, Carlos Calderon and Philip James Escuela Superior Politécnica del Litoral, Ecuador Planning energy infrastructure at the local level is the key to addressing some of the most difficult challenges in climate change and energy policy planning (i.e. fuel poverty) and to unlock the transformative potential of distributed energy technologies. The scientific field of urban energy and carbon modelling is becoming a fundamental instrument to estimate an energy and carbon baseline at a point in time and to quantify the impact that policy-driven technological interventions that could have on the overall carbon footprint of a city. This capability enables an evidence-based approach in which the economic case towards a low-carbon economy can be made. Transformative local distributed energy technologies such as CHP or district heating have a strong spatial component due to a need to identify synergies with adjacent properties or heating loads. Currently available domestic building energy models often do not take into account spatial information. Accessing geo-referenced data for energy modelling can also be particularly useful as validated outputs (i.e. heating and electricity loads, energy profiles) can be mapped using spatial modelling techniques that help to easily identify high and low energy consumption areas and potential synergies in local energy infrastructure planning. In Newcastle upon Tyne UK, the council is exploring the opportunities for the installation of renewable heat technologies on their own stock as a matter of urgency. Identification of potential sites and feasibility for technical and financial applicability within the UK policies will be addressed by this paper.
G2004 **(17:45-18:00)**	Flexible Production Cell Applying Artificial Vision Concepts and Open Source CNCs Luis Javier Diaz Ochoa and **Assoc. Prof. Thomas Martin Rudolf** Instituto Tecnológico Autónomo de México ITAM, México The presented paper describes the integration of an artificial vision system into a flexible production cell: the production cell consists of a material storage box with an artificial vision system (AVS) and a 5-DOF robot type Scorbot ER 4. The camera system detects the geometry of the rough material typed to be used in a manufacturing process. Further, it identifies the position and orientation of the material. This information is sent to the robot that starts moving to take the material for further processing. The Cartesian Coordinates are processed so that the robot joints can be positioned correctly. The described system is part of an ongoing development of a smart factory for investigation and educational purposes
	Parameter Prediction using Machine Learning in Robot-Assisted Finishing Process **Mr. Bobby K Pappachan**, and Tegoeh Tjahjowidodo Nanyang Technological University, Singapore In finishing processes equipped with real-time pro- cess monitoring, analyzing real-time data acquired is vital to ensure product quality and safety compliance. The quality and

G2011 **(18:00-18:15)**	dimensions of a finished product is often times dictated by the process parameter set initially. However, changes in parameter occurs whenever an unexpected event such as an equipment failure or voltage fluctuations occurs. This could result in a finished product with a below par quality and subsequently delays in production due to rework or machine downtime. With an indirect monitoring method to continually monitor these parameters such as spindle speed, these occurrences can be minimized. Here lies in the benefit of an integrated parameter prediction model, which is able to detect deviation from normal operation early, hence enabling the capability of delivering actionable insights in a real-time basis to shop-floor engineers. This paper presents a parameter prediction method tested successfully on data acquired from a robot-assisted deburring process.
G2012-A **(18:15-18:30)**	A Study on the Reduction of the number of Measurements in Degradation Test Using Clustering Hyun Su Sim, **Ms. Ki-Yeon Kim**, Na-Yeon Kim, HaeJee Kim, and Yong Soo Kim Kyonggi University, Republic of Korea Measurements are required during degradation test to determine the lifetime of the product. However, many products consume a lot of time and cost in measurements during the test. Hence, to reduce time and cost, it is intended to replicate degradation patterns by minimizing reduction of predictive power even when the number of measurements is reduced. First, it makes the ordered pairs with a pair of independent and dependent variables in the data conducted existing degradation test. Then, clusters of ordered pairs with similar trends were generated through clustering and the desired number of measurements was derived. After that, the median of the order of each cluster is adopted, and the measurements are performed in time or cycles corresponding to the independent variables of the ordered pairs. To evaluate this process, we applied it to degradation test of camera lenses. As a result, it was mainly shown that the predictive methodologies using Gaussian Process Regression, Linear Regression Model, SVR and Artificial Neural Network were predominated over the generally reduced cases. This methodology may be applied when further testing is carried out in the degradation test of the machine where the existing test data are present. This is expected to significantly reduce the time and cost of measurement.
	Dinner **18:30-19:30**

Poster Presentation

Saturday, 29 June, 16:15–16:45

G1008	A Preventive Strategy of Voltage Stability based on Characteristic Analysis **Zhen Hu**, Ding Wang, Daojun Chen, Yongyan Liu, and Yangwu Shen State Grid Hunan Electric Power Company Limited Research Institute, China The purpose of voltage stability prevention and control strategy is to minimize the impact of expected accidents on the whole power grid while ensuring safe power supply. In this paper, it is expected that the accident has a large impact on the system voltage and makes the voltage margin of each node low. in order to not only adjust the node voltage, but also reduce the disturbance impact, a voltage stability prevention and control strategy is proposed based on the characteristic analysis.
G1009	Islanded Mode Response Verification of AC Microgrid under Symmetrical and Non-symmetrical Short Circuits **Maruf A. Aminu** Nile University of Nigeria, Nigeria The assumptions and parameters required in modeling a microgrid depend on the platform, among other variables. It is therefore pertinent to verify the response of a modeled testbed to establish its validity. This work reports on verification of the response of a wind turbines-based microgrid to symmetrical and non-symmetrical short circuits. The testbed consists of 2 units of 5.5 kW 400 V wind turbines capable of connecting to the utility. Short circuits are introduced at 6.00 second and withdrawn at 8.00 second, measuring the dynamic response of the testbed while the microgrid is in islanded mode alternately under voltage and reactive power control strategies. The response is shown to be consistent, symptomatic of the type of short circuit and therefore suitable for short circuit detection and diagnosis, verifying validity of the microgrid testbed. The testbed can therefore be used for short circuit related studies, design optimization and performance prediction.
G2008	Upgrading Strategy of Small and Medium Manufacturing Enterprises (SMME) to Smart Manufacturing **Asst Prof. Baolei Zhang**, Fuquan Zhao, and Zongwei Liu Tsinghua University, China The contribution of Medium Manufacturing Enterprises (SMMEs) will not only weaken but also be strengthened under the background of smart manufacturing. It is the key point of achieving mass individualized production that lots of SMMEs with specialized and excellent manufacturing capability connect to smart manufacturing network. Nowadays, SMMEs of China are facing survival pressure and various severe challenge. Meanwhile, the developing experience and characteristics of SMMEs of China leads to the particularity of their upgrading process to smart manufacturing. The problems of process normalization, essential data, talents, and funds restrict SMMEs from upgrading to smart manufacturing seriously. It is very important for government, professional organizations, scientific research institutions, enterprises to do well on division of work and cooperation aiming at the key problems that enterprises are confronting now, in order to push forward the upgrading task to smart manufacturing together.
G2018	Determination of Dislocation Density by XRD in Cold Rolled Pure Copper **Mr. Heng Feng**, Bi Zhang, and Qian Bai Dalian University of Technology, China The dislocation densities of cold rolled pure copper were determined by X-ray diffraction

	(XRD) in this paper, and the micro-hardness was also measured as the indicator of the dislocation hardening of the workpieces. This paper is aimed to introduce a systematic method to measure dislocation density in rolled copper and investigate the effects of rolling reduction on it. Williamson-Hall method combined with modified Warren-Averbach was used to calculate the dislocation densities based on the diffraction patterns. The result shows that the dislocation density increased from 6.1×1014mm-2 to 7.8×1014mm-2 with the increase of rolling reduction from 17% to 50%. The variation of dislocation density was validated by the measured micro-hardness. This paper functions as a feasible way to determine the dislocation density to reveal the hardening conditions for cold rolled pure copper.

Listeners

Ms. HaeJee Kim
Kyonggi University, Republic of Korea

Ms. Na-Yeon Kim
Kyonggi University, Republic of Korea

Author Index

One Day Tour

Attention:
This tour will charge 100USD for each person. (Pay to join before June 26, 2019, or you could choose to enjoy free time on June 30 to explore Rome yourself.

7:10 AM (June 30), pick up at gathering sport.

Please be there on time, or you will miss the tour without no refound.

Time:	Destination
7:10	Gathering Place-Viale dei Bastioni di Michelangelo, 21
7:30-8:00	On the Way to Napoli
8:00-12:00	Piazza del Plebiscito, Piazza del Municipio, Galleria Umberto I, Teatro San Carlo
12:00-13:30	Lunch Time
13:30-19:00	Pompeii
19:00-21:00	Back to the gathering place

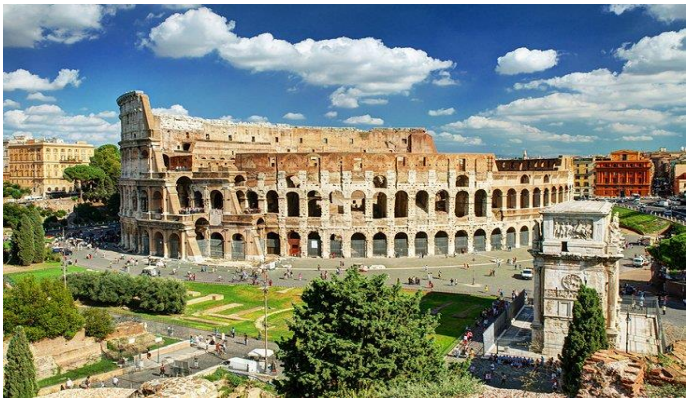
Service included:
Tour guide
Tips for tour guide and driver
Tickets
Lunch

Service excluded:
Personal expenses (not mentioned above)

If you want to join in us, please contact the conference secretary.

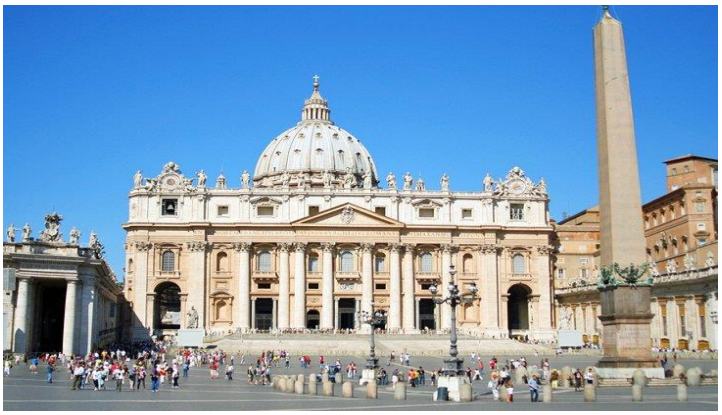
Top 10 View Points in Rome

1. The Colosseum and the Arch of Constantine



Rome. The largest structure left to us by Roman antiquity, the Colosseum still provides the model for sports arenas - present day football stadium design is clearly based on this oval Roman plan. The building was begun by Vespasian in AD 72, and after his son Titus enlarged it by adding the fourth story, it was inaugurated in the year AD 80 with a series of splendid games. The Colosseum was large enough for theatrical performances, festivals, circuses, or games, which the Imperial Court and high officials watched from the lowest level, aristocratic Roman families on the second, the populace on the third and fourth.
Beside the Colosseum stands the almost equally familiar Arch of Constantine, a triumphal arch erected by the Senate to honor the emperor as "liberator of the city and bringer of peace" after his victory in the battle of the Milvian Bridge in 312. Lines are long and move slowly, so you can save time by joining the Skip the Line: Ancient Rome and Colosseum Half-Day Walking Tour and have a knowledgeable guide, as well.

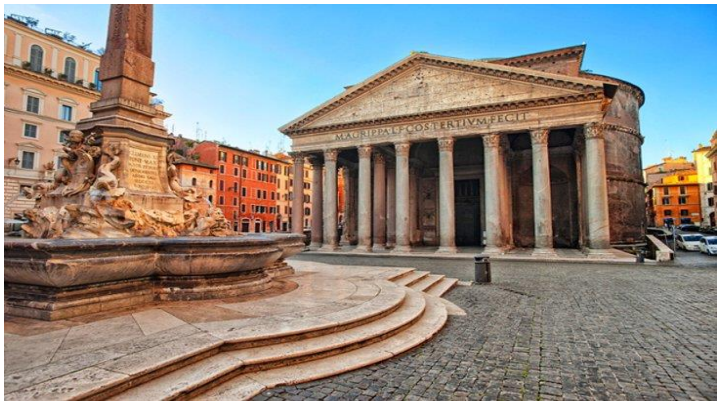
2. Vatican City



The Vatican is the smallest independent state in the world, with an area of less than half a square kilometer, most of it enclosed by the Vatican walls. Inside are the Vatican palace and gardens, St. Peter's Basilica, and St. Peter's Square, an area ruled by the Pope, supreme head of the Roman Catholic Church. This compact space offers much for tourists to see, between its museums and the great basilica itself.
Inside St. Peter's Basilica is Michelangelo's masterpiece, Pieta, along with statuary and altars by Bernini and others. The unquestioned highlight of the Vatican museums is the Sistine Chapel, whose magnificent frescoed ceiling is Michelangelo's most famous work. Inside the Vatican Palace are the Raphael Rooms, the Borgia Apartments, the Vatican Library, and a number of museums that include the Picture Gallery, Museum of Secular Art, Etruscan Museum, and others. The collections you can see in these cover everything from papal coaches to 20th-century art reflecting religious themes.
Ticket lines for the Vatican's top attractions are incredibly long, and you can spend several hours waiting in

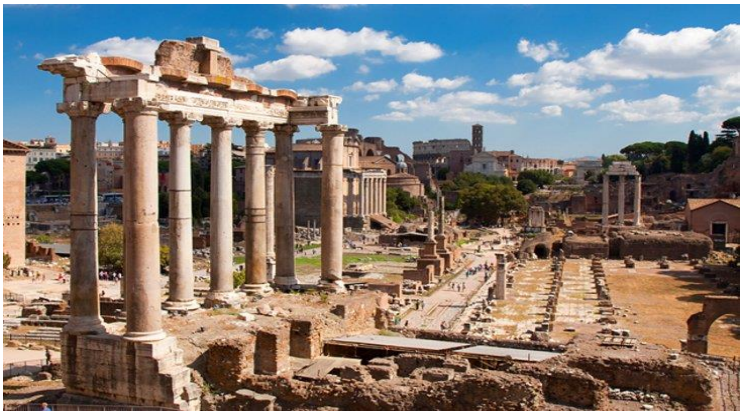
line. To save time, purchase a Skip the Line: Vatican Museums with St. Peter's, Sistine Chapel, and Small-Group Upgradetour in advance. This three-hour tour allows you to bypass the long lines and walk straight into the museums with a knowledgeable guide. Headsets are provided, and you can choose from several different departure times or upgrade to an evening or small-group tour.

3. The Pantheon



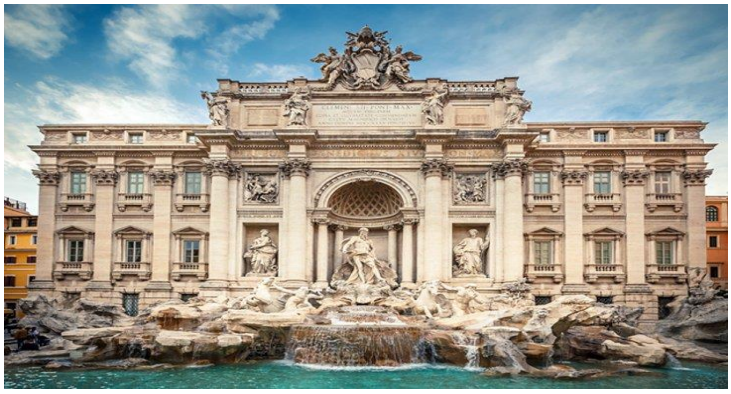
The Pantheon - the best preserved monument of Roman antiquity - is remarkably intact for its 2000 years. This is despite the fact that Pope Gregory III removed the gilded bronze roof tiles, and Pope Urban VIII ordered its bronze roof stripped and melted down to cast the canopy over the altar in St. Peter's and cannons for Castel Sant'Angelo. The Pantheon was rebuilt after damage by fire in AD 80, and the resulting brickwork shows the extraordinarily high technical mastery of Roman builders. Its 43-meter dome, the supreme achievement of Roman interior architecture, hangs suspended without visible supports - these are well hidden inside the walls - and its nine-meter central opening is the building's only light source. The harmonious effect of the interior is a result of its proportions: the height is the same as the diameter. Although the first Christian emperors forbade using this pagan temple for worship, in 609 Pope Boniface IV dedicated it to the Virgin and all the Christian martyrs, and since then, it has become the burial place of Italian kings (Victor Emmanuel II is in the second niche on the right) and other famous Italians, including the painter Raphael.

4. Roman Forum



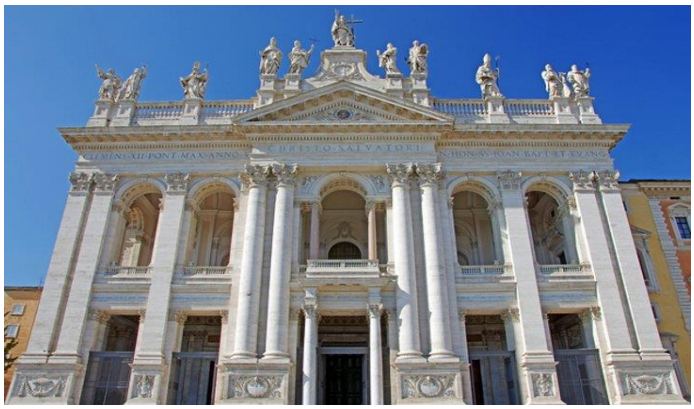
Walking through the forum, now in the middle of a throbbing modern city, is like stepping back two millennia into the heart of ancient Rome. Although what survives of this center of Roman life and government shows only a small fraction of its original splendor, the standing and fallen columns, its triumphal arches, and remains of its walls still impress, especially when you consider that for centuries, the history of the Forum was the history of the Roman Empire and of the western world. Roman political and religious life was centered here, along with the courts, markets, and meeting places. After the seventh century, the buildings fell into ruin, and churches and fortresses were built amid the ancient remains. Its stones were quarried for other buildings and it was not until the 18th and 19th centuries that systematic excavations brought the ancient buildings to light from under a 10-meter layer of earth and rubble. Highlights not to miss are the Temple of Antoninus Pius, the Temple of Castor and Pollux, the Temple of Saturn, the Arch of Septimus Severus, the Curia, the Temple of Vesta, and the Arch of Titus.

5. Trevi Fountain



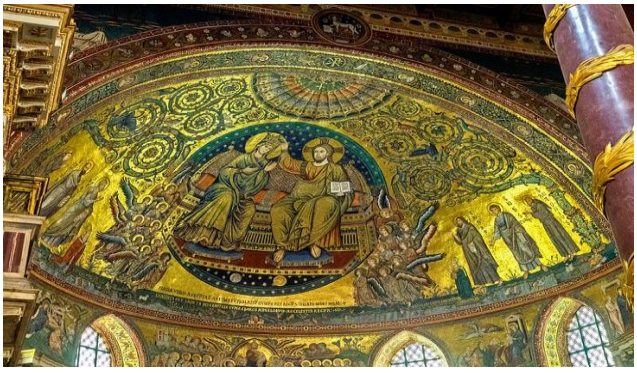
One of the city's most popular tourist attractions, this 17th-century masterpiece has been immortalized in films until it is almost a required visit. Throwing a coin (not three) into the Trevi Fountain (Fontana di Trevi) is a tradition that is supposed to assure your return to Rome. Rome's largest fountain, Fontana di Trevi is supplied by an aqueduct originally constructed by Agrippa, the great art patron of the first century BC, to bring water to his baths. The fountain was created for Pope Clement XII between 1732 and 1751 by Nicolò Salvi, and built against the rear wall of the palace of the Dukes of Poli. It depicts the sea god Oceanus (Neptune), with horses, tritons, and shells. The water swirls around the figures and the artificial rocks, and collects in a large basin, always filled with coins.

6. San Giovanni in Laterano (Basilica of St. John Lateran)



As you might expect for the episcopal church of the Pope, St. John Lateran is one of Rome's most impressive churches. After centuries of alterations, it still retains its original form from the age of Constantine, when it was built. Its façade, by contrast, is a purely baroque embellishment and a fine example of that period. Along with the mosaics in the apse, be sure to notice the beautiful 16th-century wooden ceiling. If the octagonal baptistery, San Giovanni in Fonte, looks a bit familiar, it's because it provided the model for later ones throughout Europe. Built by Constantine, it is the world's oldest Christian baptistery. Across the piazza, in the church of the Scala Santa, is the Holy Staircase, 28 steps believed to have been brought to Rome in the fourth century by St. Helen, from Pilate's palace in Jerusalem.

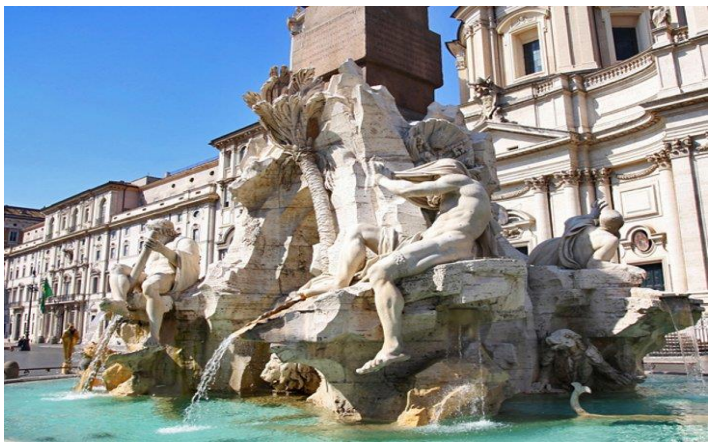
7. Santa Maria Maggiore



One of Rome's most majestic churches, Santa Maria Maggiore has stood here since the fourth-century Pope

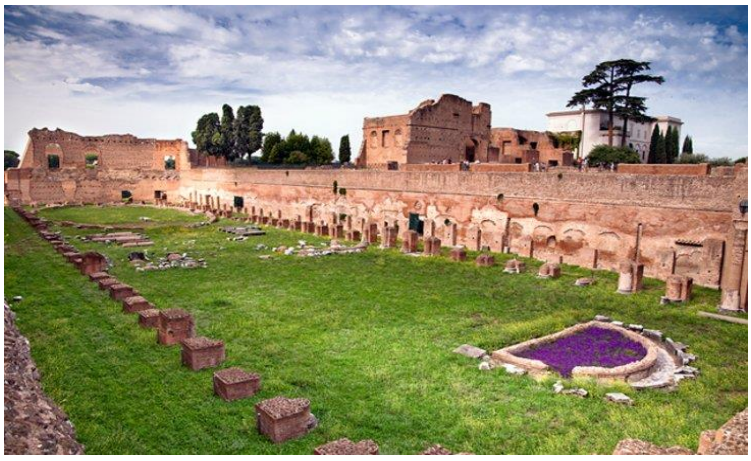
Liberius had a vision of the Virgin directing him to build a church where snow fell the following day. Although it was August, snow did fall on the Esquiline hill the next morning, so here the great basilica was built. Mass has been celebrated here every day since the fifth century. The three aisles of its 86-meter-long interior are separated by 40 columns of marble and four of granite, and the apse added in the 13th century is lined with mosaics of Old and New Testament themes, masterpieces of Rome's famous mosaic artists.
Rome's oldest mosaics, as old as the fourth century, decorate the upper walls, and the floor is inlaid with colored stone in the style of the expert 12th-century artisans of the Lake Como region. The first gold to reach Italy from the Americas shines on the coffered ceiling. Two popes are buried here; it's one of Rome's four papal basilicas, an important place of pilgrimage church.

8. Piazza Navona



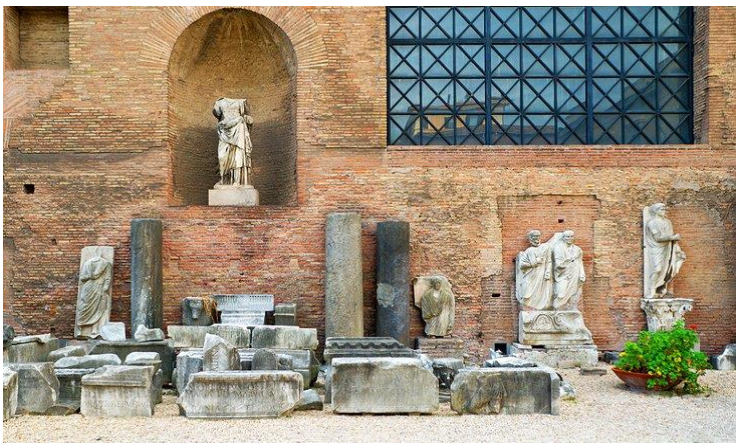
One of Rome's most characteristic Baroque squares, Piazza Navona still has the outline of the Roman stadium built here by Emperor Domitian. It was still used for festivals and horse races during the Middle Ages, and was rebuilt in the Baroque style by Borromini, who also designed the magnificent series of palaces and the church of Sant'Agnese, on its west side. Its facade, campanile, and dome highlight the way Baroque architecture weaves convex and concave surfaces, gables, windows, columns, and piers into a unified design. In the crypt of Sant'Agnese are Alessandro Algardi's 1653 The Miracle of St. Agnes and the remains of a Roman mosaic floor. Sant'Agnese provided a model for Baroque and Rococo churches in Italy and elsewhere.
Although Borromini designed the square and its surrounding facades, it was his archrival, Bernini, who created its centerpiece, the beautiful Baroque fountain, Fontana dei Fiumi. The spirited fountain represents the four rivers then thought to be the largest on each of the known continents, with figures personifying the Nile, Ganges, Danube, and Rio de la Plata around the large basin, each accompanied by plants and animals of their respective regions. The two other fountains in the square are the 16th-century Fontana del Moro in front of the Palazzo Pamphili, erected by Giacomo della Porta, and the 19th-century Fontana del Nettuno with its figure of Neptune. Today, the square is filled with Romans, tourists, street artists, souvenir kiosks, cafés, and during December, one of Rome's best Christmas markets. Nearby, between the Piazza and the Pantheon, the church of San Luigi dei Francesi contains three major paintings by Caravaggio from the late 16th century.

9. Palatine Hill



Strategically set 50 meters above the Tiber, the Palatine Hill shows evidence of Rome's earliest settlement: rock-cuttings found in front of the Temple of Cybele show human activity as long ago as the ninth century BC. Later, this was the site chosen by the emperors and great aristocratic families for their palaces. The Farnese Gardens were laid out on the hill in the 16th century for Cardinal Alessandro Farnese, a pleasure park of terraces, pavilions, lawns, flowerbeds, trees, and fountains designed as a kind of stage-setting for social gatherings. Highlights of the Palatine Hill are the House of Livia (Augustus' wife), the semi-subterranean Cryptoporticus, Domus Flavia, Domus Augustana, and most imposing of all, the Baths of Septimius Severus. The Palatine Hill is a lovely place to explore, combining a park with magnificent and impressive ruins of ancient Rome.

10. Terme di Diocleziano (Baths of Diocletian National Museum)



Diocletian's baths were so enormous that today, they contain two churches, large parts of a Carthusian monastery and a major museum. Michelangelo used the vast tepidarium (hot baths) as the shell for his church of Santa Maria degli Angeli, and the Museo Nazionale Romano, Rome's National Museum, fills another section with treasures of antiquity: Greek and Roman sculpture, pre-Christian and later sarcophagi, and beautiful mosaics and frescoes. The late-16th-century church of San Bernardo alle Terme was built in a rotunda at the corner of the baths; its dome is like that of the Pantheon, but only half its size.

*Part of the local information and entrance fee above comes from the network.

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