EEDAL : LS:17

11th Energy Efficiency in Domestic Appliances and Lighting

17th International Symposium on Science and Technology of Lighting

11th EEDAL

Session by session

Contributed papers Abstract Booklet

ISBN 978-2-492754-02-9

Sessions at a glance

Wednesday June 1st, 2022

Session 1.01 – Afternoon

Policy 1					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 1st 14:00-15:40**
1.01.01	EEDAL 88	U.S. Consumer Electronics in 2020: Ownership, Usage, and Energy Consumption Amid COVID-19	Bryan Urban	Bryan Urban, Fraunhofer USA Center for Manufacturing Innovatio, United States	
1.01.03	EEDAL 100	Introducing Mepsy: The Appliance & Equipment Climate Impact Calculator	Angellah Wekongo	CLASP, Kenya	
1.01.04	EEDAL 26	Evaluation of Television Efficiency Policy and Market Transformation in India	Pravatanalini Samal	Bureau of Energy Efficiency, India	
1.01.05	EEDAL 30	Impact mechanisms of rebate programmes for appliances: case studies in Switzerland	Eric Bush	Topten, Switzerland	

Policy 2					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 1st 16:05-18:10**
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1.01.06	EEDAL 29	The first energy labels for professional cooling appliances – lessons learnt and comparison with energy regulation for household appliances	Maike Hepp, Steffen Hepp	Topten, Switzerland	
1.01.07	EEDAL 72	New Method for Updating Measure Lifetimes: Fast, Reliable, Affordable – and Demonstrated	Lisa Skumatz, Dana D'Souza	Skumatz Economic Research Associates – SERA, United States	
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1.01.09	EEDAL 70	Advances in NEBs / NEIs: New Results, Measure Attribution, Health Effects, and the Downward-Bias in Current US NEB Adders	Lisa Skumatz, Ann Gibbs Vandervliet	Skumatz Economic Research Associates – SERA, United States	

Session 1.02 – Afternoon

HVAC 1					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 1st 14:00-15:40**
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1.02.02	EEDAL 95	Final impact assessment of the novel highly efficient and fuel flexible medium-scale HiEff-BioPower CHP technology using a solid oxide fuel cell (SOFC)	Thomas Götz	Wuppertal Institute for Climate, Environment and Energy, Germany	
1.02.03	EEDAL 24	Heating with Air Conditioners – fast and affordable transition towards carbon neutrality?	Andrea Roscetti	Politecnido di Milano, Energy Department, end-use efficiency research group, Italy	
1.02.04	EEDAL 65	Smart Economizer	Robert Mowris	Verified Inc., United States	

HVAC & Buildings					
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1.02.06	EEDAL 13	Technology Campaigns: Adapting Commercial Building Strategies to the Residential Sector	Christian Valoria, Allegra Steenson	Pacific Northwest National Laboratory, United States	
1.02.07	EEDAL 11	A baseline assessment of residential utility rates and compensation mechanisms that influence the value proposition of grid-interactive efficient buildings	Danielle Preziuso	Stevens Institute of Technology, United States	
1.02.08	EEDAL 90	Increasing cooling affordability in the ASEAN member states, a case study from Indonesia	Virginie Letschert	Lawrence Berkeley National Laboratory, United States	
1.02.09	EEDAL 77	Meeting the Challenge of Retrofitting Homes – The City of Windsor Deep Energy Efficiency Retrofit Plan	Peter Garforth, Michelle Moxley-Peltier	Garforth International, US/Canada/Belgium; City of Windsor, UK	

Thursday June 2nd, 2022

Session 2.01 – Morning

Policy 3					
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2.01.02	EEDAL 31	Efficient Coffee Machines – European energy label for residential and commercial use	Nadja Gross	Topten, Switzerland	
2.01.03	EEDAL 51	Electric kettles: A boiling product for policy makers?	Antoine Durand	Fraunhofer Institute for Systems and Innovation Research ISI, Germany	
2.01.04	EEDAL 27	Laws Matter - the Dyson vs. Commission Cases and their Consequences to EU Energy Efficiency Law	Vesa A Lappalainen	University of Vaasa, Finland	

Policy 4					
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2.01.06	EEDAL 19	Burnt Toast - Practical and Legal Justification of EU Ecodesign and Energy Labels	Mark Andor	RWI Essen, Germany	
2.01.07	EEDAL 5	Circumvention – Avoiding losses of energy savings caused by possible circumvention of EU Ecodesign and Energy labelling regulation and standards	Rainer Stamminger	Bonn University, Germany	
2.01.08	EEDAL 61	Examining the Turkish Residential Refrigeration Electricity Use by Stock Modelling and Decomposition Analysis, 2010-2020	Merih Aydinalp Koksal	Gazi University, Turkey	

Session 2.01 – Afternoon

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2.01.10	EEDAL 41	Product Registration Systems (PRS) as a tool to transform markets in ASEAN to energy-efficiency	Madeleine Edl	UNEP, France	
2.01.11	EEDAL 56	Role of Product Registration Systems in supporting compliance of energy efficiency policies	Neha Dhingra	CLASP, India	
2.01.12	EEDAL 60	When less is more: How technology can streamline and scale up the MVE process. The EEPLIANT3 'CybPort' tool for data collection and mass data migration of product cases to European Commission's ICSMS	Kyriakos Papazoglou	PROSAFE, Belgium	

	Behaviour/HVAC				
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2.01.13	EEDAL 52	Market transformation for Heating & Cooling equipment in Europe: using benchmark and advice to involve stakeholders	Sophie Attali	Guide Topten, France	
2.01.14	EEDAL 89	Behavioural change as a domestic heat pump performance driver: insights from multiple case studies in the UK	Eleni Oikonomou	University College London, United Kingdom	
2.01.15	EEDAL 87	Evaluation of the environmental benefits of energy management systems using archetypes of French households - Application to heating management systems	Alexis Wagner	Institut d'Electronique et des Technologies du numéRique (IETR), France	
2.01.16	EEDAL 96	Empowered Operators to provide direct advice on consumption habits to mitigate energy poverty with special referance to summer energy poverty (COOLTORISE project)	Marina Varvesi	AISFOR, Italy	
2.01.17	EEDAL 92	Determining potential for energy savings in space cooling by analysing air-conditioner usage behaviour	Sriraj Gokarakonda	Wuppertal Institute, Germany	

Session 2.02 – Morning

	Energy Services and Smart Buildings				
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2.02.01	EEDAL 64	Strategizing energy efficiency policies based on monitoring the market for energy efficiency services	Stela Ivanova	Federal Energy Efficiency Center (BfEE), Germany	
2.02.02	EEDAL 98	Energy Service Companies (ESCOs) in the residential sector: review of current trends and policies to foster their expansion in the EU member states	Paolo Bertoldi	European Commission - Joint Research Centre, Italy	
2.02.03	EEDAL 99	Dynamics of the smart home market: Opportunity or challenge for 2022	Jan Lorbach	GfK, Germany	
2.02.04	EEDAL 32	Data collection to support energy efficiency finance in the building sector	Eddie Streng	Joule Assets Europe, Belgium	

	Buildings				
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 2nd 10:45 -12:25**
2.02.05	EEDAL 15	Let the Sun Shine In, or Not: Automated Shades Improve Comfort and Energy Savings in Smart Homes	Katherine Cort	Pacific Northwest National Laboratory, United States	
2.02.06	EEDAL 38	Eight years measurement data of a deep renovated residential building	Matthias Haase	ZHAW, Switzerland	
2.02.07	EEDAL 20	How can residential demand in low electricity access countries be 100% met by 2030? A case study of Burkina Faso	Mounirah Bissiri	University of Coimbra; INESC Coimbra, Portugal	
2.02.08	EEDAL 7	EPC registers as a policy tool to monitor the national TBS stock and evaluate the application of the energy regulation framework	Francesca Pagliaro	ENEA DUEE SIST, Italy	

Session 2.02 – Afternoon

	Appliances				
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2.02.10	EEDAL 39	Environmental Dumping of comfort fans in Europe	Hélène Rochat	Topten, Switzerland	
2.02.11	EEDAL 74	Innovations for Sustainable Off-Grid Solar E-Waste in Sub-Saharan Africa	Monica Wambui	CLASP, Kenya	
2.02.12	EEDAL 1	Multiplexed Power Conversion improves efficiency	Adrian Lefedjiev	Power Integrations, United Kingdom	

	Monitoring & Evaluation				
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2.02.14	EEDAL 63	Evaluation of Lighting Efficiency Policy and Market Transformation in India	Kishore Kumar Pvn	CLASP, India	
2.02.15	EEDAL 71	Taking the Bias Out of Likert Scales: Four Examples Using a Better Alternative	Lisa Skumatz	SERA Skumatz Economic Research Associates, Inc, United States	
2.02.16	EEDAL 93	Design and Implementation of an Energy Metering System to Recognize the Household Electrical Energy Consumption Pattern Through an IoT Network	Johnny Arévalo-López	Escuela Colombiana de Ingeniería Julio Garavito, Colombia	
2.02.17	EEDAL 66	The usefulness of sales data to understand energy stakes for appliances	Sophie Attali	Topten, France	

Friday June 3nd, 2022

Session 3.01 – Morning

Behaviour					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 3rd 8:30-10:10**
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3.01.02	EEDAL 47	Can digital advertising raise consumer awareness of energy efficient domestic appliances? A case study of the #KenyaEnergyLabel campaign	Hannah Blair	CLASP, Kenya	
3.01.03	EEDAL 80	Why', 'how much' or both? Comparing social comparison and real-time feedback to promote resource conservation	Lukas Tomberg	RWI - Leibniz Institute for Economic Research, Germany	
3.01.04	EEDAL 73	Developments in the Study and Application of Behavioural Insights for Electricity Saving among Households	Xianli Zhu	Copenhagen Centre on Energy Efficiency, Denmark	

Policy 6					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 3rd 10:45-12:25**
3.01.05	EEDAL 86	Review and analysis of Ecodesign Directive Implementing Measures: product regulations shifting from energy efficiency towards circular economy	Robin Barkhausen	Fraunhofer Institute for Systems and Innovation Research ISI, Germany	
3.01.06	EEDAL 21	Opportunities and limits of regulating commercial kitchen appliances	Eva Geilinger, Peter Helm, Andreas Helm	Swiss Federal Office of Energy SFOE, Switzerland; MKN Maschinenfabrik Kurt Neubauer GmbH, Germany; HKI Industrial Association of House, Germany	
3.01.07	EEDAL 85	Online Energy Labeling: Regulation and Compliance in the Growing Online Market	Katriana Dubytz, Lina Kelpsaite	CLASP, United States	
3.01.08	EEDAL 9	Achievements in consumer relevant product testing	Paul Richter	Midea Europe GmbH, Germany	

Session 3.01 – Afternoon

Behaviour, Communities and Cities					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 3rd 14:00-15:15**
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3.01.10	EEDAL 81	The Effect of a Virtual Energy Community on Energy Conservation and Load Shifting	Lukas Tomberg	RWI - Leibniz-Institute for Economic Research,Germany	
3.01.11	EEDAL 83	Empowering Energy citizenship among the Energy vulnerable	Nives Della Valle	European Commission - Joint Research Centre, Italy	

Session 3.02 – Morning

ICT and MELs					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 3rd 8:30-10:10**
3.02.01	EEDAL 94	Drivers of Blockchain energy consumption and countering measures	Vlad-Constantin Coroamă	ETH Zurich, Switzerland	
3.02.02	EEDAL 14	Environmental Footprint of Data Centers and Cloud-Services	Jens Groeger	Oeko-Institut, Germany	
3.02.03	EEDAL 16	International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption	Joshua Butzbaugh	Pacific Northwest National Laboratory, United States	
3.02.04	EEDAL 18	Advancing Plug Load Efficiency with Utility Incentive Programs	Joy Pixley	California Plug Load Research Center, University of California Irvine, United States	

Demand Response					
Session slot #	**Paper number**	**Title**	**Presenter**	**Institution (Country)**	**June 3rd 10:45-12:25**
3.02.05	EEDAL 79	Methodologies and Proposals to Facilitate the Integration of Residential Consumers in Electricity Markets and Smart Grids	Antonio Gabaldon	Universidad Politécnica de Cartagena, Spain	
3.02.06	EEDAL 82	Preliminary results of a combination of change of electricity tariff and nudge-based interventions to foster energy conservation and demand response behaviour in a Spanish energy cooperative	Armando Aguayo, Cruz E. Borges	University of Deusto, Spain	
3.02.07	EEDAL 22	Signal orientated building energy management system utilizing genetic algorithms and artificial neural network for optimized battery operation and load scheduling	Stefan Dieckmann	University of Applied Sciences Biberach, Germany	
3.02.08	EEDAL 84	Verification of Demand Response: the customer baseline load in residential customers	Antonio Gabaldon	Universidad Politecnica de Cartagena, Spain	

Presenters at a glance

Session 1.01 – June 1st

Session slot: 1.01.01

U.S. Consumer Electronics in 2020: Ownership, Usage, and Energy Consumption Amid COVID-19

Presenter: Urban Bryan, Fraunhofer USA Center for Manufacturing Innovation, United States

Abstract:
To ensure policymakers are equipped with up-to-date information, the Consumer Technology Association (CTA) ® commissioned an in-depth study, the fifth in a series, characterizing the energy used by consumer electronics in U.S. homes. As in prior studies, we used a bottom-up modeling approach to develop estimates for individual device categories. The models draw upon field-monitoring studies, power databases and targeted device measurements, CTA market research, and industry input. To estimate usage and ownership, we fielded online surveys for selected categories including televisions, video game consoles, computers and monitors, smart speakers, and home security cameras. We estimate that 3.3 billion devices consumed 176 TWh, equal to about 12% of residential sector and 4.5% of total U.S. electricity consumption. This represents a 23% increase in consumption relative to 2017, apparently driven in large-part by higher usage of certain devices during the COVID-19 pandemic.
Televisions (54 TWh), computers and monitors (45 TWh), and set-top boxes (18 TWh) still represent the highest share of total consumption. Newly-studied categories include robot vacuums (0.4 TWh), smart speakers (1.7 TWh), home security cameras (3.7 TWh), uninterruptible power supplies (1.2 TWh), and virtual reality headsets (0.2 TWh).

Session slot: 1.01.02

Introducing Mepsy: The Appliance & Equipment Climate Impact Calculator

Presenter: Wekongo Angellah, CLASP, Kenya

Abstract:
Mepsy is CLASP's free digital tool to model the impacts of energy and carbon reduction policies. Setting policies and achieving their benefits requires accurate, actionable data. Mepsy's dynamic, user-friendly interface guides researchers and policymakers in identifying efficiency policy opportunities and analyzing their energy and carbon impacts. Pre-loaded with data from 162 countries, it supports analysis and prioritization for the most energy-intensive appliances and equipment— space heaters, air conditioners, refrigerators, fans, electric motors, televisions, and lighting—with more technologies being planned to be included in the tool. Efficiency standards often called MEPS, for minimum energy performance standards are a key building block in most national plans but the analytical tools used to support policy design have long been too difficult or expensive to use and customize. CLASP developed Mepsy to address these issues and make rigorous efficiency policy analysis accessible to the widest possible audience.
To simply start, users can:

- Choose a country or region, product, and expected effective date to calculate policies impacts through 2050
- Use pre-loaded data from CLASP research and other sources, or enter users' own data to customize the analysis
- Download calculation results as a CSV file for further use

Mepsy calculates product energy use according to a "bottom-up" accounting approach. The model accumulates appliances sales over lifetime to determine the number of appliances in use in a country, then incorporates the energy performance of locally-representative products, typical usage patterns, the climate-intensity of the national grid, and other variables to analyze the energy consumption, carbon dioxide emissions, and consumer energy costs associated with given policy scenarios.

Session slot: 1.01.03

Evaluation of Television Efficiency Policy and Market Transformation in India

Presenter: Samal Pravatanalini , Director, Bureau of Energy Efficiency, India

Abstract:
Television plays an essential role in the lives of millions of Indians as a source of information, entertainment and education. The television market in India has doubled over the last decade as the appliance has become commonplace across households, businesses and institutions, driven in part by increasing disposable income. The penetration of television ownership among households in the country is close to 66%, with sales of about 8.5 million units in Fiscal Year 201920.
Anticipating the rising sales of televisions and associated electricity demand, in 2009 India adopted an energy efficiency policy for televisions. The policy covers four technologies: cathode ray tube (CRT); liquid crystal display (LCD) with cold cathode fluorescent lamp (CCFL) backlit; LCD with light-emitting diode backlit (LCD-LED); and plasma. Since its adoption the television efficiency policy has been revised 3 times, raising minimum energy performance standards by 45% from initial levels and transforming the television market toward more efficient LED technologies. As of last year, India's television efficiency policy had saved 20 Terawatt-hours of electricity and reduced carbon emissions by a cumulative 16.7 million tons.
This paper analyses market growth, technology evolution and market transformation resulting from the television energy efficiency policy, assesses potential policy revisions, and calculates potential efficiency gains through 2030.

Session slot: 1.01.04

Impact mechanisms of rebate programmes for appliances: case studies in Switzerland

Presenter: Bush Eric, Topten, Switzerland

Abstract:
Rebate programmes for energy-efficient appliances are an effective measure to increase energy efficiency and reduce electricity consumption. In Switzerland, there are a large number of rebate programmes for appliances both from the central government and municipalities, and electricity utilities. Various strategies are used, different types of programme schemes are applied, and several target groups are addressed. Depending on the initial situation and objectives, promising schemes of the rebate programmes are developed. These focus on different impact mechanisms. Simple rebate programmes only target the replacement of inefficient products, which would take too much time if the products would be replaced when they break down, as it is the case for circulating pumps or electric heating systems. More sophisticated rebate programmes address the market as a whole and aim to accelerate the market transformation and increase market transparency, which is necessary for the development of measurement methods and effective policy instruments such as energy labels or minimum energy efficiency requirements. Market transparency is also the basis for good purchasing decisions and enables fair and motivating competition between manufacturers. Most of the regional rebate programs are well harmonized with identical product criteria because they base themselves on topten.ch, the national platform for sustainable products. This empowers manufacturers and more stakeholders to react in an effective way to the programmes. Communication measures and the cooperation with retailers and manufacturers are also part of the programme. Using examples from Switzerland, this article aims to provide an insight into the various types of rebate programmes. Experiences, impact mechanisms and cost efficiency are discussed on the basis of completed and current programmes.

Session slot: 1.01.05

5. Standards and Labels: Benefits of Energy Efficiency Appliance and Equipment Standards and Labelling Programs: a 2021 update

Presenter: Waide Paul, Waide Strategic Efficiency, United Kingdom

Abstract:
At least 120 countries now have energy efficiency standards and labelling programmes in place or are in the process of developing them, which makes standards and labelling one of the most commonly adopted sustainable energy policy tools. But what are these programmes achieving and how significant is the contribution they are making to energy and climate policy objectives? To help answer these questions, this paper reports on the findings of a global review of the impact of such programmes, which is derived from a comprehensive meta-analysis of over 280 specific programme impact assessments covering more than 50 countries from every inhabited continent in the world. The findings it reports address the: energy savings, reductions in greenhouse gas emissions and other pollutants, cost-benefits and a variety of co-benefits (employment creation, innovation, energy security and peak load reductions, water savings and health benefits) that have been attributed to such programmes. As such the work that the paper reports constitutes the most comprehensive international assessment of the achievements of such policies undertaken to date. Specifically, it covers:

- over 100 different types of products aggregated into X principal product groups
- electrical, gas and oil using products (excluding products involved in transportation)
- over 800 specific records on S&L product impacts

The paper summarises this research and the range of impacts reported and contextualises the findings both in terms of the scale of impacts achieved, their value proposition, past and current trends, and the relative importance of such policy measures within the broader objectives of providing decarbonised, healthy and affordable and secure energy services.

Session slot: 1.01.06

The first energy labels for professional cooling appliances – lessons learnt and comparison with energy regulation for household appliances

Presenter: Hepp Maike, Hepp Steffen, Topten, Switzerland

Abstract:
The European energy labelling and ecodesign regulations for household appliances are one of Europe's greatest success stories with regards to energy efficiency. Almost two decades after the coming into effect of the first regulation for household appliances, similar regulations for equivalent appliances in the business-to-business market segment were considered to not be feasible. Arguments from oppenents ranged from concerns about content safety and product functionality to claims of customized production that would make labelling impossible. After conducting comprehensive preparatory studies, the European Commission adopted the first energy label and ecodesign regulations for professional refrigerated storage cabinets that came into effect in 2016, followed by equivalent regulations for commercial refrigerating appliances with a direct sales function that will enter into force on 1 March 2021. Combined, they are expected to save an estimated 52 TWh of annual final energy savings in 2030. For professional refrigerated storage cabinets, the energy efficiency regulations have proven to be significantly more effective than any other previous type of intervention. Functionality and food safety have been maintained while technical innovations have boomed, bringing to the market in the last 5 years products that reach energy classes A or even A+ and giving European manufacturers an edge on the global market. Professional buyers have increased their awareness and are now able to make informed decisions and a long-term impact on pricing could not be observed. Overall, a significant market transformation has been triggered and is still taking place. Supporting the market transformation are initiatives like Topten; over the last 20 years, Topten has collected experiences with the implementation of diverse rebate schemes, technical innovation and gained a unique insight into the long-term development of best available technologies on the entire market.
This article will discuss the current and future efficiency potentials as well as the contributing effects of rebate programmes, focusing on four main aspects: (a) overview

of BAT product development with comparison of development between household and professional appliances and current saving potentials for professional and commercial refrigeration appliances (b) effectiveness of rebate programmes, esp. with regards to deadweight effects (c) analysis of especially efficient technologies for commercial and professional refrigerators (d) potential of further energy efficiency regulations for product categories in the B2B market such as medicine cabinets.

Session slot: 1.01.07

New Method for Updating Measure Lifetimes: Fast, Reliable, Affordable – and Demonstrated

Presenter: Skumatz Lisa, D'Souza Dana, Skumatz Economic Research Associates – SERA, United States

Abstract:
Measure Lifetimes, or EULs are a critical part of the benefit cost (B/C) equation, used for screening EE measures, program, and portfolios. Our research shows current EULs are:

- Poorly sourced or circular: Even "recent" values in TRMs are commonly based on other tables, and the other tables source to other lists and tables.
- Antique: Where sources can be found, they are commonly more than 20 or 30 years old and don't actually apply to current technological design or obsolescence / failure patterns.
- Not statistically valid – Most existing values are borrowed from previous tables, which were often based on consensus agreements, not statistics or studies.
- Statistical studies are limited: The statistical EUL studies that do exist are for limited measures, and there are numerous measure gaps.
- Widely varying: It is not uncommon for adopted numbers in different tables and states to vary by a factor of two to four for the same measure with no relationship to logical differences (climate, etc.)

Two main problems exist with the current approach to EULs: having to wait for years after installations to conduct the studies, and the cost of the large-scale surveys needed to find "failures" to support the estimations. This paper demonstrates successful use of entire cohorts of program-installed measures to estimate EULs, and showed strong results from half a dozen studies conducted by the authors across the US.
These studies developed very credible, statistically-based EUL estimates, and we compared the results and developed best practices guidelines for applying the work in other locations and measures. Advantages of the approach include:

- Inexpensive,
- Applies to a variety of residential and commercial measures, and
- Can be conducted right now and provide replacement EULs for PSDs / TRMs without waiting multiple years for failures – they've already occurred.

We provide best practices for using this method to update EULs in residential and commercial applications.

Session slot: 1.01.08

A review of the current legislative landscape and refrigeration market for introducing an energy efficiency standards and labelling program for refrigeration appliances in Uganda

Presenter: Agarwal Shreya, Lawrence Berkeley National Lab, United States

Abstract:
Uganda has poor grid connectivity and high utility prices, forcing its grid users to reduce appliance usage to save energy cost. In such a scenario, energy efficiency programs can be greatly beneficial for the end users to lower energy bills while increasing electricity service in appliances. The authors are providing technical assistance to the Ministry of Energy and Mineral Development (MEMD), Uganda on the design of energy efficiency standards and labelling programs for residential refrigeration products in Uganda. Refrigeration appears as the largest source of residential energy consumption in Uganda (~200 GWh/year), which represents about 28% of the electricity consumption in the residential sector. Existing opportunities for energy efficiency in refrigerators can reduce per-unit energy use by as much as 60% in developing countries with unregulated markets dominated by inefficient technology refrigerators. Improved energy efficiency of refrigeration also contributes to achieve

the UN sustainable development goals such as Climate Action and Access to Affordable and Clean Energy that have been adopted by Uganda. The authors discuss the steps for creating a database of models sold (93 models) in Uganda and estimating the baseline energy consumption. They also present a literature review of the existing legal framework, administrative and enforcement capacities in Uganda and its neighboring countries such as Rwanda and Kenya. Lessons learned from the neighboring countries will be used to address challenges in Uganda's existing legislative and administrative capabilities to publish and enforce standards. The paper concludes by highlighting the role of these aspects for designing energy efficiency standards for residential refrigeration products in Uganda.

Session slot: 1.01.09

Advances in NEBs / NEIs: New Results, Measure Attribution, Health Effects, and the Downward-Bias in Current US NEB Adders

Presenter: Skumatz Lisa, Gibbs Vandervliet Ann, Skumatz Economic Research Associates – SERA, United States; SERA, United States

Abstract:
TOPIC AREA: 14-Non-Energy Benefits

Non-Energy Benefits / Impacts (NEBs/NEIs) are the array of effects – beyond energy/bill savings -- that participating households and businesses receive from energy efficiency (EE) measures and programs. Twenty years of research monetizing values for participant, societal, and utility NEBs effects provides useful information for marketing/ uptake, tracking progress toward policy/program goals (including low income), and improved utility benefit-cost tests for measure, program, and portfolio screening. Attention to all types of NEBs is increasing annually and this study reviews key advances made in the last few years in NEB measurement and use.
This study examines advances made in better applying best practices in NEB measurement, including appropriate considerations of net NEBs, and especially the consideration of the appropriate baseline for NEB estimation and the impact that ignoring this best practice has had on overstating NEBs. The study also shows how existing program-wide NEB studies can be adapted to provide important (and more flexible) measure-based NEB values. Health impacts have been a particular focus in the US and internationally – especially in the low-income side – but health impacts have very significant benefits to businesses, and to society at large. The study demonstrates which health effects matter, and how much they are worth, and best practices in NEB estimation work.
Finally, we examine the NEB percentage adder values in used in nearly two dozen states across the US (e.g., 15% residential adder; 25% low-income adder). We use statistical analysis of a comprehensive (NEB-It) database assembled by the authors – which includes more than 38,000 lines of NEB data from more than 700 NEB studies and 160 NEBs -- to estimate deviations between adopted values for NEB adders compared to the most defensible NEB values relevant to each cost test (SCT, TRC, UCT, etc.) used by the different states. NEB gaps / next issues are also highlighted.

Session 1.02 – June 1st

Session slot: 1.02.01

Beyond the combi boiler: exploring the role of compact hybrids in domestic heating

Presenter: Bennett George, Department for Business Energy and Industrial Strategy (BEIS), United Kingdom

Abstract:
Transitioning from a predominantly natural gas domestic heating paradigm to a low carbon heating future on the road to net zero is one of the major challenges of the UK's decarbonisation pathway. Compact wall hung combination boilers are the dominant heating appliance and continue to be installed as a rate of over 1.5million per year, compared to less than 50k Heat Pumps. The disparity persists despite repeated Government financial support in the form of the Renewable Heat Incentive and the Green Homes Grant. Compact heat pump/boiler hybrid appliances offer a technology solution similar to the current combi boiler in terms of size and performance, which could be attractive to consumers and delivering carbon savings. This research systematically analyses novel real world high frequency boiler data to evaluate the potential of such appliances to make carbon saving contributions while emulating the combi boiler operation and heat delivery profile. By utilising high frequency diagnostic data from combination boilers, the disaggregated (hot water and heating) demand is mapped onto hybrid models to determine the energy and emission impact. Exploration of the relative kW output of the hybrid HP and boiler components of the modelled appliances provides insight into appropriate specification of compact hybrids which can deliver similar heat service to boilers while maximising emissions savings.

Session slot: 1.02.02

Final impact assessment of the novel highly efficient and fuel flexible medium-scale HiEff-BioPower CHP technology using a solid oxide fuel cell (SOFC)

Presenter: Götz Thomas, Wuppertal Institute for Climate, Environment and Energy, Germany

Abstract:
The EU Horizon 2020 project HiEff-BioPower (grant agreement No 727330, duration: 10/2016 – 09/2021) aimed at the development of a new, innovative, fuel flexible and highly efficient biomass CHP technology for a capacity range of 1 to 10 MW total energy output, suitable e.g. for on-site generation at larger residential apartment buildings or local heat grids. The new technology shall define a new milestone in terms of CHP efficiency and contribute to a sustainable energy supply based on renewable energies. It consists of a fuel-flexible updraft gasification technology with ultra-low particulate matter emissions, an integrated gas cleaning system and a solid oxide fuel cell (SOFC). The technology shall be applicable for a wide fuel spectrum for residual biomass (wood pellets, wood chips or selected agricultural fuels like agro-pellets) and achieve high gross electric (40%) and overall (90%) efficiencies as well as equal-zero gaseous and particulate matter (PM) emissions as non-energy benefits. At the end of the project, final technology data has become available, as well as techno-economic analyses and market studies. Based on this data, this paper presents final results from the environmental impact assessment of the new HiEff-BioPower technology.

Session slot: 1.02.03

Heating with Air Conditioners – fast and affordable transition towards carbon neutrality?

Presenter: Roscetti Andrea, Politecnido di Milano, Energy Department, end-use efficiency research group, Italy

Abstract:
There are still many inefficient direct electric heaters in use in Switzerland, as well as other heating systems emitting high amounts of CO_2 all over Europe. In some countries incentive schemes exist for the replacement of heat generators, in some cases supporting also gas or other non-renewable energy-based systems. The installation of a proper hydronic distribution system is often very expensive and not always sustainable. To reach the optimal results in terms of energy, cost and emissions savings, an attentive choice of the right system is always necessary. This paper will present the solutions in terms of highly efficient systems/products and a number of case studies in new and refurbished buildings that adopt efficient, effective and comfortable air-to-air heat pumps installation for heating. The features in terms of energy efficiency and environmental impact of best products, their consumption levels, installation features and their costs will be presented in more detail for the selected case studies.

Session slot: 1.02.04

Smart Economizer

Presenter: Mowris Robert, Verified Inc., United States

Abstract:
Research studies indicate that 50 to 70% of air-side economizers on commercial Heating, Ventilating, and Air Conditioning (HVAC) systems are not functioning properly causing energy use to increase by 18 to 37%. Many economizers have failed sensors, failed controls or incorrect settings providing insufficient or excess outdoor airflow which reduces capacity and increases energy use. To address these issues, the California Energy Commission (CEC) 2016 building energy efficiency standards require economizer demand control ventilation, high-limit shut-off temperature (HST) controls, and fault detection diagnostics to check economizer operation and excess outdoor airflow on commercial HVAC systems with mechanical cooling capacities greater than 54,000 British thermal units per hour. The CEC standards and supporting research studies are based on EnergyPlus or DOE-2.2 building simulation models which assume perfect integration of economizer and mechanical cooling, perfect outdoor airflow, no thermostat or economizer delays or dead bands, and no unoccupied fan operation. This paper provides field and laboratory tests of a smart economizer™ that brings actual performance closer to the idealized performance predicted by simulation models. The smart economizer improves cooling and heating efficiency, reduces excess outdoor airflow, corrects thermostat and economizer time and temperature delays and dead bands, provides variable fan-off delays, and overrides fan-on settings during unoccupied periods. Based on laboratory and field tests, DOE-2 simulations and post processor analyses, average annual savings are 21.7% for cooling plus fan and 42.8% for heating. The simple payback is 2.1 years based on an installed cost of $1500/unit, and annual energy savings of $712. The smart economizer may be used on commercial or residential HVAC systems to improve energy efficiency.

Session slot: 1.02.05

Energy Efficiency Measures to Improve Indoor Air Quality and Energy Efficiency in Buildings and Reduce the Spread of the SARS-CoV-2 Virus

Presenter: Mowris Robert, Verified Inc., United States

Abstract:
The SARS-CoV-2 virus has had a significant world-wide impact on human health. As of February 2021, the virus has caused 111,848,540 infections and 2,475,730 deaths (WHO 2021). This paper will summarize research findings regarding COVID-19 infection from aerosols, droplets, and fomites based on an open-access database of infectious disease transmission and super-spreader epidemiology (NIH 2021

https://datascience.nih.gov/covid-19-open-access-resources). The paper will discuss current recommendations from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) regarding technologies and building management methods to improve indoor air quality and reduce the spread of the virus. The paper will also provide an overview of current technologies to indoor air quality and reduce the spread of the virus, and an analysis of the energy efficiency impacts associated with these technologies. Evaluated technologies include: increasing outdoor airflow, social distancing, masks, high efficiency particulate air (HEPA) air filters, minimum efficiency reporting value (MERV) air filters, ultraviolet c-radiation (UVC) lamps, and bipolar ionizers.

Session slot: 1.02.06

Technology Campaigns: Adapting Commercial Building Strategies to the Residential Sector

Presenter: Valoria Christian, Steenson Allegra, Pacific Northwest National Laboratory, United States

Abstract:
The United States Department of Energy has successfully designed and delivered technology campaigns to the commercial building sector for decades. Technology campaigns are collaborative initiatives designed to help speed the adoption of new or underutilized, energy-saving technologies by providing resources helpful to decision-makers, technical assistance, and recognition of exemplary projects. In 2019, estimated energy savings from participants of three technology campaigns (focused on interior lighting, HVAC rooftop units, and energy management systems) totaled over $250-million dollars. For example, from 2015 through 2019, the Interior Lighting Campaign focused on speeding the adoption of high-efficacy lighting options in commercial spaces, resulting in 800 million kilowatt-hours energy savings from 92 campaign Participants, 10 case studies published, and 3.5 million high-efficacy luminaires documented. This paper reviews lessons learned and best practices from past and current technology campaigns focused on commercial buildings, and describes how they are being applied to the design of two residential-focused technology campaigns to be released in 2021 – The Secondary Glazing Campaign, focused on increasing adoption of low-e interior and exterior storm windows, and the HVAC Smart Diagnostic Tools Campaign, focused on improving the operation of HVAC equipment at installation and maintaining performance over time. It also will discuss opportunities and challenges to program design related to technology campaigns that seek to target sectors that possess both commercial and residential elements, such as multi-family and small commercial buildings. The paper will also discuss technology campaign strategies to address emerging goals such as international coordination, social justice and disadvantaged communities, workforce development, and carbon reduction (in addition to energy efficiency).

Session slot: 1.02.07

A baseline assessment of residential utility rates and compensation mechanisms that influence the value proposition of grid-interactive efficient buildings

Presenter: Preziuso Danielle, Stevens Institute of Technology, United States

Abstract:
Grid-interactive efficient buildings (GEBs) integrate intelligent technologies, energy efficiency, and distributed energy resources that generate value to a range of stakeholders including the GEB owner, the electric grid, the environment, and society. The right combination of utility policies must be implemented to incentivize the operation and adoption of GEB-enabling technologies to fully realize this value. Utility policies vary widely across the United States due to differences in utility ownership types, regulations, and the local mix of energy generation sources. Consequently, the value proposition of GEBs also varies across the country. Limited research to date has tried to understand how this value is affected by utility policies. To address the research gap, this work surveys the current landscape of residential utility rates and distributed generation compensation mechanisms in the United States, highlighting likely interactions between utility policies and GEBs and identifying potential regions for early adoption.

Session slot: 1.02.08

Increasing cooling affordability in the ASEAN member states, a case study from Indonesia

Presenter: Letschert Virginie, Lawrence Berkeley National Laboratory, United States

Abstract:
ASEAN member states (AMS) are considering revising their regional efficiency targets for Minimum Energy Performance Standards (MEPS) for air conditioners (ACs) for the first time since 2015. The authors have recently provided recommendations for a roadmap for harmonization of AC efficiency standards in the AMS. In the past, the authors have also demonstrated the extremely favorable impacts of cooling efficiency in Indonesia to reduce greatly peak load, CO2 emissions, while also benefiting local consumers and AC manufacturers.
Because energy-efficient technologies (e.g., inverter-driven units achieving between 30-50% savings) are becoming widely available in the region, there is a great opportunity for the AMS to improve their efficiency targets consistent with international best practices. In addition, China's recent transition to inverter technology in the room AC market, which was achieved by revising the energy efficiency standards to be more stringent, is expected to drive down the costs worldwide through economies of scale (which is already being observed in China). At the same time, Indonesia has started producing inverter ACs locally, instead of importing them from neighboring countries. Indonesia is also transitioning rapidly to low global warming potential (GWP) refrigerants, which brings the opportunity for coordinated efficiency design upgrades, using energy-efficient technologies.
The upfront cost of efficient units is often mentioned as a barrier for setting higher efficiency standards in Indonesia. Our study will explore ways to access electricity bill savings provided by efficient technologies for Indonesian consumers, building on the authors' research and current collaboration with the AMS to highlight how affordable efficient cooling is achievable from the consumer perspective.

Session slot: 1.02.09

Meeting the Challenge of Retrofitting Homes – The City of Windsor Deep Energy Efficiency Retrofit Plan

Presenter: Garforth Peter, Garforth International, US/Canada/Belgium; Moxley-Peltier Michelle, City of Windsor, UK

Abstract:
Hundreds of cities in North America have the goal to create nearly zero greenhouse gas (GHG) emissions from their energy use and supply by 2050 or sooner. A common feature in all these plans is the dramatic increase in the average energy efficiency of their existing stock of homes. Homes are a large portion of the energy and emissions footprint of most cities, such that failure to achieve this efficiency gain jeopardizes the city's ability to meet its wider GHG reduction goal. Despite the almost universal recognition in the USA and Canada of the need to retrofit most homes in 20 to 30 years, there is no evidence of any existing home efficiency programme that is delivering retrofits at the necessary scale and speed to meet the challenging climate and economic development goals. There is plenty of evidence of many excellent examples of retrofit pilot programmes that clearly show the very high efficiency potential using proven and readily available measures.
This paper discusses the approach adopted by the City of Windsor, in southern Ontario, Canada to create a residential Deep Energy Efficiency Retrofit (DEER) programme that has the potential to deliver thousands of home retrofits every year to support its overall GHG reduction commitments to mitigate the climate crisis. DEER will also be challenged to make a positive economic development contribution throughout its implementation.
Windsor has a population of about 220,000 with about 56,000 existing homes. In 2018 these represented about 25% of the source energy use and 22% of the GHG emissions of City, with a total utility cost of more than $185 Million to consumers.
The DEER programme was developed with over-riding framing goals that addressed multiple economic, environmental, and social factors:

- Existing homes will meet or exceed energy and climate performance levels necessary to support Windsor's Community Energy Plan targets.
- By 2042 the pool of existing homes in Windsor will be at least: 35% more source energy efficient; 60% less carbon intensive; and 20% more water efficient.

- Homeowners' utility saving will be more than retrofit cost.
- Investors will receive attractive returns.
- Contractors will gain volume and margins.
- City Corporation will not be exposed to unacceptable financial risks.

The resulting DEER Business Case met or exceeded all these goals. The business case analysis clearly identified the priorities for DEER by both property age and type. Single family homes accounted for over 90% of residential energy use and GHG emissions, and over 80% of utility cost. Homes that were at least 20 years old made up 85% of the energy use and GHG emissions in this sector. The conclusions were clear. To be a scale success, the DEER programme must immediately focus on delivering attractive retrofits to older single-family homes as the highest priority, with later phases to retrofit more recent single-family homes, and low- to mid-rise apartment buildings. The fact that the vast majority of single-family homes are owner-occupied further underlined the prioritization from the standpoint of transactional simplicity.
The DEER Business Case addressed the potential market obstacles identified through a series of systematic risk assessments, including the creation of a new retrofit entity which will facilitate scale sourcing of material, contractor partnerships, and private sector investment. In Windsor's case, it also allows the programme to take advantage of local legislation that allows the efficiency gain to be viewed as a community benefit, which will facilitate homeowner repayment as part of the local property tax. For the homeowner this will have the benefit of guaranteed, low-interest long-term financing of the retrofit. The combination of a more convenient, lower cost retrofit with convenient low-interest repayment means the Windsor homeowner should immediately find their utility savings covers the cost of the retrofit, and results in a more comfortable, higher value home. The combination of standardized packages and retrofit volume will allow contractors to operate far more productively, both improving the homeowner experience and enhancing their margins. These higher margins on increased revenues and will allow them to hire and train many new employees

Session slot: 2.01.01

Energy efficient and climate friendly cooling in Southern and Eastern Africa

Presenter: Edl Madeleine, UNEP, France

Abstract:
Growing populations, urbanization and rising living standards in the regions of the East African Community (EAC) and Southern African Development Community (SADC) are driving an increased demand for cooling services. If policies are not implemented in response to this demand, the electricity consumption for room air conditioners and residential refrigerators is expected to increase by 2.5 times by 2040 compared to current consumption.
The United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative, East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE) and SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) are working together to adopt sustainable cooling solutions without causing undue harm to the environment. The aim of the project is to collaborate in order to multiply the effect on the ground through a broader regional collaboration.
The project is developing a policy framework for energy efficient and climate friendly refrigerators and air conditioners with the ultimate goal to implement Minimum Energy Performance Standards (MEPS) and labelling for both products. The MEPS are being developed in consultation with the countries and regional bodies to leverage the policy effects. Up to date, a regional market assessment was conducted, technical notes and the MEPS and labels itself were developed. Currently, the policies are being discussed with the countries to tailor them for adoption.

Session slot: 2.01.02

Efficient Coffee Machines – European energy label for residential and commercial use

Presenter: Gross Nadja, Topten, Switzerland

Abstract:
As of 2015, Switzerland has a mandatory energy label for residential coffee machines. It is based on the measurement standard EN 60661:2014 and also takes into account Regulation (EC) No 1275/2008 on standby. While the adoption of auto-power-off and low standby was mainly driven by the EC standby regulation, it can be said that the Swiss label led to the adoption of more efficient technologies such as better insulation of boilers and the very effective flow through-type heaters. The annual consumption of coffee machines dropped from an average of 180 kWh (2006) to below 50 kWh for efficient models (2018). This success story could be transposed to the European Union, regulating a much bigger market and saving much more energy in the process. The stock of residential coffee machines in the EU is estimated 100 Mio units, consuming 17'000 Mio kWh per year. Estimates of annual sales are roughly 30 Mio units by 2025.
A recent Swiss study (to be published in spring 2021) looks into energy efficiency of commercial coffee machines and ways to boost innovation. While some differences exist (e.g., energy consumption for cooling of fresh milk), there are also many similarities to residential machines. The higher complexity of commercial coffee machines poses a challenge for developing a comprehensive testing standard (measuring the production of several different kinds of beverages with high accuracy). Other approaches focus only on energy losses as one of the key drivers of efficiency. Pragmatic and broadly applicable solutions that focus on key drivers, e.g. energy losses and how to prevent them, are necessary. The stock of commercial coffee machines in the EU is estimated at 5.9 Mio units, consuming 13'600 Mio kWh per year. Estimates of annual sales are roughly 700'000 by 2025.
This paper discusses the success of the Swiss energy label for residential coffee machines and its possible application to the European market as well as for commercial coffee machines. The trade-off between a pragmatic measurement method and the complexity of coffee machines is discussed.

Session slot: 2.01.03

Ecodesign for electric kettles: A hot product for policy makers?

Presenter: Durand Antoine, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Abstract:
Electric water kettles can be found in almost every household in the European Union. The Preparatory study to establish the Ecodesign Working Plan 2015-2017, estimated an electricity consumption of 20 to 33 TWh for this product group in Europe in 2012 with an energy saving potential of more than 20%. This gave impetus to an Ecodesign Preparatory Study on kettles in 2020 to further analyse the potential role of environmental policy-making for electric kettles in Europe. Based on this study, the paper will review current policies worldwide covering this product group and methods used to assess its energy efficiency. It will also include an analysis of technical improvement potentials to enhance energy efficiency including an analysis of power-temperature measurements of selected kettles under different usage scenarios.
Findings indicate that the potentials to improve the energy efficiency of kettles from technical optimizations are limited. For customers, it is also difficult to choose a well-performing product as only little technical information is available and there is no standard to measure the energy consumption of electric kettles. Yet there seems to lie a large room for savings in the way kettles are operated. Boiling excessive amount of water or heating to higher temperatures than required contribute to considerable losses of energy in private households.
This could open up a leverage for policy makers to improve the market and to reduce the environmental impact of this product group beyond mere technical optimizations of energy efficiency, including aspects related to circular economy and energy sufficiency. Finally, such a paper could be useful for many policy makers outside the EU, since data on kettles are scarce.

Session slot: 2.01.04

Laws Matter - the Dyson vs. Commission Cases and their Consequences to EU Energy Efficiency Law

Presenter: Lappalainen Vesa A, University of Vaasa, Finland

Abstract:
This paper discusses three Dyson vs. Commission court cases pursued in the General Court and the European Court of Justice in 2013–2018. The final judgment of the General Court, adopted on 8 November 2018, upheld the original arguments of the appellant, Dyson Ltd., of Malmesbury, UK, concerning the correct measurement of energy efficiency of vacuum cleaners. The judgment annulled the Commission Delegated Regulation (EU) No. 665/2013 on energy labelling of vacuum cleaners. This is the first and only case where the European combined regime of ecodesign and mandatory energy labelling has been challenged by a manufacturer – and challenged with success.
The Dyson cases seem to have attracted little scientific interest, although the final judgment crushed the latest building block of the regulatory edifice constructed over forty years around Ecodesign Directive 2009/125/EC, Energy Labelling Directive 2010/30/EU, and the predecessors and successors of said Directives. Regulation 665/2013, effective since September 2014, was annulled in toto. In January 2019, retail stores around Europe were obliged to remove energy labels from an untold number of vacuum cleaners and their packaging, although the goods had already been released into the Common Market. Suddenly, energy efficiency regulation was seen as a folly, indeed a breach of the rule of law.
This paper sets out to discuss and analyse the following aspects of the Dyson vs. Commission cases:
1. The main arguments of the appellant: the necessary and sufficient conditions for winning the case. It should be noted that Dyson Ltd. was not the original inventor of the bagless vacuum cleaner, despite Dyson's advertising. A U.S. patent for a "Bagless Vacuum Cleaner" (No. 1,937,765) was filed in 1930, granted in 1933, for a W. Leathers, who worked for or with an enterprise called Quadrex Corporation. For reasons unknown, Quadrex did not become the Hoover of its time.
2. Judgment of the General Court (GC) in 2015. Dyson appealed to the European Court of Justice (ECJ).

3. Judgment of ECJ in 2017. The ECJ referred the case back to the GC.
4. Final judgment of GC in 2018.
5. Conclusions regarding
   a. EU ecodesign and energy labelling regimes. Special report No. 01/2020 of the European Court of Auditors ("EU action on Ecodesign and Energy Labelling: important contribution to greater energy efficiency reduced by significant delays and non-compliance") will be addressed in detail.
   b. relevant development of EU law in general.
6. Recommendations ("de lege lata").

Session slot: 2.01.05

Exploring the integration of energy sufficiency in climate and energy strategies of "catching-up" economies: examples from the building sector in Hungary and Lithuania

Presenter: Konstantinaviciute Inga, Lithuanian Energy Institute, Lithuania

Abstract:
While the role of energy sufficiency as an essential driver towards reaching climate goals has been discussed in the European context for a few years, it still faces obstacles to make its way towards policy agendas. On one hand, existing policies tend to focus on energy efficiency and the development of renewable energies, which are more clearly identified, thoroughly assessed and integrated in available scenarios. On the other hand, energy sufficiency is commonly perceived as a limitation to individual needs and thought of in terms of willingness for behavioral change, although the concept has also to be considered at the policy level, resulting in infrastructural changes.
This paper addresses this gap in understanding energy sufficiency and its role in strengthening the climate mitigation actions, with a focus on the context of “catching-up” economies in the Central and eastern European region. It summarizes results from the CACTUS project, which analyses the status quo in Hungary and Lithuania, as the target countries, in the sectors with the highest energy consumption shares, namely buildings and transport.
First, the study examines the potentials of energy sufficiency regarding energy and climate policy goals in these sectors and discusses the building of energy sufficiency assumptions in the perspective of a European convergence. Then, considering the crucial role that scenario development plays in framing climate policies, the study follows a capacity building approach for key scenario builders in the target countries by analyzing the methods and challenges for integrating energy sufficiency assumptions in scenario modelling in the key emitting sectors. The results of the study are expected to pave the way for more ambitious mitigation strategies by providing exploratory quantitative and qualitative analysis on sufficiency’s mitigation potentials and to support the development of sufficiency policies by raising the awareness of policy-decision makers on the sufficiency concept and its mitigation role.

Session slot: 2.01.06

Burnt Toast - Practical and Legal Justification of EU Ecodesign and Energy Labels

Presenter: Andor Mark, RWI Essen, Germany

Abstract:
This paper analyses the legal justification and correct targeting of EU ecodesign and energy labelling regimes – why certain appliances are regulated while others are not. This is a serious rule-of-law question.
David Coburn, a MEP for UKIP in 2014–2019, attracted media attention in 2016 by criticising EU interference in his breakfast menu. He claimed that EU regulations forced the manufacturers of electric toasters to reduce their capacity to such a low level that Scottish appetites would be ruined by bland, underdone slices of toast.
Mr. Coburn's statements were undoubtedly aimed at the Brexit news market and were useful for his cause. He was incorrect in many respects. In 2016, the EU did not, and still does not, regulate the design of toasters on the basis of Ecodesign Directive 2009/125/EC (EDD) – or require energy efficiency labels on them.
Since 2017, energy labelling is addressed by Regulation (EU) 2017/1369 (ELR), the fourth such basic statute in forty years. EU regulation is gaining momentum and expanding: while the number of labelled appliances was eight in 1979, it will be 16 at

the end of 2021. Counting pages is the classic "student's first approach" to legislation: EU energy labelling law has grown from six OJ pages in 1979 to 539 pages in 2021.
In 2014, toasters were, indeed, considered for both ecodesign and energy labelling in a preparatory study for the EU Ecodesign Working Plan 2015–2017. Its conclusions were negative, essentially for de minimis reasons. Market failure was not implied.
Counting toasters out, current EDD covers 32 products (602 OJ pages). All products subject to ELR are subject to EDD, but not vice versa. Energy labelling is mandatory for most large household appliances, such as refrigerators and washing machines.
Mr. Coburn's concerns about the EU involving itself in matters outside its remit have some merit. Both EDD and ELR now refer to energy-related products, while energy-using products were sufficient before. Ecodesign and labels could be made mandatory for any products, while allowing ubiquitous appliances like toasters to escape them.
Tasking EU legislation to venture far beyond the territory of commercial, market and traditional regulatory law is risky. The spectre of Soviet-style planned economy still looms large in much of the EU. As for toasters, there was only one model and one manufacturer in the Soviet Union, Fabrika im. V.I. Lenina in Moldovan SSR. The fixed price was 15 roubles in 1970.

Session slot: 2.01.07

Circumvention – Avoiding losses of energy savings caused by possible circumvention of EU Ecodesign and Energy labelling regulation and standards

Presenter: Stamminger Rainer, Bonn University, Germany

Abstract:
The European Commission (2019) estimates that 10-25% of products on the market do not fully comply with energy efficiency labelling regulations and that around 10% of potential energy savings are lost due to non-compliance. According to the Special Report ‘EU action on Ecodesign and Energy Labelling: important contribution to greater energy efficiency reduced by significant delays and non-compliance’ of the European Court of Auditors (2020) this would roughly correspond to the final electricity consumption of Sweden and Hungary combined. Whereas reasons for and remedy against non-compliance under EU Ecodesign and Energy labelling have already been well analysed, the topic of suspected manipulation of test results or ‘circumvention’ received a lot of policy and media attention, not only for car emissions, but also regarding potential negative effects in other EU legislation.
For this reason, the European Union’s Horizon 2020 research and innovation programme funded the project ‘ANTICSS –Anti-Circumvention of Standards for better market Surveillance’. Overall objective of the project is to assess and clearly define ‘circumvention’ in relation to EU Ecodesign and Energy labelling legislation and relevant harmonised standards, assess the potential impacts of circumvention and to prevent future circumvention acts under EU Ecodesign and Energy labelling.
One of the project´s key findings was that ‘circumvention’ goes far beyond ‘non-compliance’. Ecodesign and Energy labelling legislation states that ‘non-compliance’ can be determined only by Market Surveillance Authorities through product inspection, i.e. laboratory testing, and/or checking of the data and information provided in the technical documentation and/or any other information provided by the manufacturer or supplier against the requirements and conditions as defined in the legislation and standards.
In contrast, ‘circumvention’ does not make a product appear as non-compliant during testing. In the first instance products appear to comply with all the requirements and conditions, but the test results are specifically influenced, resulting more favourable for the product, by the use of ‘circumvention’ behaviour or by the exploitation of (possible) weaknesses or loopholes in standards and legislation by the manufacturer.
The paper provides a clear definition and examples of ‘circumvention’ in the context of EU Ecodesign and Energy labelling legislation. It shows a rough estimation of the magnitude of possible energy saving losses due to ‘circumvention’ and presents alternative test procedures to unmask ‘circumvention’ under testing conditions. Finally, initial recommendations for policy makers and standardisation bodies to prevent future ’circumvention’ under EU Ecodesign and Energy labelling are given.

Session slot: 2.01.08

Examining the Turkish Residential Refrigeration Electricity Use by Stock Modelling and Decomposition Analysis, 2010-2020

Presenter: Duzgun Bilal, Aydinalp Koksal Merih, Gazi University, Turkey

Abstract:
The available data on the major appliances stock and electricity consumption is very limited for Turkey. The existing studies are mostly based on survey studies applied to limited numbers of households, which can not be accepted as the dependable representation for the Turkish residential sector. The refrigerators have the highest electricity consumption and ownership in most households. Thus, determining the stock and the electricity consumption of the refrigerators plays a vital role in residential end-use energy studies. In the first step of the study, the annual refrigerator stock and ownership between 2000 and 2019 are determined using the annual sales data, appliance service life, and the number of households. The service lives of refrigerators are estimated using a modified Weibull distribution function. The refrigerators' annual ownership is then determined by dividing the stock by the number of households. The historical refrigerator stock is then used to determine the residential sector's annual refrigeration electricity consumption using the energy label data of the refrigerators sold each year. The average refrigerator annual electricity consumption is estimated to decrease from 680 kWh/year in 2005 to 401 kWh/year in 2019, where the ownership is estimated to increase to 96% in 2019 from 87% in 2005. In the second step of the study, the theoretical electricity savings due to efficiency improvement in the refrigerators are estimated between 2005 and 2019 based on the scenario developed using the historical sales. The results revealed that the electricity consumption of the total refrigerator stock would be %44 higher if energy efficiency had frozen at its 2005 level.

Session slot: 2.01.09

Guidelines for Anti-circumvention in standards supporting EU Ecodesign and Energy labelling Regulations

Presenter: Stamminger Rainer, University of Bonn, Germany

Abstract:
The topic of manipulated measurement results also referred to as ‘circumvention’, has recently received considerable public and media attention, not only for car emissions (e.g. diesel-gate), but also concerning other EU legislation. ‘Circumvention’ is mostly seen as hiding, cheating, deceptive and usually illegal practices. It can result in increased energy consumption or release of pollutants, all in all, in economic, societal and environmental damage. This issue is highly relevant as the detection and/or avoidance of circumvention contributes to achieving targeted reductions of electricity and resource consumption for energy-related product groups covered by Ecodesign and Energy labelling legislation.
Experience has shown that some measurement standards could be affected by ‘circumvention’ as they can be used to allow deviations or interpretations of the test methods described. Although measurement standards are just one part of broader aspects of ‘circumvention’, they play a fundamental role in enabling the implementation of the Ecodesign and Energy labelling policy in Europe.
Circumvention during product testing according to European harmonised standards can take place in a variety of forms. The examples gathered on this issue should serve for internal reflection and consequent action within Technical Committees for such situations to be corrected. While those examples are not yet proven to be ‘circumvention’ according to the Ecodesign and Energy labelling regulations, they are certainly suspicious cases that need to be carefully addressed by standardisers in order to avoid loopholes and weaknesses in the methods they develop.
Alteration of the product performance and/or resource consumption during test is generally accepted as circumvention. This may be done by detection of the test conditions; this specific situation is already disallowed by the Ecodesign and Energy Labelling frameworks. Yet, in some cases it may be necessary to bring a product into a specific situation to allow for a repeatable and reproducible measurement of some provisions. However, the alteration of the product’s behaviour may be misused to bring the product into a state which is either no longer representative of the real usage by

the end-user, or not the worst-case real use conditions. Additionally, the alteration of the performance within a short period after putting the product into service may also be seen as a circumventing condition.
With the objective of providing clarity on all those suspicious cases, the Guide will provide recommendations for product experts writing standards on how to detect and avoid Ecodesign and Energy Labelling test methods being misused for circumvention.

Session slot: 2.01.10

Product Registration Systems (PRS) as a tool to transform markets in ASEAN to energy-efficiency

Presenter: Edl Madeleine, UNEP, France

Abstract:
The implementation of energy efficiency policies to drive the market toward higher efficiency products is a multifaceted effort that requires a wide variety of stakeholders to work in unison.
Proper information management among those stakeholders is key to ensure the correct implementation and regular update of the policies developed. In particular, market surveillance and enforcement mechanisms, market transformation programmes, and financing mechanisms benefit enormously from a trusted and centrally managed Product Registration System (PRS). In this context, a PRS is used to capture specific information on products to underpin policies or programs and to provide an initial compliance gateway for products to enter into the market. It serves thus as a product data repository, market monitoring platform, and communication interface with the various stakeholders.
United for Efficiency (U4E), together with the ASEAN countries, has developed a product registration database which harmonizes product registration activities in the region to transform the regional market to energy-efficient lighting, refrigeration and air conditioners. The leveraging effect of regional coordination enables governments to reduce costs for product registry activities significantly and enhance the enforcement of the regulations in place while avoiding dumping grounds. In addition, countries of the region that do not have a national PRS in place can use the prototype national PRS developed by U4E.
The product registration framework, which can be also implemented by other countries and regions, is a fully functional system based on best practices. It includes a modular design that enables the users to individualize the systems and is also designed to work with slow connections and data requests.

Session slot: 2.01.11

Role of Product Registration Systems in supporting compliance of energy efficiency policies

Presenter: Dhingra Neha, CLASP, India

Abstract:
Robust policy compliance and enforcement are key to realizing and safeguarding the benefits and the impact of appliance energy efficiency policies and market transformation initiatives. A product registration system is an integral tool to support policy compliance both at the national and regional level. It serves as an initial compliance gateway where manufacturers and suppliers register eligible products market entry, thereby accelerating implementation of the national and regional product efficiency policies. The product registration system also enables compliance authorities to share market intelligence on non-compliant and suspicious products, so they can strategically target their market surveillance activities and allocate resources for more effective compliance initiatives. The data captured within the tool can also be used to guide consumer and procurement purchasing decisions, and to track product trends and efficiency levels, which can inform new and future policy revisions.
A well-maintained and resourced tool can help transform the market towards more efficient appliances, build credibility of the energy efficiency program amongst consumers and provide a level playing field to the industry. The paper will cover qualitative analysis of regional product registration systems across the world with a specific focus on Economic Community of West African States (ECOWAS) regional product registration system. The paper will share key lessons and considerations for policymakers to develop a regional system ranging from political buy in, early agreements, consultative process amongst others. This paper will shed light on what goes into the development and operation of these tools; potential barriers and provide recommendations to develop and run a robust system. The comparative analysis of different systems will benefit countries developing a new product registration system or upgrading an existing one.

Session slot: 2.01.12

When less is more: How technology can streamline and scale up the MVE process. The EEPLIANT3 'CybPort' tool for data collection and mass data migration of product cases to European Commission's ICSMS

Presenter: Papazoglou Kyriakos, PROSAFE, Belgium

Abstract:
Recent impact studies have shown that Ecodesign (ED) and Energy Labelling (EL) are responsible for almost half of the 20% EU2020 energy efficiency target, achieving 175 Mtoe primary energy savings per year (at EU level), 340 Mt CO_2 equivalent less GHGs, and €102B estimated net savings on consumer expenditure, some €465 annually per household. Monitoring, verification and enforcement (MVE) is an integral part of the ED/EL policy frameworks. It is carried out by the national Market Surveillance Authorities (MSAs) with the objective to verify that the products on the EU market are compliant with the ED/EL requirements, thus guaranteeing fair competition and protecting consumers and the environment from defective products.
With energy efficiency assumptions predicated on the condition that all products placed on the EU market comply with the sector-related requirements, and with large-scale cross-border EU projects such as the EEPLIANT trilogy (EEPLIANT1, 2, and 3) delivering significant energy savings whilst still revealing a consistent high noncompliance rate, the question remains: Is a 100% compliance rate realistic considering the vast number of products on the market versus the limited national resources (human, financial, technical) and the complexity of today's trade environment (e-commerce)?
If no, the next question to be examined is how can we, then, achieve (even) more (from MVE) with less? So, how to improve the cost-effectiveness of EU market surveillance.
Alleviating information asymmetries among MSAs with the application of new technologies and smart digital tools to the MVE process can be a game-changer. Empirical evidence from MSTyr15 and EEPLIANT2 Joint Actions proves that IT tools are highly effective in saving MSAs' resources and bridging the information gap as regards the exchange of information on non-compliant products between Member States.
The IT system engineered and tested under these two projects regards the recording and semi-automatic bulk upload of big inspection data to ICSMS, the European Commission's platform used by MSAs to share information about the enforcement of European internal market legislation on non-food products.
Recording national cases into ICSMS in reality can be burdensome and time-consuming for MSAs as it requires manually encoding data for each single case and for all data fields relevant to each category of products.
This tool is further developed under the ongoing EEPLIANT3 Concerted Action to upgrade its utility beyond the project specifications. How does it work? What are the results to date and what the benefits? What is its long-term potential and utility?

Session slot: 2.01.13

Market transformation for Heating & Cooling equipment in Europe: using benchmark and advice to involve stakeholders

Presenter: Attali Sophie, Guide Topten, France

Abstract:
Space heating and water heating consume over 5,000 TWh/a, nearly 50% of the primary energy consumption of the EU and more than 50% of greenhouse gas emissions in CO_2 eq. (in 2015). Space cooling equipment rates grew in the last years, due to climate conditions and comfort requests.
The most beneficial action to take is first to insulate buildings to reduce energy needs and improve comfort and air quality. While not all households can retrofit their house, many are anyway in a situation of either investing in a new system or developing low-cost strategies to improve their comfort. The H2020 project "HACKS – Heating and Cooling Knowhow and Solutions" works on both these axes: 1) For all consumers, especially those who cannot invest in a new system, it provides advices on how to improve comfort and air quality and lower energy bills. 2) For consumers ready to invest, it provides tools enabling them to make informed decisions such as benchmarks and lists of most energy efficient products elaborated thanks to continuous market studies. For example, once the decision is taken to invest e.g. in a heat pump system, all other things being equal, there are large performance differences between products on the market.

In order to achieve a fast market transformation, all relevant stakeholders need to be involved: not only manufacturers and consumers but also installer networks, retailers, consumer organisations and governmental policies such as rebate programmes. The paper will discuss different strategies to connect those stakeholders, within the HACKS project which is implemented in 15 countries in Europe. It will give a broad overview of different strategies, environments and levels of success. Best practice examples will be highlighted as well as the tools developed by the project: papers for each technology presenting the key points to watch, a product database showing market evolutions, a calculator, a catalogue of advices, communication campaigns, etc.

Session slot: 2.01.14

Behavioural change as a domestic heat pump performance driver: insights from multiple case studies in the UK

Presenter: Oikonomou Eleni, University College London, United Kingdom

Abstract:
Heat pumps (HPs) are seen as an increasingly important technology able to contribute significantly towards the decarbonisation of the domestic stock in the UK. However, there appears to be a performance gap between predicted and real-life HP performance. This gap is partly attributed to poor heat pump installation and incorrect assumptions about how they are used in practice, and several studies have highlighted the need to examine HP performance from a wider perspective, including the HP's interaction with users. In this context, this study examines the role of user behaviour and how performance could be improved from a systems perspective. A sample of 21 case studies was selected from 700 domestic HPs monitored across the UK via the government's Renewable Heat Premium Payment Scheme for the collection of qualitative and quantitative socio-technical data. The data collection process involved in-depth interviews and direct observational methods. The application of systems thinking to the analysis of the socio-technical data collected facilitated the identification of the underlying complex interactions between the HP system and its users. The systems model revealed that HP performance relies on an extensive network of complex socio-technical system interactions, many of which relate to behavioural patterns. These may act through various direct and indirect paths, the majority of which converge at two points, namely compressor power consumption and heat generation by the HP-incorporated resistance heater. The systems analysis revealed that enabling feedback processes, e.g. through real-time system status indicators and summary displays, can have a significant impact on user behaviour and facilitate the timely identification of technical issues and actions that are likely to be detrimental to the system's efficiency. The study enabled a deeper perspective on performance influencers relating to behavioural patterns and achieved new insights into the requirements for well-performing HPs, e.g. by highlighting the need to prioritise user-oriented technological advancements and policies supporting behavioural change. These findings have important implications for policy makers, installers and manufacturers of HP systems and their users.

Session slot: 2.01.15

Evaluation of the environmental benefits of energy management systems using archetypes of French households - Application to heating management systems

Presenter: Wagner Alexis, Institut d'Electronique et des Technologies du numéRique (IETR), France

Abstract:
The climate plan adopted by France in 2017 aims to achieve carbon neutrality by 2050. The building sector, accounting for 27% of national greenhouse gas emissions, is targeted by several policies aiming at a massive housing park renovation. However, this task is expected to take more than 60 years at the current rate. Nevertheless, better energy management of these buildings through the implementation of control systems seems to be a complementary solution in the short term. While the smart home market is growing rapidly ($80 billion turnover in 2021 according to Statista), it seems necessary to evaluate the environmental relevancy of these devices. Louis et al. [1] compared the energy savings and the life cycle impacts associated to energy management devices. The limitations of this work are that the authors consider an "average" Finnish household, living in a fully automated dwelling. This approach does not consider the diversity of housing situations and the possibility of having a higher or lower level of automation of services, which makes it difficult to conclude on their

relevance. The development of sound environmental information on automation systems should enable the deployment of adapted solutions. Assessing the environmental benefits of these systems raises two major issues: the calculation of energy consumption in homes (including high variability in behaviour) and the calculation of the environmental impacts of the systems. This paper makes then two major contributions. Firstly, a methodology is developed to determine the environmental contribution (kgCO2 eq, kWh) of a management system for a French household by weighing the life cycle impacts of the added control system against the impact reduction associated to the heating system. Each simulation is carried out using archetypes of household [2], housing [3] and behaviour [4]. This combination makes it possible to build case studies of fictitious households that are representative of segments of French households. Secondly, the methodology is applied to three case studies with four different heating control systems. The heating consumption is calculated for each household-control system combination by dynamic thermal simulation with STD-COMFIE. This paper concludes that there exists a system minimising the impacts depending on both the case study and the observed impact. Moreover, the result also strongly depends on the energy used for heating. All in all, a more complex management system systematically improves thermal outcomes but does not necessarily reduce the environmental impacts.

[1] J. N. Louis et al. , «Environmental Impacts and Benefits of Smart Home Automation: Life Cycle Assessment of Home Energy Management System.» IFAC-PapersOnLine, 2015.
[2] J. P. Lévy et al. , «The determinants of domestic energy consumption inFrance: Energy modes, habitat, households and life cycles.», Renewable and Sustainable Energy Reviews, Elsevier, 2017, 81 (2), pp.2104-2114.
[3] ADEME, «Bâtiments résidentiels: Typologie du parc existant et solutions exemplaires pour la rénovation énergétique en France.» 2015.
[4] M. Heinrich et al. , «Who does what in dwellings? Learnings from archetypes of energy-related behaviour based on cross-sectional data.» 2021 (submitted).

Session slot: 2.01.16

Empowered Operators to provide direct advice on consumption habits to mitigate energy poverty with special referance to summer energy poverty (COOLTORISE project)

Presenter: Varvesi Marina, AISFOR, Italy

Abstract:
Energy transition risks to become something reserved to wealth people, with the dangerous veneer of fancy new products and un-wised government policies favouring specific classes of the population, while now a day it is estimated that more than 50 million households in Europe live in a situation of Energy Poverty 1 , and this number is susceptible to vary considerably in the next future because of many different factors. Climate change will increase temperature variability and the connected comfort in the houses, new energy policies could lead to an increase in energy prices and market instability and, lastly, the Covid pandemic has forced many at home increasing energy consuming activities and often, considerably cut households' wages.
These considerations lead to a simple understanding: energy poverty is an issue which needs to be faced with appropriate and effective actions at different levels of governance, with the aim to overcome simple assistance support and to put in place long lasting empowerment strategies tailored on vulnerable consumers, stimulating, at the same time, cultural awareness, and public debate. At the
same time, it is evident how reaching vulnerable and under informed targets not only for support but also for proposing an effective change in their habits and lifestyle is the (often underestimated) counterpart of this difficult challenge.
The HORIZON funded ASSIST project, which recently ended in June 2020, successfully tested a 3-stepmodel to ensure a concrete and on-the-ground assistance model to energy poor consumers based on training-networking-action of HEAs (Household Energy Advisors), i.e. operators working in different sectors (i.e. energy, social, wellbeing) and in different context (i.e. public, private, associations). During
the project pilot phase, the successful implementation of the models was proved, showing how factors such as trust, honesty and human contact are essential in reaching vulnerable consumers. The promising results of the project and the urgency of the problem have created the will to extend the pilot with follow-up initiatives in 5 European countries (Italy, Spain, Poland, Bulgaria and Romania), to create a strong and

capillary network to tackle Energy Poverty empowering people and creating value where poverty risks to become an insurmountable obstacle to taking part in this coveted transition.

Session slot: 2.01.17

Determining potential for energy savings in space cooling by analysing air-conditioner usage behaviour

Presenter: Gokarakonda Sriraj, Wuppertal Institute, Germany

Abstract:
A field study was conducted to analyse the air-conditioner (AC) usage behaviour and its impact on AC energy consumption in a typical urban high-rise residential building in Ahmedabad, India. Field measurements include indoor air temperature, globe temperature, relative humidity, AC set point temperature, fan settings and energy consumption. For data collection, the study used custom-built Internet of Things (IOT) enabled devices and demonstrates their reliability and usefulness for conducting cost effective research. Specific to the current study, the results quantitatively shows that duration of operation and set point temperature of AC significantly impacts its energy consumption than the indoor and outdoor air temperature and relative humidity or the difference between them. It identifies indoor air temperature and relative humidity as key drivers that trigger turning on the AC, and air temperature alone triggers turning off the AC. Furthermore, the results indicate that there is a 79% probability that comfort conditions can be maintained by achieving a temperature drop of 3K through passive measures (low-hanging fruits), as much as possible, which results in the reduction of duration of operation of AC and cooling energy savings by 67.5 and 58.4%, respectively. Such intricate understanding of user behaviour helps in better customizing renovation recommendations that provide monetarily compelling prospect for homeowners and have high cumulative impact. Low cost IOT devices demonstrated in this study can be easily integrated into existing homes to enhance thermal comfort and provide user feedback to reduce energy wastage and help smart grids to improve demand side management, for example, by remotely changing the AC set point temperature or turning off the AC while maintaining desirable indoor environmental conditions.

Session 2.02 – June 2nd

Session slot: 2.02.01

Strategizing energy efficiency policies based on monitoring the market for energy efficiency services

Presenter: Ivanova Stela, Federal Energy Efficiency Center (BfEE), Germany

Abstract:
In collaboration with scientific partners the German Federal Energy Efficiency Center (BfEE) monitors the market for energy efficiency services, energy audit and other energy efficiency measures in Germany. The results help improving energy efficiency policies to 1) enhance the market for energy efficiency and 2) ultimately increase the energy efficiency in the residential, private and the public sector. The annual market study examines issues such as consumer behavior, energy demand, applied energy efficiency technologies and subsidies. Besides, it examines the role of energy efficiency for the different customer groups in the market, especially for residential households. 3000 households, including tenants and property owners, are surveyed. The results are enriched with qualitative data and are subject to quantitative statistical analysis. Based on the results in the last 5 years of market surveillance the paper outlines the links between the usage of subsidies and the implementation of efficiency measures as well as different trade-offs in customer behavior and expectations. Furthermore, it concludes how energy efficiency policy and tools should be adjusted to account for results of the analysis of the current market situation. Thus, the paper offers insights in the impact of policy incentives, significant barriers and suitable strategies for increasing energy efficiency in the residential sector.

Session slot: 2.02.02

Energy Service Companies (ESCOs) in the residential sector: review of current trends and policies to foster their expansion in the EU member states

Presenter: Bertoldi Paolo, European Commission - Joint Research Centre, Italy

Abstract:
The paper will review the role of and the market potential for Energy Services Companies (ESCOs) in the residential sector. The ESCO market is well developed for the non-residential (in particular for large and/or public) buildings and to a lesser extent in the industrial sector, but it is not yet penetrating the residential sector, in particular for building renovation projects. There are some recent evidences that for large multifamily buildings the ESCO can be an effective players in stimulating and implementing building renovations. In particular, the paper focuses on the European experience in ESCO activities and projects in the residential sector, including a review of the most developed markets, the typical projects, the financing mechanisms and the remaining barriers. The paper will also present a few successful case studies. The concepts of Energy Service Agreements and One Stop Shops will also be introduced and compared to ESCOs model. Finally the papers proposes policies to further promote ESCOs and financing for residential building renovations.

Session slot: 2.02.03

Dynamics of the smart home market: Opportunity or challenge for 2022

Presenter: Lorbach Jan, GfK, Germany

Abstract:
The Technical consumer goods market has been strong and resilient in 2021. 2022 will be however challenged by increasing prices due to pressures on the supply chain built by several external factors. This paper will focus how smart products are one of multiple ways to offer better value propositions. In the past year across 7 major European markets smart home products grew faster than total market growth. Nonetheless barriers around smart home continue to exist which hamper the smart home adoption. New standards being discussed could potentially address some of these barriers and propel the adoption of smart home products.

Session slot: 2.02.04

Data collection to support energy efficiency finance in the building sector

Presenter: Streng Eddie, Joule Assets Europe, Belgium

Abstract:
The speaker will bring value to the session by presenting the EN-TRACK H2020 project, led by Centre Internacional de Metodes Numerics en Enginyeria (CIMNE). The project aims to build an online platform that collects valuable data for project developers and investors on energy efficiency projects in the building sector.
The lack of empirical evidence and statistical data on the actual energy and costs savings achieved is today one of the key challenges to overcome in order to increase energy efficiency investments. Data is still hard to access because it is decentralized and in different formats. Consequently, only a small part of this can be used to produce reliable empirical evidence on the performance of the energy efficiency investment.
The goal of EN-TRACK is to create a one-stop-shop platform with standardized data related to the energy efficiency performance of the public and private building stock. The platform will e.g. allow for benchmarking of the financial performance of specific energy efficiency measures (EEM). The user can analyse trends in financial performance of EEM investments by defining (ranges of) financial parameters and seeing distributions and standard deviations of various EEM types. Several filter criteria (location, building type and use, etc.) will allow a more customized analysis, ensuring a minimum number of projects to be included in the sample. The tools and platform developed through the EN-TRACK project will be based on enabling interoperability with most currently active databases and tools (e.g. DEEP and eQuad platforms) that will support more efficient building refurbishment decision-making processes, putting it into practice with the financial sector.
During the presentation, the speaker will present the first development of the project and a practical demonstration of the platform.

Session slot: 2.02.05

Let the Sun Shine In, or Not: Automated Shades Improve Comfort and Energy Savings in Smart Homes

Presenter: Cort Katherine, Pacific Northwest National Laboratory, United States

Abstract:
While daylighting and views are an obvious benefit of windows, the positive and negative impacts of windows on space heating and cooling can be considerable. Solar heat gain can benefit interior comfort if properly managed but unwanted heat transfer through windows can account for a significant percentage of a home's peak cooling load in the summer and heating losses in winter. Automated interior and exterior shades, blinds, and shutters offer the potential to reduce or optimally control these heat gains and losses. As automated versions of these shading devices have become available, questions have arisen as to how much energy they can save, what operating schedules are most ideal for optimizing savings, and how acceptable these products would be to consumers. To answer these questions, our organization has conducted numerous studies at our Lab Homes site, two fully monitored, identical, side-by-side manufactured homes where interior and exterior temperatures and heating and cooling energy use can be continually measured and recorded. These Lab Home studies have been supplemented by field studies conducted at three occupied field sites to measure shade usage, document installation practices, and survey customer perspectives. The results of both heating and cooling season experiments are presented, where testing was designed to assess the heating, ventilation, and air conditioning (HVAC) savings resulting from the thermal insulating properties as well as the automated and dynamic control strategies of these various shading devices. Control schemes tested include common "connected home" strategies where controls are integrated and coordinated between the window shading device, building thermostats, and external sensors. The paper will also include results from testing designed to examine the benefits (in terms of comfort, energy savings, and responsiveness to control) of coordinating the operation of cellular shades with HVAC control as a demand response measure. These experiments demonstrate that highly insulating, dynamic window coverings that are reliably controlled can dramatically reduce the heating and cooling energy use associated with windows and should be considered as an important component of any "smart" home design.
This submission is for Topics Related to Specific Technologies, #9. Smart Meters, Smart Appliances, Home Automation, Smart Homes...

Session slot: 2.02.06

Eight years measurement data of a deep renovated residential building

Presenter: Haase Matthias, ZHAW, Switzerland

Abstract:
A typical residential building from 1937 located near Wuerzburg in Germany, was deep retrofitted in 2013. Roof, façade and ceiling in the basement were highly insulated and thermal bridges were minimized. Windows were replaced with three-layered glazed windows with wood-aluminium windows. A compact unit (balanced ventilation system with integrated air-to-water heat pump) was installed together with an 8 kW PV system with a south-west orientation and 50 degrees angle (roof-integrated). The ventilation ducts were integrated into the existing chimneys. Residential appliances/white goods (Refrigeration, Laundry, Dishwashing) were installed/replaced by A^{+++} equipment. Cooking equipment was replaced by induction device. Lighting fittings were replaced with LED in the whole building.
The key performance indicators were measured over a period of six years (2014-2020). Energy production, energy use, energy costs, self-consumption and export of electricity to the grid was monitored. The results show variations in performance indicators, e.g. self-consumption varied between 6% and 25.5%. Thus, annual energy costs vary between 785,54 (2014) and 913,40 Euros (2015) which has implications for economic evaluation (payback period).The robustness of the key performance indicators is discussed. Recommendations for designers and planners as well as policy makers are given on the usefulness of the different indicators.

Session slot: 2.02.07

How can residential demand in low electricity access countries be 100% met by 2030? A case study of Burkina Faso

Presenter: Bissiri Mounirah, University of Coimbra; INESC Coimbra, Portugal

Abstract:
Energy transition risks to become something reserved to wealth people, with the dangerous veneer of fancy new products and un-wised government policies favouring specific classes of the population, while now a day it is estimated that more than 50 million households in Europe live in a situation of Energy Poverty 1, and this number is susceptible to vary considerably in the next future because of many different factors. Climate change will increase temperature variability and the connected comfort in the houses, new energy policies could lead to an increase in energy prices and market instability and, lastly, the Covid pandemic has forced many at home increasing energy consuming activities and often, considerably cut households' wages.
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Session slot: 2.02.08

EPC registers as a policy tool to monitor the national TBS stock and evaluate the application of the energy regulation framework

Presenter: Pagliaro Francesca, ENEA DUEE SIST, Italy

Abstract:
The performance of Technical Building Systems (TBSs), together with building envelope and Renewable Energy Sources (RESs), plays an important role in reducing building energy consumption and greenhouse gas emissions. For this reason, the monitoring of existing TBSs is crucial for identifying suitable energy policies and adopting building renovation strategies. In this context, Energy Performance Certificates (EPCs) are an important data source on building thermal and geometrical characteristics and final energy uses. The management of EPC data allows a combined analysis of different parameters to evaluate the existing building and TBS stocks. The Italian EPC digital register, the Informative System on EPCs (SIAPE in Italian), collects and organizes the EPCs transmitted by Regions and Autonomous Provinces. In this study, EPCs issued from 2015 to 2021 were analyzed to evaluate TBS characteristics on the Italian territory by combining them with other building information, such as the construction period or the purpose for EPC issuing. In this way, not only the mapping and the investigation of the existing TBSs on the Italian territory can be analyzed, but also the influence of the energy regulatory framework and the energy system evolution in specific building categories. According to the Italian energy regulations, the analyses focused on the residential sector and its main final energy uses (space heating (SH) and domestic hot water (DHW)). The paper aims to introduce SIAPE and EPC register as tools for describing the TBS stock, providing useful information for policymakers to define and monitor building renovation strategies.

Session slot: 2.02.09

Dishwashing Efficiently—What is Next?

Presenter: Gopal Sriram, AHAM, United States

Abstract:
AHAM represents manufacturers of major, portable and floor care home appliances, and suppliers to the industry. AHAM's more than 150 members employ hundreds of thousands of people in the U.S. and produce more than 95% of the household appliances shipped for sale within the U.S. The factory shipment value of these products is more than $50 billion annually. Home appliances also are a success story in terms of energy efficiency and environmental protection. New appliances often represent the most effective choice a consumer can make to reduce home energy use and costs.
In this paper, AHAM argues that cost-effective efficiency gains in dishwashers are no longer achievable with existing technology. At levels beyond the current energy star criteria, dishwasher performance is at risk. Moreover, the payback period for increased efficiency gains is longer than the appliance's useful life, and the reduction of environmental impacts are insignificant. Therefore, manufacturers and governments should claim success in transforming the energy and water efficiency for dishwashers and shift focus on consumer behavior to encourage increased and proper use of dishwashers and reduced handwashing and pre-rinsing. Regulators, in partnership with other stakeholders, can also encourage dishwasher ownership, as using these appliances instead of handwashing dishes dramatically reduces the water and energy use associated with the kitchen. There are significantly more energy and water savings to be achieved through these non-regulatory means than through continuing to make energy and water energy conservation standards more stringent.

Session slot: 2.02.10

Environmental Dumping of comfort fans in Europe

Presenter: Rochat Hélène, Topten, Switzerland

Abstract:
Comfort fans are included in the European Ecodesign regulation on air conditioners (EU 206/2012). However, unlike most Ecodesign regulations it only contains information requirements for the products and no requirements on the energy efficiency of the products. As the revision of the Ecodesign and Energy Label regulation is taking place on the European level, it is being considered to introduce minimum energy performance standards as well as an energy label for these products. In other regions of the world, these requirements exist including in regions that produce comfort fans that are destined for the European market. The paper will illustrate the environmental dumping that is taking place in Europe where the products that are being exported from the manufacturing country have a lower energy efficiency performance than the domestic minimum energy performance standard in place. It will subsequently compare the products available in Europe with the mandatory energy efficiency requirements in China and the voluntary scheme in India. In 2015, 25 million units were sold in the European Union and with the increase of temperatures, this number is increasing dramatically. An efficient comfort fan can also be an alternative solution to installing an air conditioner, thus achieving additional energy savings.

Session slot: 2.02.11

Innovations for Sustainable Off-Grid Solar E-Waste in Sub-Saharan Africa

Presenter: Wambui Monica, CLASP, Kenya

Abstract:
The rapid expansion of the off-grid solar sector over the past decade has been one of the most exciting trends in clean energy generation, reducing CO2 emissions and granting energy access to hundreds of millions of people living in off- or weak-grid environments. Since 2010, sector has seen incredible growth especially across sub-Saharan Africa, the region that hosts 50% of global off-grid solar sales. But this rapid expansion has come at a cost.
The proliferation of solar e-waste in communities around the world poses a threat to the environment and to the health of the very people benefiting from off-grid energy services. The region is characterized by un- and under-developed e-waste management infrastructure, leaving end-users with limited to no options. Most consumers dispose of their end-of-life solar products by storing, dumping, burning or disposing of them in water bodies or latrines. To stimulate innovations and collaboration for off-grid solar e-waste management, in 2019 the Efficiency for Access Coalition launched the inaugural Global LEAP Awards Solar E-Waste Challenge.
The Challenge selected eight companies– off-grid solar companies, recyclers and waste management companies from five sub-Saharan African countries – to test different aspects of e-waste collection and disposal, including recycling, repair and refurbishment, take-back and collection, and awareness raising and incentives. Over the 12-month implementation period, the projects built waste processing facilities, purchased crucial equipment, explored repair and refurbishment possibilities, conducted consumer-awareness campaigns across a variety of platforms, and implemented a number of different e-waste take-back schemes. They collectively amassed more than 250,000kg of off-grid solar waste, a small fraction of the total levels, but enough to identify key lessons about the design and implementation of e-waste management programmes.
This report aims to share the good practice that emerged from these projects, to inform future efforts to address growing amounts of e-waste and advance the state of practice in the sector. We explore programs that succeeded in reaching hard-to-reach, underserved rural off-grid populations across the continent. Through the case studies, we share logistic and communications strategies employed by solar companies and recycling facilities to educate and incentivize customers to relinquish their end-of-life solar lights and appliances. In examining and analysing the experiences of these eight companies, we gleaned data and insights for others to replicate their successes and avoid some of their pitfalls.

Session slot: 2.02.12

Multiplexed Power Conversion improves efficiency

Presenter: Lefedjiev Adrian, Power Integrations, United Kingdom

Abstract:
The functional electronic blocks of modern appliances require multiple tightly regulated Constant Voltage (CV) power supplies. Where such appliances include LED displays or lighting, Constant Current (CC) supplies are also required. The switched-mode power supplies (SMPS) used in domestic appliances are also required to have high efficiency and low component count. When implemented with a multiple-output Flyback topology the Multiplexing Power Control Technique (MPCT) described in the article addresses all of these requirements. The resulting multiple-output SMPS has a single power-conversion stage without post-regulation, delivering high efficiency over a wide range of operating conditions. The article is aimed at SMPS designers and systems engineers working in the field of appliance manufacturing.
The control algorithm of the MPCT is explained in relation to a generic multiple-output Flyback architecture. Circuit-diagrams of multiplexed converters with up to three CV outputs and a single CC output are shown. Two converter design examples and their characteristics are presented.
The first converter delivers total power of 26W. It is intended for use in bathroom heaters with LED lighting. It has two CV outputs (+5V and +12V) and one CC output driving four individual 40V/0.25A LED stacks.
The second converter is designed for use in microwave ovens with LED displays. It delivers maximum continuous output power of 70W and peak power of 81W. A single 12V/2A/3Apk CV output powers the appliance control electronics in the appliance. The second (CC) output drives 75V/0.65A LED stack.

Both converters operate from universal mains input 90Vac-265Vac; achieve up to 91% efficiency; have no-load consumption below 150mW and regulation error well below ±1%. The components' temperature rise above ambient is within 45°C without external heat sinks and force cooling.
The design experience shared in the article shows that, when used in an appropriate converter topology, the described MPCT overcomes the poor cross-regulation of the conventional multiple-output Flyback converter, thus obviating the need for post-regulation.
The resulting single-conversion-stage, multiple-output SMPS has low component count and efficiency in excess of 90%, while maintaining accurate regulation. Furthermore, the high efficiency achieved by the designs eliminates the need for heat sinks in the PSU assembly, facilitating high power density, low component and labour cost.
The design examples presented prove, that both CV and CC outputs can be generated in a single-stage converter when employing Multiplexing Power Control. This is particularly useful in appliances incorporating LED displays.

Session slot: 2.02.13

After 25 years of European Eco design and Energy Labelling Regulations: where do we stand today? In-depth scan of the French household electricity consumption

Presenter: Dupret Muriel, Ingénieur Conseil, France

Abstract:
France has the fourth largest electricity consumption per household in the EU-28. In this context the French Energy Agency (ADEME) and the French Transmission System Operator (RTE) have decided to fund together the PANEL ELECDOM project. It aims to provide yearly an accurate household electricity consumption baseline dataset. To achieve this goal, two thousand five hundred connected sensors have been installed in the electrical panel or directly to appliances in a representative sample of one hundred French households since April 2019. It contributes to a better understanding of how electricity is consumed in French dwellings and where the main challenges remain.
The paper gives an analysis of the data collected during the first year of this monitoring program. It provides precious insights on the French residential electricity consumption, its key drivers and its precise breakdown between end-uses. Eighty different types of equipment are covered, including some that have never been audited before like home automation, medical device, and electric mobility. This in-depth study highlights trends in the evolution of the electricity consumption over the last twenty five years. It assesses the impacts of recent technological developments (e.g. leds, heat pumps) and of fast growing uses (e.g. electric mobility, air conditioning, private swimming pool). It also gives valuable answers to questions related to the European Eco design and Energy Labelling Regulations: how efficient has the process been so far? Are there still any improvements possible? Are there any high-consumption devices that are not regulated? Finally it sketches out specific ways in which French White Certificate Scheme and French Thermal Regulation could be adapted to reduce residential electricity consumption.

Session slot: 2.02.14

Evaluation of Lighting Efficiency Policy and Market Transformation in India

Presenter: Pvn Kishore Kumar, CLASP, India

Abstract:
Electric lights are used by millions across India. The lighting market has increased exponentially over the years due to rapid population growth, more dwelling units, concept of smart lighting, and electrification at remote places. In Fiscal Year 2018-19, India manufactured about 1.4 billion lamps and tube-lights. The lighting segment consumes approximately 18% of total electricity use in the residential sector, resulting in 40 million tons of greenhouse gases (GHG) emissions.

Energy efficient lighting is one of the most cost-effective measures to address the impacts of growing electricity demand from the sector. Recognizing this, India adopted an energy efficiency policy for Tubular Fluorescent Lamps (TFL) in 2006. A decade later, an efficiency policy for LED bulbs was also announced to cover another new category of lamps as LEDs gaining a mainstream lighting market across industrial, commercial and residential installations. Since its adoption, 1.2 billion TFLs and 0.8 billion LED lamps

have been star-labeled, thereby developing the market towards more energy-efficient lighting. India has experienced one of the most remarkable successes in market transformation for lighting as a result of efficiency policies and mass procurement exercises such as the UJALA scheme. Over the last 15 years, lighting efficiency policies have resulted in cumulative electricity savings of 18 Terawatt-hours and reduced GHG emissions by 15 million tons.
This paper analyses and discusses the trends in market growth, technology evolution, and market development as a result of lighting efficiency policies and further assess the potential for future policy revisions.

Session slot: *2.02.15*

Taking the Bias Out of Likert Scales: Four Examples Using a Better Alternative

Presenter: Skumatz Lisa, SERA Skumatz Economic Research Associates, Inc, United States

Abstract:
TOPIC AREAS: 05-Standards and Labels; 06-Measurement Methods and International Harmonisation

Likert Scales (5, 7, or 9-point) are in common use in energy efficiency (EE) evaluation. This study provides examples of much more defensible approaches that should be considered in place of this common metric. LIKERT scales generally assign equally-spaced numbers or percentage values, but our research shows equally-spaced differences between the numeric or verbal extremes are biased, and we suggest adaptations of "labeled magnitude scaling (LMS)" as more appropriate scoring values for the Likert increments.
Process Evaluations: Likert scales abound in process evaluations (e.g., metrics of "satisfaction", and "ease of participation"). We use academic research and real-world examples to show the differences in scores realized from use of traditional Likert vs. LMS estimates.
Net to Gross: In the most sophisticated NTG methodologies, exemplified by the array of questions and corroborating elements for estimating free ridership and spillover in Massachusetts, relies on several Likert scales for the formula. The author identified the bias introduced by use of these Likert scales and developed an improved methodology for NTG computations in Connecticut research. Again, resulting differences will be presented.
Quantifying Better/Worse Program Changes: In matrices used to analyze or score program options, Likert or linear scales are often used for those elements cannot be monetized; for example, options are scored better or worse on a 1-7 scale. A LMS scale better represents differences than the "one unit" differences arising from Likert scales.
Barriers Analysis: Most importantly, barriers analysis commonly relies on Likert scales. However, a barrier scoring 1.5 out of 5, or changes of 3.4 to 3.6 between years provides no meaningful program recommendations. Instead, using NEB analysis that uses LMS provides explicit recommendations on the dollar size of the barrier and the incentive / intervention value needed to erase the barrier.
Examples are provided throughout.

Session slot: *2.02.16*

Design and Implementation of an Energy Metering System to Recognize the Household Electrical Energy Consumption Pattern Through an IoT Network

Presenter: Arévalo-López Johnny, Escuela Colombiana de Ingeniería Julio Garavito, Colombia

Abstract:
Energy efficiency is a widely studied topic not only from a technical perspective but also from a technology transfer perspective. Nevertheless, there are not many investigations nor contributions that discuss in a broader way an issue as important as the behavior of household electric energy consumption.

This research work aims to focus on consumers and study their energy consumption patterns. When a consumer receives their monthly electric energy bill, conventionally it reports the amount of kWh consumed and its cost, it could inform also the historic data for some months; in the most evolved version, it includes the daily average

consumption. However, this information does not discriminate the consumption behavior of household appliances and loads. Furthermore, the behavior of energy consumption at different times of the day or week is not directly inferred.
Therefore, the consumer is almost blind, in the age of information, taking corrective actions that effectively reduce the electrical energy consumption. If consumers could identify those devices which have a higher consumption based on historical consumption data or baseline consumption, they could take actions that impact effectively its consumption.
Due to the spread of the Internet of Things (IoT) and Wireless Sensor Networks (WSN) with high capabilities for data acquisition and analysis, the inference process has improved in the last few years. Since the user's decision-making actions to reduce the electrical monthly energy consumption are supported on better analysis, proper actions are expected. This novel research contribution describes the design methodology and the implementation of a system that integrates energy measurement techniques through IoT networks, providing to the user detailed information regarding electrical energy consumption behavior. Additionally, field measurements are analyzed for households located in Bogotá, Colombia.

Session slot: *2.02.17*

The usefulness of sales data to understand energy stakes for appliances

Presenter: Attali Sophie, Topten, France

Abstract:
Knowing the market is key for deciding on energy label classes' thresholds, minimum energy performance standards (MEPS) and revisions of these. The EPREL database has started to be operative but in absence of sales data, will it fulfill one of its purpose, i.e. to provide the Commission with up-to-date energy efficiency information for products for reviewing energy labels?
Our paper demonstrates the potential of systematic market monitoring based on sales data.
In a report to be published in March 2021, updating a previous report published in 2017, comprehensive sales data from GfK is analysed for refrigerators, washing machines and tumble driers. The data covers the years 2004 – 2019 and the national markets of France, Germany, Italy, and for the whole EU market. It includes information on sales per energy efficiency class, average energy consumption, size and price.
The results show that the efficiency of refrigerators has improved by 40% since 2004. The energy consumption, however, has decreased less than that. For washing machines, large drums confirm their popularity, in part because high efficiency is strongly linked to large drums. Considering the low efficiency of small partial loads, the calculated energy and cost savings are up for discussion. Heat pump tumble driers have continued to extend their popularity among consumers: this energy-efficient technology made up nearly 60% of all drier sales in the EU in 2019. On national markets, their sales share can be even higher. A ban of non-heat-pump models could save Europe around 8 TWh per year. The results further show large differences between national markets – even though the same regulatory framework applies in all EU Member States, and the same international manufacturers dominate most markets.

Session slot: *3.01.01*

kWh versus Euro – What is the most effective way to inform about efficient products?

Presenter: Rüdenauer Ina, Öko-Institut e.V., Germany

Abstract:
Particularly efficient products often have a higher purchase price than less efficient alternatives. However, the total costs over the life cycle are often lower due to the lower operating costs. Overall, efficient appliances are therefore not only ecologically but also economically advantageous for consumers and, accordingly, should actually be bought more often than less efficient appliances from a purely economic point of view. In reality, however, this does not always happen and the discrepancy between the expectation with regard to the lower life cycle costs and actual consumer behaviour is often discussed in the literature, e.g. under the keyword "energy efficiency gap" (cf. e.g. Jaffe & Stavins 1994).
Labels are high potential instruments to close this gap by increasing the visibility of follow-up costs at the point-of-sale, e.g. by the EU-Energy Label. The absolute energy consumption is communicated with the help of physical units and thus made transparent to the consumer. For a long time, however, there has been a discussion on whether rather the monetary costs associated with the energy consumption should be communicated, since the calculation by the consumer is not always possible or only with a high cognitive effort. The costs in euros, on the other hand, are easy to grasp and directly comparable with the purchase price.
Furthermore, the focus of the EU energy label is on the efficiency of the products, not least because of the graphically very appealing presentation of the energy efficiency classes. The absolute level of energy consumption is perceived less. Due to its relative character, the label thereby contributes to consumers buying larger appliances with high energy efficiency but still high energy consumption or losing reservations about products that typically have a high absolute level of energy consumption (cf. Wächter et al. 2015a/b). Communicating operating costs in monetary units may be a way to draw more attention to absolute consumption.
In this study, a comparative literature analysis was carried out as part of a project of the German Federal Ministry of Economic Affairs and Energy. International publications with experimental analyses and field studies on a total of almost 20 product groups were evaluated with regard to the question of whether and how the indication of costs has a positive effect on the choice or sales figures of particularly economical products.

Session slot: *3.01.02*

Can digital advertising raise consumer awareness of energy efficient domestic appliances? A case study of the #KenyaEnergyLabel campaign

Presenter: Blair Hannah, CLASP, Kenya

Abstract:
In an effort to promote high-quality, efficient lighting and appliances to reduce consumers' electricity costs and national energy use, the Kenyan government developed and implemented minimum energy performance standards (MEPS) for refrigerators, freezers, room air conditioners, motors, and lighting products. Included in the MEPS program is an energy labelling scheme. Labeling is a critical component of effective appliance energy policy, encouraging consumers to make informed purchase choices and protecting them from poor quality, inefficient products. However, consumer awareness, understanding and trust of an energy label is central to its success.
In 2019, EPRA requested support from CLASP to design and run an energy label consumer awareness campaign. This is the first energy label campaign conducted in East Africa and the third major campaign conducted in sub-Saharan Africa. This paper will share insights from the design and implementation of the digital consumer awareness campaign, evaluating its impact on consumer choices and preferences in Kenya.
Prior to campaign development, CLASP conducted a comprehensive baseline survey of appliance consumers in Kenya to better understand user demographics, factors they consider when making purchasing decisions, and recognition of the energy label. The team sent 8 surveyors to shopping centers in major cities across the country to survey

more than 900 appliance customers. The analysis found that the majority of users (81%) care about their products' energy consumption, but few (27%) were tracking it in practice. The majority of consumers (66%) did not recognize the Kenyan energy label and a further 85% did not know what it meant.
CLASP is implementing the 4-month Kenya Energy Label campaign, with high-level inputs from EPRA. The campaign focuses on refrigerator/freezer, air conditioner, and motor labels, but will also establish brand recognition for subsequent campaigns on other products covered by energy performance standards. The campaign is running on Facebook, Twitter, Instagram, and Google Ads from October 2020-January 2021. The central campaign message, More Stars, More Savings, speaks to the five-star guide that demonstrates how much energy, and correlated energy expenditures, can be saved by purchasing appliances with higher star-ratings.

Session slot: *3.01.03*

Why', 'how much' or both? Comparing social comparison and real-time feedback to promote resource conservation

Presenter: Tomberg Lukas, RWI - Leibniz Institute for Economic Research, Germany

Abstract:
Based on a field experiment, we estimate and compare the effects of three different kinds of informational interventions on resource use and consumer surplus. The three interventions are real-time feedback (RTF), social comparisons (SC) and their combination (DUAL). In a field trial with around 600 participants, we study the effects of these interventions on showering behavior. Based on real-time behavioral data and a randomized experiment, we estimate the causal effects of these interventions on water consumption per shower. Furthermore, we analyze survey data providing background information on the subjects and willingness-to-pay statements for the different interventions at different points in time. We find that all the interventions lead to substantial reductions in water use per shower. The effect of RTF exceeds the effect of SC, while the effect of DUAL amounts to roughly the sum of the effects of RTF and SC, with reductions of more than 30% compared to the water use per shower of the control group. On average, the subjects indicate exceptionally high amounts they are willing to pay to receive one of the interventions, and these amounts are nearly unchanged through first experiences with these interventions. Tentative evidence suggests that the willingness-to-pay for the SC intervention is slightly lower than for RTF and DUAL. Overall, the results suggest that most participants view all interventions as helpful and appreciated tools to reduce their own resource use, and based on the field trial data, these tools prove to be highly effective. In a further step, a structural economic model is used to combine the showering behavior data and the survey data into one model to quantitatively estimate the welfare effects of the interventions.

Session slot: *3.01.04*

Developments in the Study and Application of Behavioural Insights for Electricity Saving among Households

Presenter: Zhu Xianli, Copenhagen Centre on Energy Efficiency, Denmark

Abstract:
The recent developments in behavioural economics provide essential insights into the actual processes in human decision making and behaviours. The integration of these insights is expected to generate low-cost interventions that can effectively influence consumer choices and behaviours towards energy efficiency and conservation. The existing international experiences indicate that the social, economic, and cultural contexts of the targeted social groups can, to a large extent, determine the effectiveness of behavioural integrated policies and interventions. This paper will do a thorough review of behavioural insights application trends in energy efficiency policies and programs targeting household electricity consumption. It will cover the published studies since 2010 on the relevance, designing, and effectiveness of various solutions and their effectiveness. Based on the above analysis, the author will also map the methodologies and findings of these studies and the gaps and issues for further research.

Session slot: 3.01.05

Review and analysis of Ecodesign Directive Implementing Measures: product regulations shifting from energy efficiency towards circular economy

Presenter: Barkhausen Robin, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Abstract:
The EU Ecodesign Directive was introduced in 2005 as a framework to improve the environmental impact of energy-consuming and, since 2009, energy-related products. As a holistic framework, the Directive offers the possibility to consider not only the energy consumption of a product during its use phase, but a wider range of environmental aspects along the entire life cycle, including local and global emissions, waste generation and material reuse and recycling.
Over the years, the number of implementing measures regulating individual product groups increased, as did the variety and ambition of product requirements. Today, more than 25 product groups are covered and the regulations increasingly exhaust the possibilities to go beyond pure energy efficiency improvements and use a wide range of functional and informational requirements to address broader resource efficiency options.
We take a look back at the development of the Ecodesign Directive's implementing measures to analyse their past and current status and to detect trends. By screening the implementing measures developed since 2005 and the current draft regulations, the diversity of requirements is captured and visualised. Against the background of the EU Circular Economy Action Plan (CEAP) from 2020 and the Sustainable Product Initiative currently under preparation, special attention is given to the role of regulatory measures supporting the circular economy within the Ecodesign framework, such as requirements on the use of materials suitable for reuse and recycling or requirements aimed at the extension of product lifetime.

Session slot: 3.01.06

Opportunities and limits of regulating commercial kitchen appliances

Presenter: Geilinger Eva, Swiss Federal Office of Energy SFOE, Switzerland; Peter Helm, MKN Maschinenfabrik Kurt Neubauer GmbH, Germany; Andreas Helm, HKI Industrial Association of House, Germany

Abstract:
Commercial kitchen appliances sell in relatively low volumes compared to household appliances, but their energy consumption accounts for a visible share of a country's electricity demand. Which is why the EU is considering whether to introduce ecodesign requirements and energy labelling for this product group. A single deep fat fryer or professional cooking kettle uses as much energy as three entire households (over 10'000 kWh per year).
Organizations such as HKI with the CERT commercial catering equipment database for self-regulation in Germany, ENAK in Switzerland, and the EPA with the ENERGY STAR program in USA and Canada are developing measurement methods and making energy data available for calculations and comparisons. This work happens at national level and the methods are not compatible with one another. This paper illustrates the different sets of energy performance data on the example of deep fat fryers.
The authors in this paper explore two approaches for ecodesign requirements they believe could be implemented with relative ease. The first proposal are minimum requirements regarding technical features like insulation or controls that avoid energy waste. The second proposal is to demand of the suppliers that they provide helpful information for staff training on how to operate the equipment economically. The authors draw on results of comparative measurements with and without insulation carried out by a manufacturer and HKI member for the purpose of this paper. They also consider findings from a recent study by ENAK on the energy efficiency of 16 commercial kitchen appliances in Switzerland.

Session slot: 3.01.07

Online Energy Labeling: Regulation and Compliance in the Growing Online Market

Presenter: Dubytz Katriana, CLASP, United States

Abstract:
Energy labels engage retailers in promoting efficiency and influence consumers to choose more efficient products. To achieve this goal, they need to be visible where the purchase choices are made. With the steady growth of e-commerce, it is becoming increasingly important to require the display of energy labels for appliances sold online. In 2015-2020, e-commerce annual growth for major appliances was estimated at 17% globally, which increased to over 25% in 2020 due to the Covid-19 pandemic. Appliance e-commerce growth is expected to continue as consumers gain confidence in online purchasing and e-commerce capabilities. Regulating and enforcing online efficiency labeling regulations is necessary to secure market transformation, emissions reduction, and energy conservation targets.
Only the European Union (EU), United States, and South Africa have mandatory online labeling requirements, while the e-commerce growth has been recorded in markets in Asia Pacific, North America, the Middle East, and Africa. The EU has one of the world's most comprehensive energy standards and labelling programs, and since 2015, has required the display of energy labels for online appliance sales. This paper discusses the status of online regulations and enforcement mechanisms globally, including unique challenges such as regulating online retail platforms for third-party sellers. It uses the EU case study, informed by the quantitative and qualitative evaluation of labeling compliance on 72 online retail websites for 5 products in six member states to provide insights and recommendations for policy makers and experts seeking to develop and increase compliance with online labeling regulations.

Session slot: 3.01.08

Achievements in consumer relevant product testing

Presenter: Richter Paul, Midea Europe GmbH, Germany

Abstract:
In this paper a general methodology to assess the consumer-relevance of test methods was presented, offering a first step towards more systematic assessments of test methods. In addition, at EEDAL 2019 findings from first implementations of the methodology have been presented and discussed as well. This paper is summarizing tangible achievements with regards to new EU regulations which are meanwhile in effect on refrigerators, washing machines, washer-dryers and dishwashers. An overview of recent achievements and underlying issues and possible solutions will be provided and discussed.
Consumer relevant testing procedures provide results that correspond to findings obtained when consumers use the product in practice. The results shall be representative. This is a challenge because consumer relevant testing is still conducted in a laboratory environment, where testing must be repeatable, reproducible, and at a reasonable cost level.
In view of the new EU regulations on energy labelling and ecodesign, there was the need to completely revise test procedures. This circumstance was welcome in order for test procedures to better represent real conditions of use. In addition, the requirements set by the regulations themselves were also included with regard to this aspect.
For washing machines, the loading in particular was adapted to reflect better the user habits. Another new element is that the test procedure is supplemented by additional procedures for determining the rinsing effect and the maximum temperature to which the textiles are exposed during washing. For refrigeration units an approach was adopted, measuring the energy efficiency under two ambient temperatures covering the range of consumer relevant ambient conditions. For dishwasher testing the variety of dishes was expanded, now also including plastic items, pots and mugs. A new market-relevant detergent was also introduced. These are only a few examples of achievements that have been validated. In addition to the presentation of these achievements, ways are also shown to transfer the knowledge to test procedures of other appliance categories analogously.

Session slot: 3.01.09

Behavioural analysis of dishwasher consumers during coronavirus outbreak

Presenter: Sünetci Önder, Aydoğdu Selin Buket ARÇELİK A.Ş., Turkey

Abstract:
The fast-adapting era of the Coronavirus Disease 2019 (COVID-19) pandemic causing perpetual disinfecting of the living quarters, and isolation at home for long periods brought along the salient alterations in dishwasher consumer habits just as changes in many human behaviors. This study aims to reveal main characteristics related with this change or transformation. A questionnaire research including specially selected questions was conducted with 506 respondents in Turkey to comprehend the general perception of the dishwasher users and the behavioral alterations during COVID-19 outbreak. In the scope of the questionnaire, demographic characteristics of the respondents, technical specifications of the dishwashers and auto-dishwashing behaviors were asked. General auto-dishwashing preferences disclosed with this study to observe changes in energy efficiency and water consumption. Mostly preferred programs emerged as quick wash, eco, and hygiene respectively and more than half of the respondents prefer running the dishwasher chiefly after dinner time. Additionally, the awareness of the additional functions in the dishwasher was researched considering environmental and societal sustainability. The empirical findings were discussed by comparing this research with the previous European and Turkish studies. The research yielded that the frequency of operating dishwasher amplified by 0.38 cycle per week during 2021 in comparison to the 23 European countries in 2017 (A.I.S.E., 2017). Moreover, operating it specifically on intensive mode 13.5% increased from 2015 to 2021 in Turkey (Pala and Esen, 2015) and there was 9% increase in 2021 in comparison to the European Countries in 2007 (Stamminger, 2007). It has been evaluated that these results are directly related to the fact that people spend more time at home during the pandemic period and eat their meals more at home (causing more dirty dishes), and at the same time, people's hygiene sensitivities increase.

Session slot: 3.01.10

The Effect of a Virtual Energy Community on Energy Conservation and Load Shifting

Presenter: Tomberg Lukas, Andor Mark A., RWI - Leibniz-Institute for Economic Research, Germany

Abstract:
Clean energy communities are characterised by their aim to promote renewable energy as well as energy efficiency (Gui & MacGill, 2018; Mlinarič et al., 2019). They are social networks and often entail interaction between community members, which may be conducive to creating a new social identity within their members. Initial qualitative evidence suggests that involvement in energy communities may indeed encourage sustainable energy behaviours (Biddau, Armenti, & Cottone, 2016; Middlemiss, 2011). Sloot et al. (2018) observe based on survey data that being part of an energy community potentially enhances community members' motivation to engage in energy conservation. Yet, none of these studies accounted for the self-selection of individuals into energy communities. Furthermore, an extensive literature has considered the effect of behavioural interventions on stimulating electricity conservation (e.g. Alcott, 2011; Brandon et al., 2019; Tiefenbeck et al., 2019; Andor and Fels, 2018; Buckley, 2020). While these interventions usually focus on regular customers of energy suppliers, to our best knowledge, they have not been applied in the context of clean energy communities so far. Yet, energy communities have distinct features that render the application of behavioural interventions to stimulate conservation behaviour very promising. Energy communities allow for testing the combination of new technologies with interventions that harness the potential of the new social network. This paper investigates to what extent the membership in an energy community can induce electricity conservation. It is the first study to explore this relationship in a field experiment, in which random assignment of 300 participants to treatment groups allows for the estimation of causal effects. Half of the participants are assigned to a virtual energy community. During a period of five months, the community receives monthly newsletters with energy saving tips, testimonials, comparison reports of electricity use within and outside the community, and members have access to an interactive virtual portal. Random assignment as well as access to quarter-hourly electricity data allow us to estimate the causal effect of energy community membership. We do not find any considerable effect of energy community membership on energy conservation. One possible explanation is that group identity among community members did not evolve as expected.

Session slot: 3.01.11

Empowering Energy citizenship among the Energy vulnerable

Presenter: Della Valle Nives, European Commission - Joint Research Centre, Italy

Abstract:
The literature on energy citizenship points out that citizens should engage in the energy transition in a meaningful way, without being reduced only to the role of passive consumers. This is especially crucial for the energy poor and vulnerable citizens, who, by facing multiple injustices, are at the risk of being excluded from a fair engagement. Recent studies also highlighted that promoting energy citizenship can be a way to address energy poverty and vulnerability. However its potential is still under-researched. This study contributes to this recent emerging literature by critically investigating the concept of energy citizenship in the context of energy vulnerability or poverty. More specifically, it investigates how (and whether) energy citizenship is enacted among the energy vulnerable and energy poor, and through which mechanisms is empowered. To this aim, the study employs a systematic review of best practices derived from the related academic literature and European projects. Based on the collected evidence, the study concludes with a set of recommendations for policy makers on how to promote energy citizenship among energy vulnerable and poor citizens.

Session 3.02 – June 3rd

Session slot: 3.02.01

Drivers of Blockchain energy consumption and countering measures

Presenter: Coroamă Vlad-Constantin, Roegen Centre for Sustainability, Switzerland

Abstract:
The principles of the first cryptocurrency Bitcoin were published in 2008; along with them the enabling blockchain technology was developed. Blockchains build on several pre-existing computing concepts (such as cryptographic hashes, hashpointers, and consensus mechanisms in distributed systems), combining and adding to them in an innovative way to provide secure and immutable transactions without the need of a trusted central authority. Quickly after their inception, it became clear that extending blockchains with the capability to automatically execute small pieces of code called smart contracts, extends their potential application domains far beyond cryptocurrencies.
While in the beginning a notion for specialists, blockchain technologies have recently received much public and media attention due to price surges of several cryptocurrencies, but also due to their ability to prove and transfer ownership through non-fungible tokens (NFTs), a special type of smart contracts. At the same time, it quickly became clear that the trustless consensus mechanism needed to register new transactions and produce new cryptocurrency, called mining, needs a large, continuously growing, and possibly unsustainable amount of energy.
Given growing concerns about this energy consumption, but also the diversifying application domains for blockchain technology, the current paper analyses the different factors that affect the energy consumption of one blockchain, and identifies the best levers to mitigate this energy consumption as a consequence. The results confirm that the trustless consensus mechanism based on what is called proof-of-work (PoW) dominates the energy consumption of a blockchain by a margin: While it can be responsible for over 100 TWh per year, the storage of the blockchain requires over 4-6 orders of magnitude less energy (30 MWh – 3 GWh, depending on whether its copies are stored in data centres or domestic PCs) and the coordination messages sent across the Internet over 7 orders of magnitude less (around 6 MWh).

Energy conservation measures must thus address above all the PoW consensus mechanism: Individual blockchains can switch to alternative consensus mechanisms that do not rely on proof-of-work, while company and public policies can aim at discouraging proof-of-work-based blockchains, and encourage the uptake of blockchains with alternative consensus mechanisms. The paper finally discusses both technological as well as policy measures to discourage PoW, together with their implications, in particular how they are likely to affect the storage of blockchain copies and thus domestic energy consumption.

Session slot: 3.02.02

Environmental Footprint of Data Centers and Cloud-Services

Presenter: Groeger Jens, Oeko-Institut, Germany

Abstract:
Just as it is common today to already declare the energy consumption of a washing machine on the energy efficiency label, it should be a self-evident fact in the future to also make the energy consumption and greenhouse gas emissions of an hour of video streaming, an online game or cloud software transparent for the consumer. Even if this energy consumption takes place in data centres or telecommunications networks, the consumer wants to have the choice between different efficient and environmentally friendly service providers.
The digital transformation, or "digitalisation" for short, is currently leading to a very rapid and extensive expansion of digital infrastructures and services. The expansion is accompanied by an increase in the consumption of valuable and critical raw materials, mining which leads to considerable environmental problems, high energy consumption for the production and use of IT technology, which in turn is associated with considerable greenhouse gas emissions, and the generation of electrical and electronic waste from obsolete devices, the disposal and proper recycling of which cannot currently be guaranteed.
The magnitude of the environmental effects from digitisation can only be estimated at present. Even the electricity consumption through data centres can currently only be quantified based on simple estimates. The electricity consumption of telecommunications networks is completely unknown. The poor knowledge of the energy consumption and environmental impacts of digital infrastructures is problematic for several reasons. The availability of sufficient and securely available raw materials is a prerequisite for the future production of IT technology. Resource conservation and the establishment of a recycling system for rare raw materials are therefore essential for future viability in this area.
Parallel to the digital transformation, a transformation of the energy supply ("energy transition") towards more renewable energies, decentralised energy generation and a stronger coupling of generation and consumers is underway, with the goal of making the energy supply climate-neutral by 2050. Since data centres have a high electricity demand, which will continue to rise sharply in the future, they must also be integrated into a changing energy supply. For this to happen, knowledge about the energy demand of data centres must increase, data centres must exploit opportunities to increase efficiency and, comparable to other energy-intensive industries, they must ensure flexibility in load management.
This conference contribution will present the methods "Key Performance Indicators for Data Center Efficiency" and "Green Cloud Computing Indicators" developed in the context of a current research project to measure the efficiency and environmental impact of data centres and cloud services and to communicate these values as environmental footprints to consumers. In principle, these methods are suitable for establishing better monitoring and making the necessary information accessible for the operators themselves, their customers and public infrastructure planning.
Topics (from the mentioned list):
4. Strategies for Increasing Efficiency: new policy tools, voluntary vs. mandatory approaches, such as building energy codes and building energy and/or environmental rating systems, policy analysis and evaluation, stimulating innovation (nationally and internationally), new programmes and barrier analysis, strategy development, priority setting, monitoring and review.
4. Electronics (Televisions, Set Top Boxes, PVRs, DVDs, Audio, Digital TV services, Power Supplies, Telephony), HomeOffice Equipment, Broadband Communication Equipment, miscellaneous electric loads (MELs), and Low Power Modes: R&D and innovation, technologies, test methods, programmes, market trends, stand-by losses, active and low power mode, technology transfer from non-domestic markets.

Session slot: 3.02.03

International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption

Presenter: Butzbaugh Joshua, Pacific Northwest National Laboratory, United States

Abstract:
Miscellaneous electric loads (MELs) research dates back over 30 years, with the earliest publications about MELs originating in the late 1980s. As the number and types of MELs have grown during the intervening decades, so has the body of minimum energy performance standards (MEPSs) and regulations put in place to control what is now a significant energy end use in the residential and commercial sectors. In particular, these MEPSs are designed to control off-mode, standby, and connected standby power consumption to prevent energy waste.
Research on MELs focuses a great deal on analyzing the characteristics of MELs, approaches for measuring their consumption, and at a higher level what constitutes a MEL. Despite these advances, there has yet to be a comparison of different approaches to curtail MELs energy consumption across regulatory bodies of MELs—both between and within countries—to identify similarities, gaps, and opportunities for crafting common language and standards. This study provides an analysis of international MELs-related voluntary and mandatory MEPSs across 12 economies to address this gap. The analysis demonstrates that although economies may share the commitment to regulate the energy consumption of MELs, there still is no common language for framing MELs, nor is there a shared understanding for harmonizing MEPSs for MELs.

Session slot: 3.02.04

Advancing Plug Load Efficiency with Utility Incentive Programs

Presenter: Gladych Katie, Pixley Joy, California Plug Load Research Center, University of California Irvine, United States

Abstract:
Energy efficiency (EE) programs have largely focused on incentivizing investments in major end uses, particularly in heating, cooling, and lighting, to great effect. However, in order to meet aggressive goals for reducing GHG emissions we must also address energy inefficiencies of plug load devices, most of which individually use relatively little energy but are present in ever-growing numbers. In the U.S. commercial sector, end uses such as cooking, computing, and office equipment made up 18% of the electricity purchased in 2019 and “other” uses, such as medical and laboratory equipment, made up 32%. In the residential sector, 14% of the electricity purchased was attributed to household appliances (cooking, clothes washers and dryers, refrigerators and freezers), 6% to electronic devices (televisions and related equipment, computers and related equipment) and 31% to other uses, such as miscellaneous electric loads. Energy use from plug load devices is expected to rise due to increases in both the types and numbers of devices across building types. Incentivizing customer investments into more efficient models and efficient use of these devices is complicated by a number of factors, including the wide range of device types and usage patterns. This paper presents research on how U.S. utilities can highlight plug load in their EE programs. We begin by reviewing the types of downstream and midstream incentives utilities use to foster EE. We report results of an in-depth examination of the EE programs of 19 major U.S. utilities, describing the range of approaches they exhibit toward plug loads and linking them to best practices in the field. We expand this into an international context by reviewing approaches in selected EU countries to seek additional ideas. For example, a preliminary examination of German and Austrian policies shows that energy saving at the plug load device level focuses largely on upstream efforts aimed at manufacturers rather than downstream or midstream incentives. However, utilities and other stakeholders in these countries offer many insights into how to encourage energy-efficient investments and user behavior through advice and motivation. We conclude with recommendations about how to effectively integrate plug loads into utility EE incentive programs.

Session slot: 3.02.05

Methodologies and Proposals to Facilitate the Integration of Residential Consumers in Electricity Markets and Smart Grids

Presenter: Gabaldon Antonio, Universidad Politécnica de Cartagena, Spain

Abstract:
Future electricity grids need to be flexible on the demand-side to make credible EU energy policy (specially the integration of renewable). Therefore, international trends establish that power systems will need an active consumer. Traditional barriers begin to break down; for instance, the consideration and remuneration to demand and generation resource (nowadays equal if they demonstrate similar capabilities). Active participation of customers and demonstration of their capabilities are important challenges for small and medium segments (they account for more than 50% of demand). The research network REDYD-2050 is being funded by Spanish Ministry of Science and integrates ten research groups in key technologies for DER development. This work presents the objectives of REDYD-2050, its works, points of view and experiences in different problems dealing to load and storage modeling, aggregation, load control and monitoring, markets, forecasting..., to integrate DER technologies and propose innovative solutions to problems such as:

- Modeling and aggregation of DER: The participation of demand in Markets needs the aggregation of load. Load response can be almost immediate (seconds) or out of phase to a few minutes (20-30 minutes in Ancillary Services). In Energy markets the time for response is not a problem. The idea of REDYD is to present models (load and storage) with a common framework (Physically Based Load Models) which use the same parameters to characterize response independently of requirements of markets while aggregation procedures are tuned to save time in simulation processes.
- Certification and verification of response performance: The purpose of these tools is to maximize the use of ICT, for reducing investment needs in the demand-side, and obtaining accurate information on customer end-uses (including storage) and their response. Definition of baselines are also considered.
- Economic models for DER: making easier the engagement on DER (and Energy Efficiency) through the development of a methodology to define the size of energy packages and their monetary value to deploy offers in Energy, Balance and Capacity Markets with DER portfolio but taking into account the foreseeable synergies with other policies and tools (i.e. ICT, EES or management costs).
- Enhancing the role of ICT: It plays a key role in the implementation of DER. First in terms of communication capacities, there are a plethora of DR policies with different time requirements and a wide range of technologies with different features. Therefore, it is important to own and develop simulation tools that allow both the design of communications architecture and choose the most appropriate technologies to assess the limitations of an infrastructure minimizing time and costs. Second, technologies like Big Data and Cloud Computing are critical to process (in fixed times), large volumes of data (different in nature and format) on which DR decisions are taken. Both topics are of interest for REDYD-2050 and will be discussed in this work. Finally, the use of ICT can bring some risks. For instance, a third-party access to ICT infrastructure could cause imbalances and perhaps some risks for the power system. Therefore, cyber-security is an issue of paramount importance inside REDYD-2050.

Session slot: 3.02.06

Preliminary results of a combination of change of electricity tariff and nudge-based interventions to foster energy conservation and demand response behaviour in a Spanish energy cooperative

Presenter: Aguayo Armando, Borges Cruz E., Aguayo Armando, University of Deusto, Spain

Abstract:
Applying time-of-use electric tariffs is one of the most recurrent strategies available that contemporary policy makers employ to foster changes in consumer behaviour. However, a change of tariff applied in a particular moment without an accompanying dissemination campaign, regular follow-ups or engagement strategies could lead to end-user dissatisfaction, distrust and/or relapse (e.g. rebound effects). Therefore, in this article, the results of a combined intervention related to change in the electrical tariff plus a nudge-based message to foster demand response and energy conservation actions are presented. The unit of analysis for this intervention is ten thousand

customers of an energy cooperative in Spain to whom different types of nudge messages (i.e., economic, social justice and comparisons) have been sent to different experimental groups in the cohort under study. The experiment is measuring not only the most effective change of behaviour (measured in both the reduction of the energy consumption and the modification on the load profiles of the customers) but also the impact of each of them on the purchase strategy of the energy cooperative as well as other environmental and social impact which are discussed throughout the article.

Session slot: 3.02.07

Signal orientated building energy management system utilizing genetic algorithms and artificial neural network for optimized battery operation and load scheduling

Presenter: Dieckmann Stefan, University of Applied Sciences Biberach, Germany

Abstract:
The increasing share of renewable energies is challenging the stability of today's electrical power system due to their fluctuating feed-in, making a CO_2-free energy supply more difficult. A current policy to manage occurring power peaks is the Redispatch, that obliges grid- and plant-operators to combine their forecasted demand profiles in order to predict and avoid bottleneck situations which otherwise might cause a downregulation of renewable energy plants. However, this strategy focusses on the flexibility of the production site, neglecting the grid smoothing potentials of industrial and residential "prosumers". Especially the latter provide a significant flexibility regarding flexible devices in every household and the increasing number of PV-storage systems and electric vehicles.
In this paper, a user-orientated and grid supportive operation of a prosumer's household is achieved by optimizing the battery usage and the time schedule of flexible loads with respect to an external grid signal. The system is modeled via timeseries of solar yields and electric demand, the latter consisting of a baseload and individual load profiles of flexible devices. As a reference system, no shifting is done and the battery operation is simulated as non-grid-supportive and simply surplus-charged. Optimizing the storage operation, a reduction of the cost function, being the integrated product of the grid signal and grid power over time, could be achieved by the implementation of an improved genetic algorithm that schedules battery usage and a minimum amount of grid interaction. Next, a second genetic algorithm was applied to a flexible load shifting. Although restricted by the user defined shift range and the prediction horizon, which is dependent on the forecast's accuracy, the algorithm is able to schedule flexible loads efficiently. Combining the optimized storage operation with the flexible load shifting a significant drop of the cost function is achieved, leading to a user orientated operation that reduces the carbon dioxide emission of consumed energy, the electricity costs or any other criteria represented by the grid signal. Since both optimization approaches are dependent upon the forecast of the electric baseload, this part is a crucial factor for the optimization efficiency. Therefore, an artificial neural network is implemented and evaluated due to its flexible adaption to changing demands. In future applications of this optimization strategy a system monitoring is to be considered for the continuous improvement of the integrated forecasting tools.

Session slot: 3.02.08

Verification of Demand Response: the customer baseline load in residential customers

Presenter: Gabaldon Antonio, Universidad Politecnica de Cartagena, Spain

Abstract:
A main concern for energy actors and authorities is to develop the portfolio of demand response (DR) on an equal footing with respect to conventional supply-side resources. For instance, article 17 of the EU Directive 2019/944 establishes that "Member States shall allow final customers, including those offering DR through aggregation, to participate alongside producers in a non-discriminatory manner in all electricity markets ". This issue includes the payment for the resource's performance potential. This must be measured and verified in an easy and right way.
The achievement of this objective requires right and understandable economic flows: customers should receive credit according to the flexibility they provide, which needs an accurate evaluation of the changes in demand that occurs while DR performs. A forecast of demand (demand and generation in the case of prosumers) considering loads and DER resources is needed. The physical behaviour of loads and customers can

change due to several parameters: weather, type of day, end-use shares or the frequency in DR calls. It is important to state that both in “real-time” and after a DR event happens. Aggregators, LSE, LCE, and System Operators (DSOs or TSOs) should estimate the “steady-state” load of their customers without DR (that is, the so called Customer Baseline Load, CBL) with respect to smart meter measurement after DR.
Some factors should be considered during the development of a baseline: accuracy, simplicity and integrity. The accuracy of both the baseline estimation and the achieved flexibility is important to avoid paying too high an incentive for DR while still encouraging participation. It is also crucial, for the customers, to recognize their value in participating in DR and to avoid non-performance penalties or the underestimation of demand reductions. For instance, some utilities and operators argue that when a market participant schedules DR policies for many consecutive days, baselines no longer reflect a customer’s “normal” electricity usage. These remarks are a concern because the interest in DR may be reduced on the premise that its costs are usually high, and this casts a doubt on the recovery of the investment made in enabling technologies.
Moreover, a baseline methodology must be robust to face to manipulation attempts of some customers or entities. SOs think that customers could simply shift load from day-to-day to different hours to affect the calculation of actual curtailment. These changes in patterns should be detected by baselines to ensure DR integrity. Besides, CBL methodology should be as simple as possible and should consider the characteristics of customers and markets where DR resources are deployed. If CBL is too complex when it comes to providing a more accurate estimate of “normal” demand, it could lead to a lack of interest on the part of aggregators and customers.
The main results and contributions of this paper can be summarized as follows:

1) The paper presents a review of main CBL methodologies: advantages and drawbacks found in the literature for specific methodologies (ANN, machine learning, regression) and traditional approaches.
2) The paper compares selected conventional methods (HighXofY,MidXofY, NearXofY…) for some small and medium customers, and discusses the exclusion periods and days to be applied for the evaluation of CBL. Aggregated and elemental baselines are considered.
3) The paper discusses a method to improve the performance of previous CBLs methods through the consideration of Physically-Based Load Models (PBLM) that can also be used by aggregators to evaluate the potential of DR: air conditioning, heat pumps, ventilation (HVAC) and water heaters (WH), which are relevant load for the DR portfolio. This approach usually outperforms conventional CBLs.
4) The proposed CBL allows a double adjustment: forward and backward. The forward adjustment considers the possibility of preheating/precooling or weather changes, whereas the backward adjustment improves the errors due to energy payback (energy recovery periods) before the control. This is of interest for balancing purposes.
5) The paper compares errors in demand (a usual metric in the literature) but also describes some errors in income due to the change of Energy Market prices that customers lately suffer in tariffs in some EU countries, for example, the residential customer segment in Spain during 2021.
6) The methodology can take advantage from other potential tools being used by aggregators or utilities, for example: Non-Intrusive Automated Load Monitoring (NIALM), Short Term Load Forecasting (STLF) and renewable forecasting, in the case of prosumers, which makes more complex the approach.
7) The proposed CBL can be useful in complex services related to load energy recovery after DR (payback/snapback) and determine the energy balance between aggregators (and customers), Load Serving Entities (LSE) and Balance Responsible Parties (BRP).

Methodologies and Proposals to Facilitate the Integration of Residential Consumers in Electricity Markets and Smart Grids

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Abstract

Future electricity grids need to be flexible on the demand-side to make credible decarbonizing energy policy (specially, the integration of renewable sources). Therefore, international trends establish that Power Systems will need more active consumers which will have small generation resources, some storage facility and should increase electrification (e.g., transportation). Traditional barriers begin to break down; for instance, the consideration and remuneration of demand and generation resources (considering their capacities). An active participation of customers and the demonstration of their real and future capabilities are important challenges for small and medium segments. The research network REDYD-2050 has been funded by Spanish Ministry of Science since 2015 and it integrates ten research groups in key technologies areas for the development of Distributed Energy Resources (DER). This work presents the objectives of REDYD-2050, some of its works, points of view and experiences in different problems dealing with load and storage modeling, aggregation, load control and monitoring, enabling technologies, cybersecurity concerns, markets, demand and generation forecasting. All these methodologies with the aim to integrate DER and propose innovative solutions to problems which will appear in the short and medium term.

1 Introduction

The main purpose of REDYD-2050 research network is to exchange knowledge and experiences that will contribute to the development and deployment of DER in Power Systems. For this purpose, it is necessary to develop and improve methodologies to evaluate technical capacities of DER and compare them with "conventional" supply-side resources. Also, it is important evaluate their cost-effectiveness in future [1] and non-conventional markets [2] because different revenue (supply vs. demand) is a barrier of entry for new technologies. Obviously, equality in revenue must be based in the principle of equality in capabilities. These hypotheses must be demonstrated and verified for DER, and specially for Demand Response (DR, e.g., equality in revenue has been established in the USA in 2011 but modified in 2020 [3]). The so-called "Energy Union" is one of the thematic priorities for the European Commission (EC), where DER should play a key role in energy policy if the integration trend of RES aims to be credible. According to IEA reports [4], the share of RES in residential and service buildings in the EU increased around 24% in 2017. In this year, total renewable energy accounts for around 50 Mtoe (the direct use of RES for electricity and district heating in building). EC states [1] that the future electricity market should have at its core an active consumer taking advantage of new and enabling technologies to reduce their costs and allowing that customer fully participate in the energy transition. From the economic point of view, the potential of DER is relevant.

For instance, benefits from 120 M€/year to 1440 M€/year in the EU (depending on the scenario being considered). Technically, DR could explain 24% of peak shavings in the most favorable and ideal forecast [5].
On the other side, small and medium consumer segments explain for more than 50% of consumption of EU-27 [6], so their contribution in new markets and services is of the highest economic interest. But customers need demonstrators, pilots, and in-depth exploration of their possibilities. The development of DER in these segments is complex and includes the linkage amongst many different problems (figure 1): the need for aggregation and third parties; the deployment of Information and Communication Technologies (ICT) and the capital cost efficient loads; the complexity of markets; the lack of experience or pilots (e.g., in local markets); lots of barriers (legislative, education, minimum aggregation levels); complexity of products and markets or the volatility and scarcity of cost and revenue.

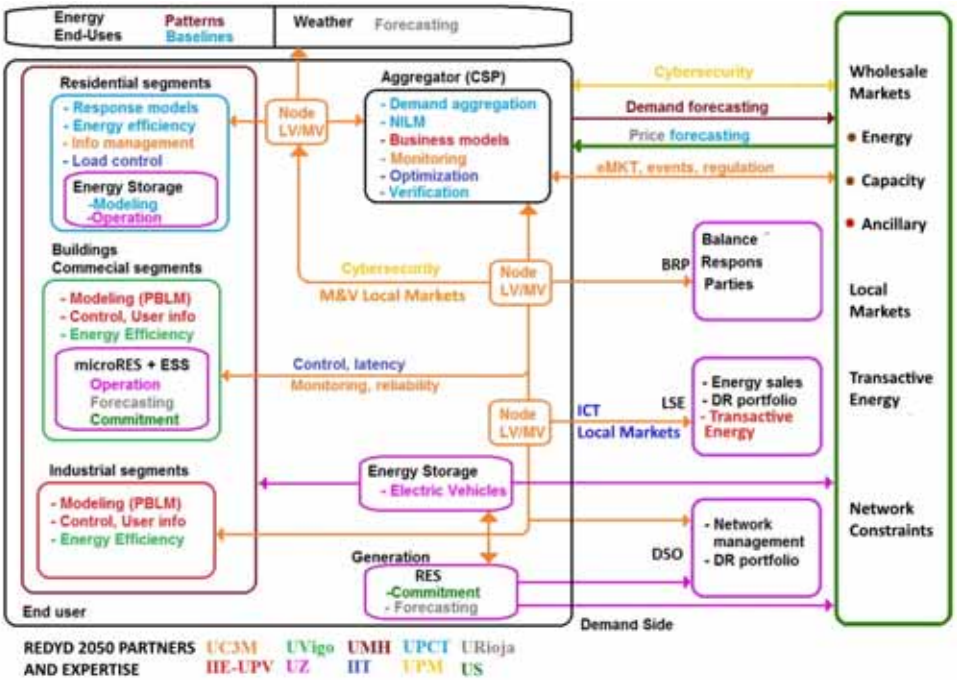


Figure 1. REDYD2050 overview of DER issues, framework, tasks, and expertise of the consortium by team (team acronyms: UC3M: U. Carlos III; UMH: U. de Elche; IIT; Comillas Pontifical; US: U. de Sevilla; UPM: U. Politécnica de Madrid; IIE-UPV; Institute for Energy Engineering; UZ: U. de Zaragoza; UPCT; U. Cartagena; URioja: U. de La Rioja; UVigo: U. de Vigo).

Main REDYD-2050 contributions and future developments in some of these areas depicted in figure 1. It represents the interaction between some of the tools being used by the different agents involved in DER: customers, aggregators, marketers, Curtailment Service Providers (CSP), Local Serving Entities (LSE), Balance Responsible Parties (BRP) or Distribution Systems Operators (DSO). A main concern is that small and medium customer need a minimum threshold to participate in markets and services (from 50kW to 1MW according to different rules of each market or country). This can be done through aggregation. First, the evaluation and deployment of DR potential need some elemental models (PBLM, left side in figure 1) and further aggregation procedures to simulate the aggregated response (houses, buildings…). In this way, the aggregator of demand is able determine the potential of resources (e.g., minimum reduction levels, loss of load service, energy recovery…). As DR is usually achieved by Thermostatically Controlled Loads (TCL) with some kind of storage (explicit or implicit, i.e., the walls of the dwellings or a heat reservoir), aggregators need some tools to perform DR simulations before the event or response is due to guarantee that customer service remains above some limits (e.g., indoor or water temperature).
Another important aspect is the necessary linkage between tools and methodologies. For example, Non-Intrusive Load Monitoring (NILM) applied to Smart Meter (SM) data to tune the parameters of each PBLM model.
But at the present aggregation is a problem that encompasses more resources than load. Prosumers increase their share in distribution systems and include storage and generation which changes net demand (left side of figure 1). Then, it is necessary to consider homogeneous and heterogeneous

groups of loads and storage resources. Another use of NILM is to help in the development of average end-use patterns (i.e., the so-called Customer Baseline Load, CBL) from smart meters' measurements. Another example of synergy between methodologies is the participation in energy markets (right side of figure 1). The aggregator needs load forecasts to define the energy requirements in day-ahead markets and avoid penalties in balance markets, but also price forecast to evaluate the potential of implicit DR through economic models for DER.
The rest of the paper is organized as follows. Section 2 is dealing with the literature review of CBLs, focusing on their importance in DR programs, the wide range of existing approaches and their relationships with STLF methods. In Section 3, a revision of traditional CBLs and their adjustments are introduced, the PBLM is explained and the procedure to evaluate the DR performance from an economic point of view is presented. Section 4 depicts the case study and illustrates the necessity of new adjustment factors to improve CBLs, whereas Section 5 shows the results obtained for the case study when the proposed method that considers PBLM is applied. Finally, in Section 6, some conclusions are stated.

2 DER and Active Customers

2.1 Characterization and Aggregation of DER

It is important that markets are not unnecessarily complex to understand (from the point of view of small/medium customers) and access to complex products (customers and aggregators). Also, it is recommended in the EU [7] that the barriers for entering multiple markets must be lowered, to help the so called "stack value" across markets. For these reasons, it seems necessary to use flexible and "simple" tools to characterize and aggregate DER.
In this case, the proposal of REDYD2050 team is the use of Physical-Based Load Models (PBLM, [8]), i.e., grey-box models. The philosophy of these models is that they intend to reflect the physical phenomena of the loads and their environment through a simplified thermal-electrical analogy. In this way, the model can be fitted and committed to develop several tasks. In this case, different commitments for energy balance, ancillary services, energy markets, or capacity markets in simple and complex products can be achieved, as it was proposed in [9].
Figure 2 depicts an example of this methodology for Water Heaters (WH). The hot water reservoir, i.e., the capacity of energy storage is modelled by two capacitors (C1 & C2) in the equivalent model (these two capacitors represent the stratification of hot/warm/cold water during the periods of use of the load, mainly during water draws). Energy conversion is represented by two current sources (for the heat pump, H_{HP}, and the auxiliary resistor). The control by a switch that can change the operation (single or dual sources) of the real load. It is also necessary to consider the service the customer obtains from this load (hot water flow q(t) at X_1 temperature) and to monitor (or simulate previously) this temperature to avoid customer discomfort during a control. All these parameters can be estimated with AI methodologies, for example Genetic Algorithms from submetering devices database or from Non-Intrusive Load Monitoring methodologies (NILM) in real situations.

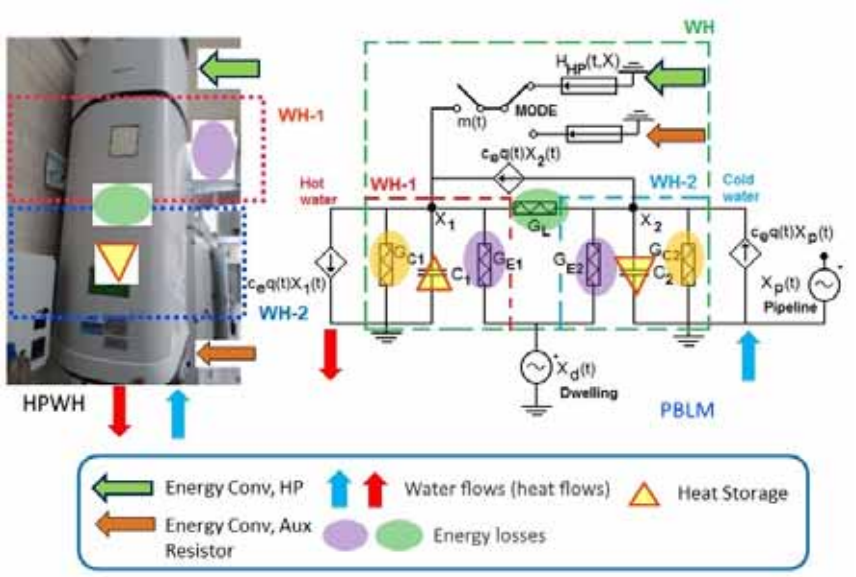


Figure 2. Electrical-Thermal equivalent of Heat Pump Water Heather (HPWH): appliance and physical processes being modelled.

This model can be mathematically represented by a state-space system. Eigenvalues of this system allow the aggregator to obtain the different periods in the load transient state and determine the necessary changes in the model (reductions/refinements) and the horizon of response of the load (i.e., demand reduction vs. load service). According to these values, specific markets and services can be selected as a suitable target for DR through the load. Moreover, these values enable the definition of criteria for the aggregation of different loads (homogeneous and heterogeneous groups, depending on minimum levels of response in each system, from 50 kW to 1MW [23]) and different end-uses to guarantee a fast or coherent response of load group in complex scenarios (e.g., several markets and services). It must be considered that other DER resources could be managed out of load. This is a core issue for REDYD2050 research groups in the future horizon 2050.
The consideration of service variables (e.g., temperature of hot water X1, state of charge…) makes possible to determine the availability of each DER resource to participate in different markets: balance (through storage) and frequency services (energy conversion through HP compressors and auxiliary resistors) without a significant loss of load service (in the case of figure 2, q(t) at a minimum temperature).

2.2 RES Forecasting

Short-term forecast of power generation in small-scale plants based on RES integrated in grids (medium and low voltage) is essential to enable a successful participation of small and medium consumers in electricity markets and smart grids. In this context, special focus has been placed on photovoltaic (PV) power generation forecast, since PV systems are the RES based generation with higher global capacity annual growth in the last three years [10], and a significant part of these systems is integrated right next to residential consumers.
The development of PV generation forecasting models has followed a parallel path to the development of load or wind power forecasting models. Models based on time-series approaches, regression techniques or machine-learning methods have been widely described in the literature in recent years. In general, short-term forecasting models of PV power generation, due to the volatility of the solar resource, present relatively greater forecasting errors than load forecast models for a same time scale. Furthermore, the performance of PV power forecasting models is site-dependent, i.e. models developed for a particular PV plant may give very different performance when applied to plants in locations with different climatic conditions.
Short-term PV power forecasting models (up to 48 hours in advance) need a set of explanatory variables including weather forecasts obtained with numerical weather prediction tools. These weather forecasts correspond to global horizontal irradiance, temperature, wind speed at a few meters above the ground surface and cloud cover, all with the desired spatio-temporal resolution. Although these models give the best forecasting results for horizons above a few hours, for smaller horizons (minutes to a few hours) persistence models can offer better results. The persistence model

[11] assumes that the clear-sky index (relation between measured power output from a PV system and the simulated power output under clear-sky conditions) remains constant.
Our works, within the REDYD-2050 network, has been aimed not at developing new short-term forecasting techniques, but at illustrating how combined load and PV generation forecasts can be useful for the proposal of efficient DR strategies, and how DR actions can damper the forecast errors due to both of the combined models [12]. We have also found that simple error adjustment techniques can substantially improve the forecasting performance for 1-2 hours horizons using the PV power forecasts obtained the previous day.
In the near future, our research works will be focused on the development of PV power generation probabilistic forecasting models, i.e., models that include information related to the uncertainty in the forecast, and their integration in decision-making processes related with DR actions and consumers' participation in electricity markets.

2.3. Integration of loads and renewable sources

Four ways of using demand flexible-load resources with some kind of energy storage can be found in papers and technical reports: peak saving, energy storage, fast response and energy efficiency. Some of them have been reported by REDYD research groups [9]. Usually, ways of using DER are centered in Power System problems but, as stated before, engineers should focus their effort on new customers, and specifically in prosumers. For instance, some authors have presented [24] an elemental and an aggregated model for the Australian Power System that intend to switch controllable demand from low to high renewable sources periods and make more profitable RES in small and medium users, independently of power system peaks. Following the example presented in subsection 2.1, HP Water Heaters have been selected to show the capabilities of an aggregated model to explain changes of demand and follow small renewable PV generation. Figure 3 depicts the demand of HPWH aggregated load (blue line) without control committed to follow low price periods (ToU, dynamic tariffs or market prices). The planned target (orange line) is to change demand from early morning to morning-afternoon period to take profit or store RES capacity of generation. The result is also shown in figure 3. It demonstrates the possibilities and flexibility of this kind of loads, the possibility of interaction between DER, and the success of this flexibility to take the maximum profit from PV potential enabling the engagement of prosumers in DER portfolio.

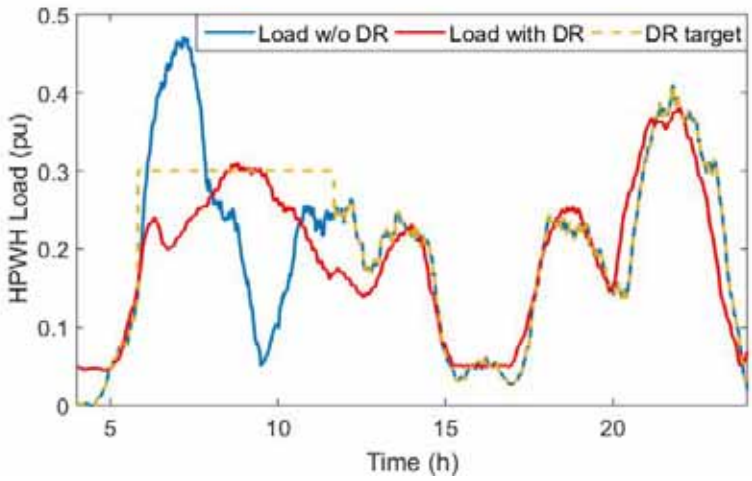


Figure 3. RES commissioning of Heat Pump Water Heater aggregated load

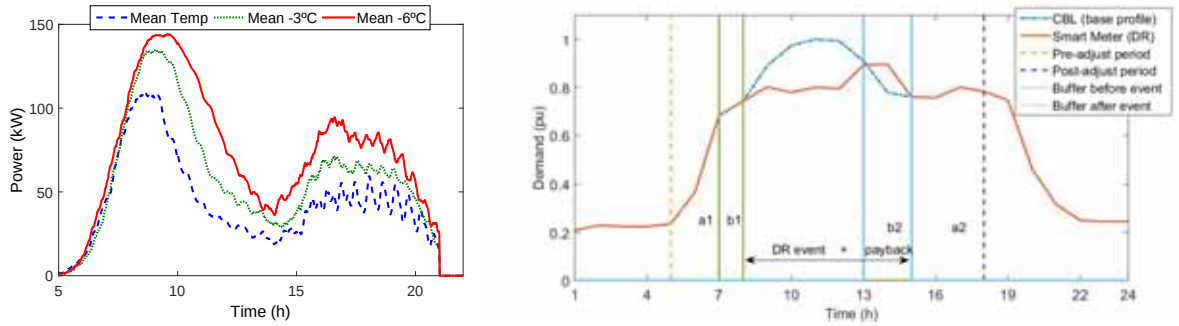
2.4 Certification and Validation: Baselines

Problems in the evaluation of revenue and the measurement of energy flows may arise when a customer has several different contracts; one with the retailer (i.e., an implicit demand mechanism appears) and another with an aggregator (providing response to explicit DR in several services or markets) [7]. Certification of DER presents the same problem. There is a need to evaluate and justify an amount of flexibility to be achieved through DER but that cannot be measured outside lab scenarios. These issues require the use of a simple and understandable Customer Baseline Load

(CBL) methodology. The lack of appropriate and standardized CBL is reported as a barrier for access to markets [7]. Usually, these CBL are not standardized or accurate, and sometimes there are specific developments for a customer (regression methods, neural networks, machine learning…) system or country. In other cases, the effort to obtain this methodology is too high and makes more difficult the penetration of DER, especially when the aggregation of resources is needed.

The proposed idea of REDYD2050 team is to use a well-known and stated CBL approach, for example the evaluation of X past data in a period Y (e.g., HighXofY, MidXofY, NearestXofY) [13] as the base profile for CBL (a basic or conventional profile), but the adjustment coefficients applied to improve the performance of CBL in conventional methods, are refined through PBLM (the same model used for the evaluation and aggregation of DER, see paragraph 2.1). This approach makes more understandable the baseline and could detect gaming or a justified change of load dynamics due to weather. A detailed example has been developed in a companion EEDAL22 paper for a commercial customer (peak load, 80kW), but other examples for university buildings (peak load, 500kW) and industrial customers (peak load, 650kW) can be found in [14], [15] and demonstrate the potential and possibilities of the proposed methodology.

The justification of the method is discussed through an example. Let us consider, for instance, the CBL in NYISO EDRP reliability program. The adjustment factor is obtained by means of the first two hours of the four-hour period prior to the commencement of the reliability event. Figure 3a depicts the behaviour of a homogeneous group of Heat Pump (HP) loads. For these loads, and for some control periods, this adjustment can be wrong. For example (figure 3.a.), from 5 to 8 am the demand is the same, irrespective of changes in weather, due to high coincidence in on periods (all loads start their duties). From a specific simulation, we can obtain, for a defined DR period (another example of DER for the overall load of an aggregated customer in depicted in figure 3b), the right periods to adjust CBL (Pre-adjust and Post-adjust, in the same figure 3b.) and the periods forbidden to choose an adjustment coefficient (buffer periods). In this case, a backward adjustment is proposed for the estimation of payback (buyback) period after control [14]. In this way, a double adjustment is proposed: before DR event to evaluate flexibility, and after DR event to asses energy recovery or "buyback", an important concern for aggregators, LCE and BRP, for balancing purposes).



a b

Figure 4. CBL proposal: (a) Simulation of HP aggregated demand for a building at three different external temperatures during winter; (b) Adjustment and buffers periods for a DR policy and period.

Table 1 summarizes some results with this methodology for three different segments: a commercial customer (SME), a university building and an industrial customer (meat sector). Table 1 compares the performance of some specific CBL approaches developed for a specific customer, the adjustment of these approaches with a "weather sensitive adjustment factor (WS) according [13], and REDYD2050 method (a base profile HighXofY, MidXofY and an adjustment coefficients based on PBLM to consider weather sensitivity of loads with double -forward and backward- adjustments, WS-PBLM).

Table 1. Evaluation of MAPE error (average event-days) for different CBL base profile and CBL with an adjustment method (WS: weather sensitive, WS-PBLM: double adjustment with PBLM).

CBL methodology		Commercial customer (EEDAL22, paper 84). MAPE	University Building [14]. MAPE	Industrial customer [15]. MAPE
Adjustment	**Base Profile**			
-	Mid6of10	14,49	-	-
-	High3of5	15,55	-	-
-	Neural Network	15,60	-	-

WS	Mid6of10	6,78	-	-
WS	Neural Network	7,09	-	-
WS-PBLM	Mid6of10	**4,78**	-	-
WS-PBLM	High3of5	5,09	-	-
-	Mid4of6	-	-	11,6
-	High5of10	-	-	13,5
-	Random forest	-	-	10,9
WS	Mid4of6	-	-	9,8
WS	Random forest	-	-	9,1
WS-PBLM	Mid4of6	-	-	**5,6**
WS-PBLM	Random forest	-	-	6,1
-	High5of10	-	10,32	-
WS	High5of10	-	4,92	-
WS-PBLM	High5of10	-	**3,87**	-

The main conclusion from this table is that "traditional" of "base-profile" baselines (HighXofY, MidXofY) reasonably estimate a wide range of customers on average DR event days, but the "traditional" methods are not the most accurate for single customers on individual event days (the table shows average values). More complex and specific baselines (Neural Networks or Random Forest, for instance) sometimes provide marginal improvements in accuracy but with a higher computational cost. PBLM adjustment enables an equilibrium between complexity and accuracy.

2.5. Local Markets and Services

New opportunities appear for DER, for instance, local markets and transactive energy [2] but they are still developed as pilots for segments of small prosumers. The increase of the price of MWh in the conventional markets (over 200 €/MWh in most EU countries since last July) opens a way to develop and evaluate new forms of energy offers and bids. The design and development of a market environment where energy transactions and operation services could be traded at local level appears as a real alternative. It will require to develop new mechanisms for the provision of services to and from prosumers to guarantee appropriate and sustainable benefits to allow the natural growing of renewables by 2050. These ideas have been grouped in the concept of "Transactive Energy". An automated energy transactions and management of DER must be developed soon. Devices such as air conditioners, water heaters, HPWH, EV, electric and thermal storage and generation would interact with aggregators, LSE, DSO, TSO and ISO. A simplified schema is depicted in figure 4, according to results presented in representative pilot experiences [2]. Home automation systems [25] have been used for REDYD2050 demonstrators showing a high performance for control and measurement [8] at an affordable cost by customers and aggregators. Other systems such as EM3 and YSI994 by Universal Devices [16] facilitate the development of the "Transactive Energy" (VTN nodes) and an effective engagement of customer. It also opens interesting possibilities for local markets, considering other methodologies developed for wholesale markets, such as PBLM, aggregation, NILM…, see figure 1. Efforts in the development of standards is also a cornerstone for this deployment of local markets (i.e., OpenADR2.0). Moreover, "enabling technology" such as EMS, SM, gateways, sensors, or actuators are the core for other DER tasks (modelling, validation, testing of DER, CBL definition), proposed by REDYD2050 teams, see figure 1.

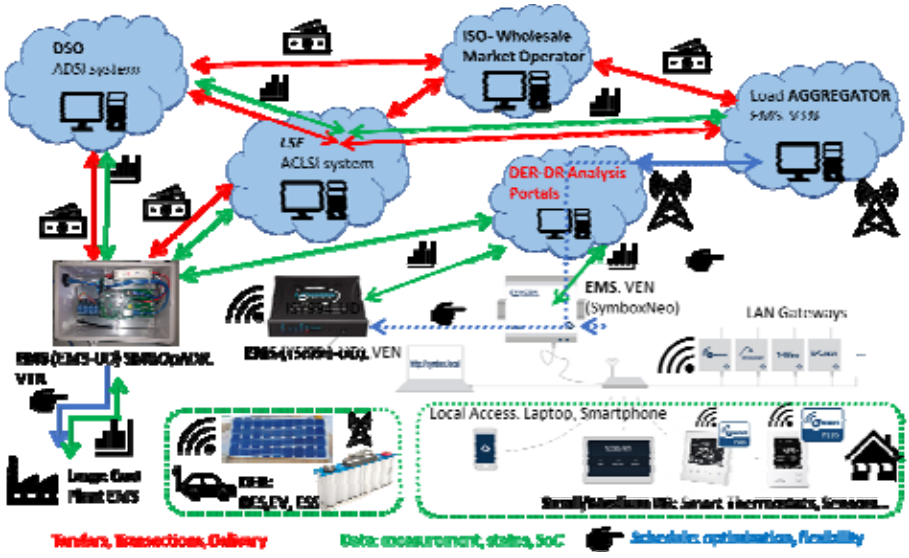


Figure 5. REDYD2050 proposed schema for Transactive Energy in the EU

The integration of enabling technologies, DER and customer opportunities through local markets requires an upgrading of the SmartGrid conceptual design as proposed in [17] to fully warranty the transparency and integrity of the transactions.

3 Barriers, Challenges and Trends for ICTs

3.1. The role of ICT in DER scenarios

Information and Communication Technologies play a key role in Distributed Energy Resources scenarios. Communications architectures, technologies, and protocols, as well as Artificial Intelligence algorithms, Big Data tools, and Cloud Computing platforms need to be carefully selected to allow monitoring and controlling consumption, generation, and storage (including Electric Vehicles) in almost real time.

Once ICT solutions have been tested in medium to large demonstrators, the next challenge is to assess how well such solutions scale (since they will be eventually deployed at medium and low voltage level) and if they can be replicated in different scenarios without incurring in huge investments. As a result, SRA (Scalability and Replicability Analysis) of ICT solutions for Smart Grids scenarios with high penetration of DER are winning momentum right now, leveraging on simulation tools as a cost and time effective mean to achieve the previously mentioned goal.

As a matter of fact, part of the REDYD team has participated in the definition and evaluation of the methodology proposed in the H2020 project INTEGRID [18] for this purpose and is currently leading the ICT SRA in the H2020 project RESPONSE [19]. Notably, the INTEGRID proposal is based on a two-stage approach: first, a qualitative analysis, mapping the infrastructure under study onto the SGAM (Smart Grid Architectural Model), is carried out to identify potential bottlenecks; second, such potential bottlenecks are quantitively evaluated by means of simulations to determine their limits [20].

In addition, to achieve the flexibility required in foreseen scenarios, the DSO-TSO coordination is essential. ICT also play an important role to allow such a coordination – in some cases – in almost real time. Part of the REDYD team is also participating in the definition of ICT architectures for DSO-TSO coordination within the scope of the H2020 COORDINET [21] and OneNet projects.

3.2. Cybersecurity concerns

ICT brings many benefits, but it also entails risks, specifically related to cybersecurity. The monitorization and control of the whole electrical infrastructure, including the low voltage level, under the IoT paradigm increases dramatically the volume of nodes with connectivity, and so the attack surface, exposing such a critical infrastructure more than ever.

Dynamic risk analysis and management methodologies and tools stands out in this scenario as a cornerstone not only to guide investments, but also to assess the risk level of the infrastructure continuously and in almost real time. However, such risk analysis resources are inherited from the IT

world, where they were developed and have been extensively used, and need to be adapted to the OT/IoT scenarios of a critical infrastructure such as the Smart Grid. These scenarios require holistic approaches, which involve proactive and dynamic cybersecurity methodologies and tools that allow identifying and responding quickly to threats that affect devices, technologies, protocols, and communications networks, as well as processes, applications, and the data they manage. The challenge now is the design of methodologies that consider the specific processes and dynamicity related to the OT systems, as well as the classical IT world.
In this context, part of the REDYD team has extensive experience researching in dynamic risk analysis and management systems [22] through several research projects. The current challenge includes the extension of this analysis to the OT scope, and the provision of and integrated cybersecurity awareness capability to the different levels of an OT management team. The work in the REDYD network is allowing to identify the specific cybersecurity requirements in the area of the DER scenarios, and how these requirements can be fulfilled in an IT/OT cybersecurity convergence approach.

4 Conclusions

Active consumer participation in electricity networks and markets is of highest interest in the EU for the development of the new internal electricity market and the decarbonization of energy mix. The existence of formal barriers for small and medium customers, the aggregation levels and, the complexity of the problem for these users, makes it necessary to share and discuss experiences amongst researchers from different academic disciplines, consumers and, in general, agents and operators of networks and markets. The sharing of experiences within the framework of REDYD-2050 platform, and the dissemination of its activities can contribute to improvements in the operation and planning of DER into the future Power Systems. The search of synergies between different research areas must be done to make possible energy objectives by 2050. REDYD is an example of this effort in the framework of R&D in Spain.
This paper has presented different methodologies and tools, and a general framework, that consider the necessary linkage between the different problems and issues in DR and DER. It has been shown that the integration of methodologies can achieve a positive benefit for the development of DER in the energy scenario in 2050, especially complex for small and medium customers. It seems necessary to develop more standard tools to avoid complexity and reduce methodological efforts in the deployment of DER, and some examples have been presented for measurement and verification issues. Also, it must be demonstrated that DER can develop a flexibility like traditional supply-side resources, and PBLM can help in this objective. Moreover, these tools need be more understandable and less complex to boost the effective engagement of customers and aggregators in DER portfolio. Finally, enabling technologies (ICT) play a main role for the management and to provide some feedback to the evaluation of modelling and the development and refining of new evaluation tools.

5 Acknowledgement

This work has been supported by the Agencia Estatal de Investigación, Ministerio de Ciencia e Innovación (Project RED2018-102618-T funded by MCIN/AEI/10.13039/501100011033)**.**

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