冰箱发展趋势及其在英飞凌可能的解决方案上的影响

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Speaker

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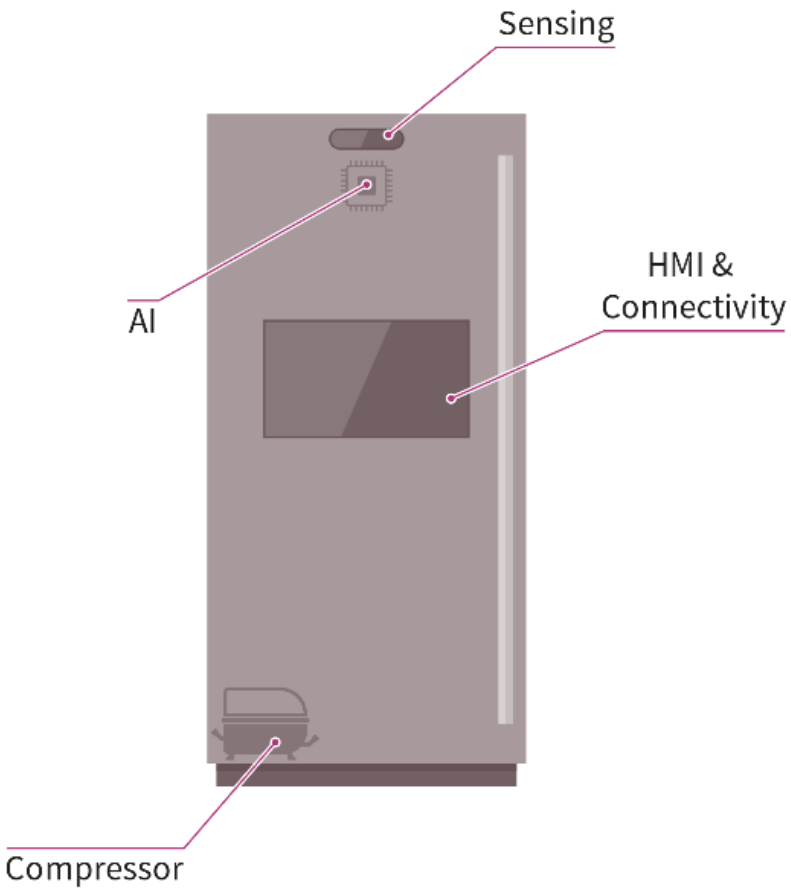
Capture and understand the application trends, then derive application roadmap and influence Infineon future system offerings.

Office: Munich

Application frame work, we take the application/system trends, break it down to various building blocks and derive requirements for offerings



Home Appliances

Washing machine | **Fridge** | ...

Motor control | ... | **Motor control** | ... | ...

Product XYZ	Product XYZ	Product XYZ	Product XYZ
Inverter	Sensor	MCU	Software / Services

System offerings

Sub-system offerings

Product offerings

Table of contents

Table of contents

Looking at major home appliances market, we observe 3 fundamental application trends but specific appliances may have their own twists

Energy efficiency and sustainability

Worldwide adaption of variable speed drive continuation; efficiency standards evolves.

System cost & size reduction

Cost sensitive market, every penny spent should enable more savings.

Smart home

Feature extension – connectivity, sensorification, Intelligence, leading to autonomous & efficient operation.

Representative smart home features

HMI

Sleek and intuitive human machine interfaces enabled by state-of-the-art touch, voice, and graphic solutions

Machine Learning

Edge computing for secure, real-time decision making

Security

Compliance with emerging policy and security requirements from node to cloud

Cloud

Secure and scalable device management with easy on-boarding supporting major public or private platforms

Wireless Connectivity

Wireless connectivity and protocols enable seamless interoperability

Sensing

Intuitive sensing bridging the real and digital worlds

Actuation

Efficient motor control

Refrigerator block diagram and corresponding Infineon product overview

Compressor motor control

- **Inverter (IPM)**: CIPOS™ Micro
- **Inverter (Discrete):** IGBTs (RC-D2 series), MOSFETs (600V CoolMOS™ PFD7), EiceDRIVER™ gate drivers ICs
- **PFC**: TRENCHSTOP™ IGBTs, Rapid and CoolSiC™ diodes and PFC gate drivers, MOSFETs (600V CoolMOS™ P7)
- **Motor Controller:** PSoC™, XMC™ and iMOTION™ family
- **Auxiliary power**: CoolSET™/ 5QR series, MOSFETs (600V CoolMOS™ P7)

Motor control

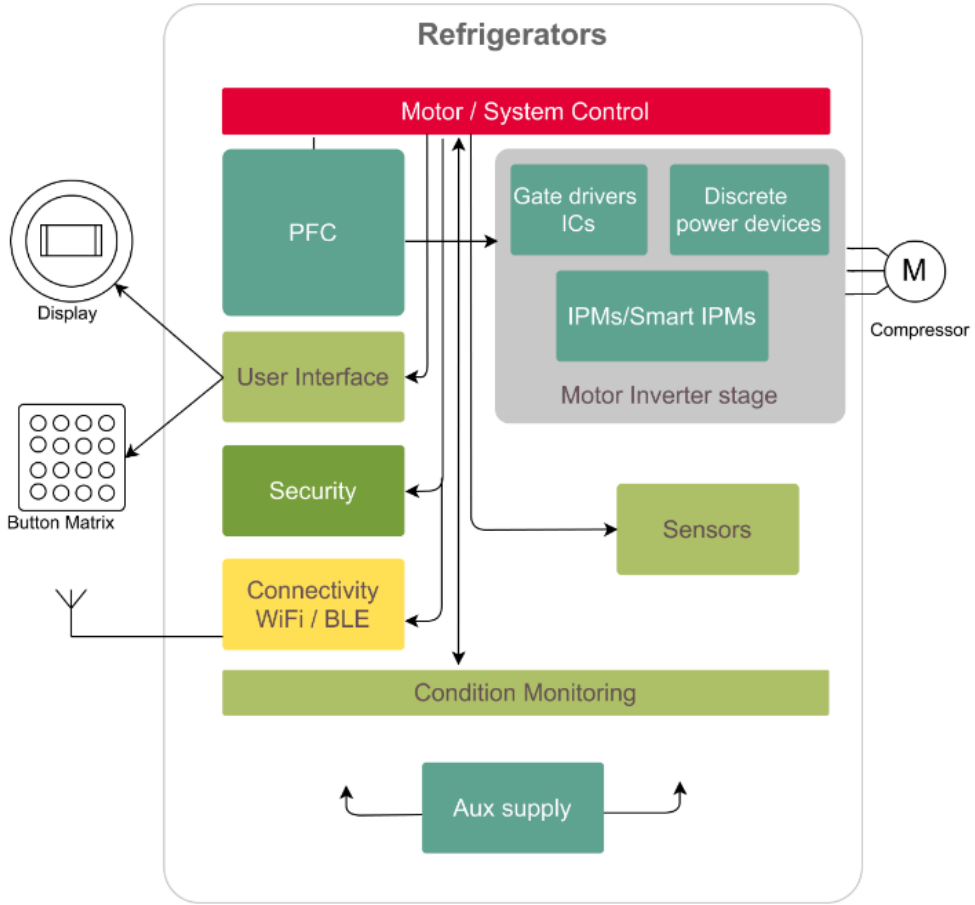
HMI & connectivity

- PSoC™ 6 for **main control, touch sensing and display**
- XENSIV™ MEMS microphone for **voice control**
- Bluetooth / Wi-Fi **connectivity** using our AIROC™ solutions
- OPTIGA™ Trust M for **secured communication**

Sensing

- XENSIV™ magnetic hall sensors for angle / **position** / 3D sensing
- XENSIV™ CO_2 sensor for **air quality** monitoring
- XENSIV™ radar sensors for **presence detection**

Smart Home



Infineon offers solutions from low to high integration choice: space, thermals & cost or assembly optimization

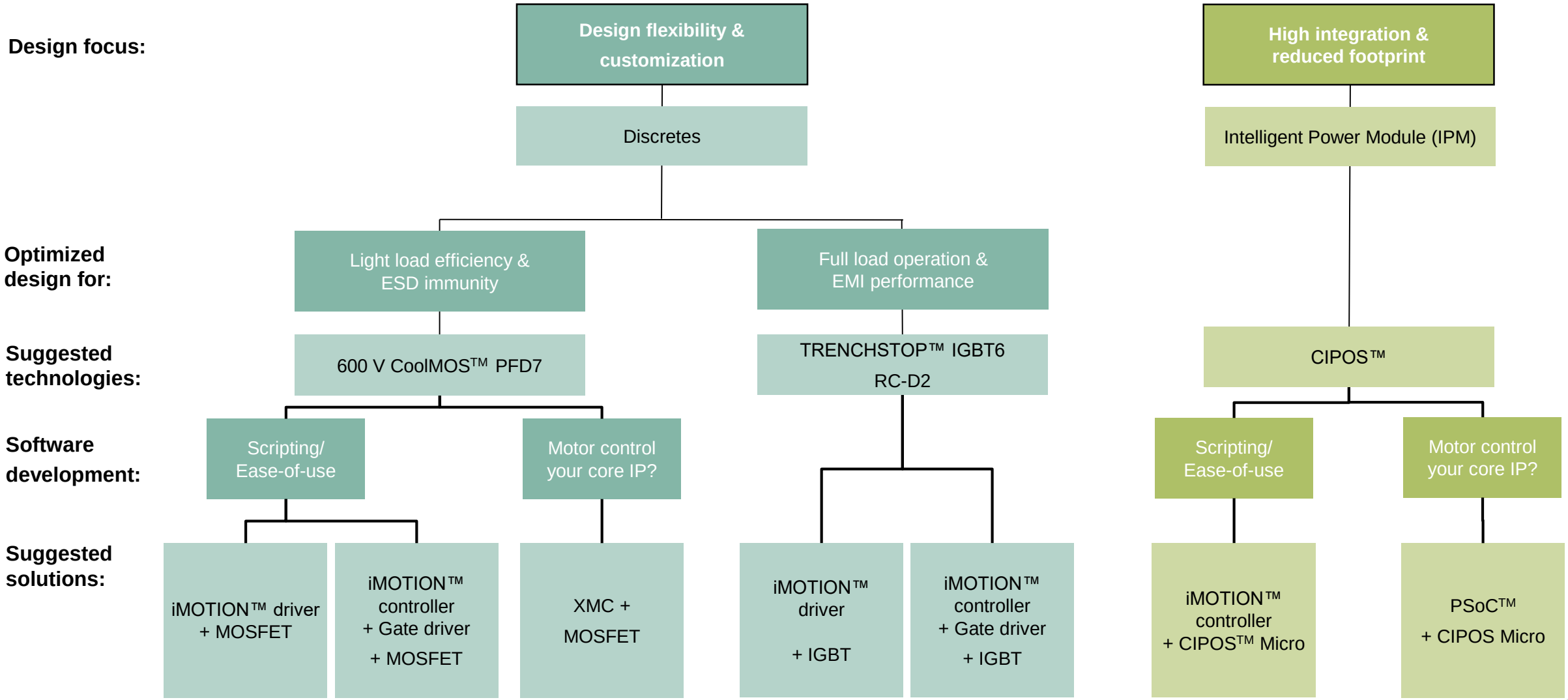
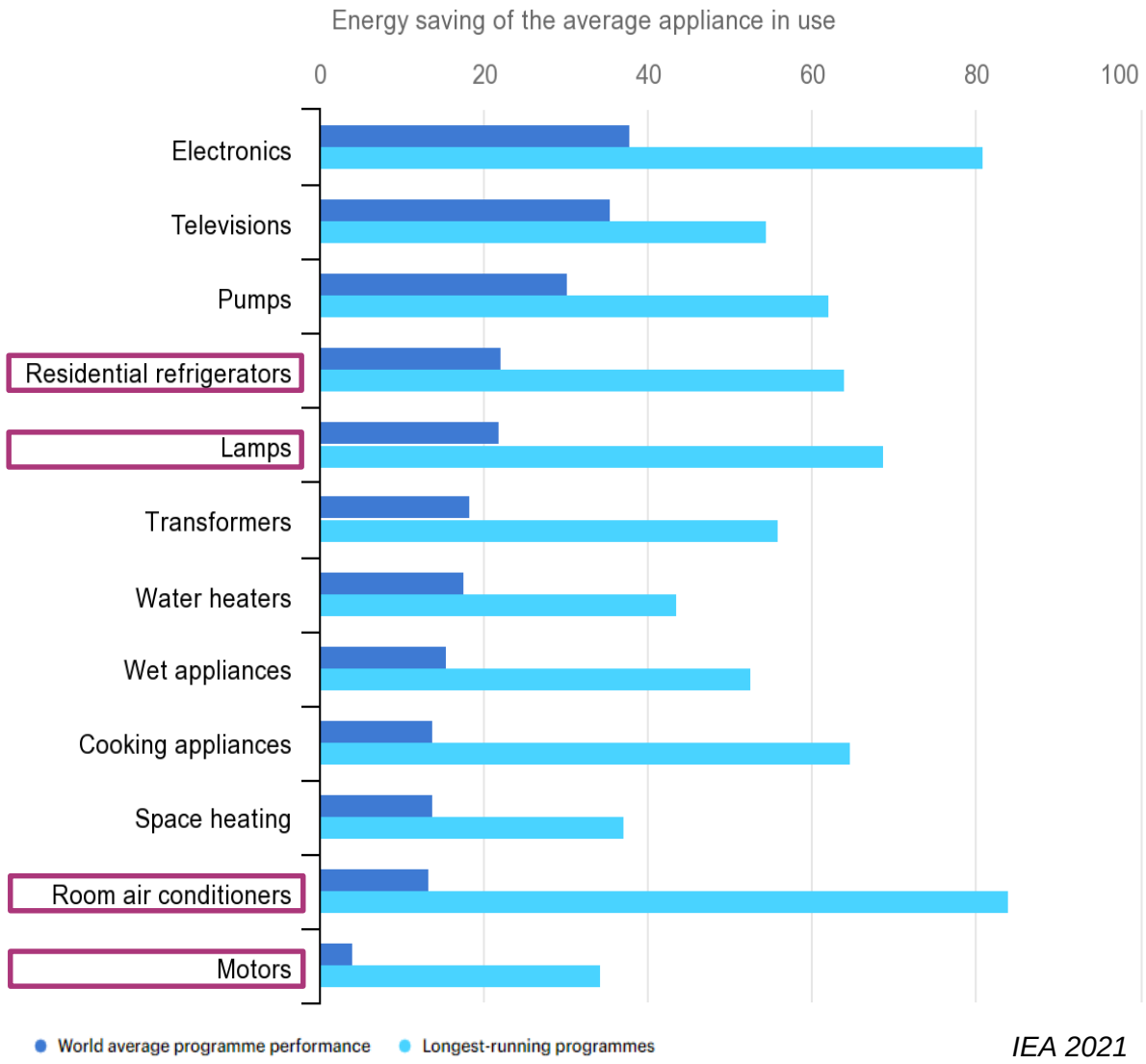


Table of contents

International Energy Agency (IEA)
Call to action on **efficient** and **smart** appliances



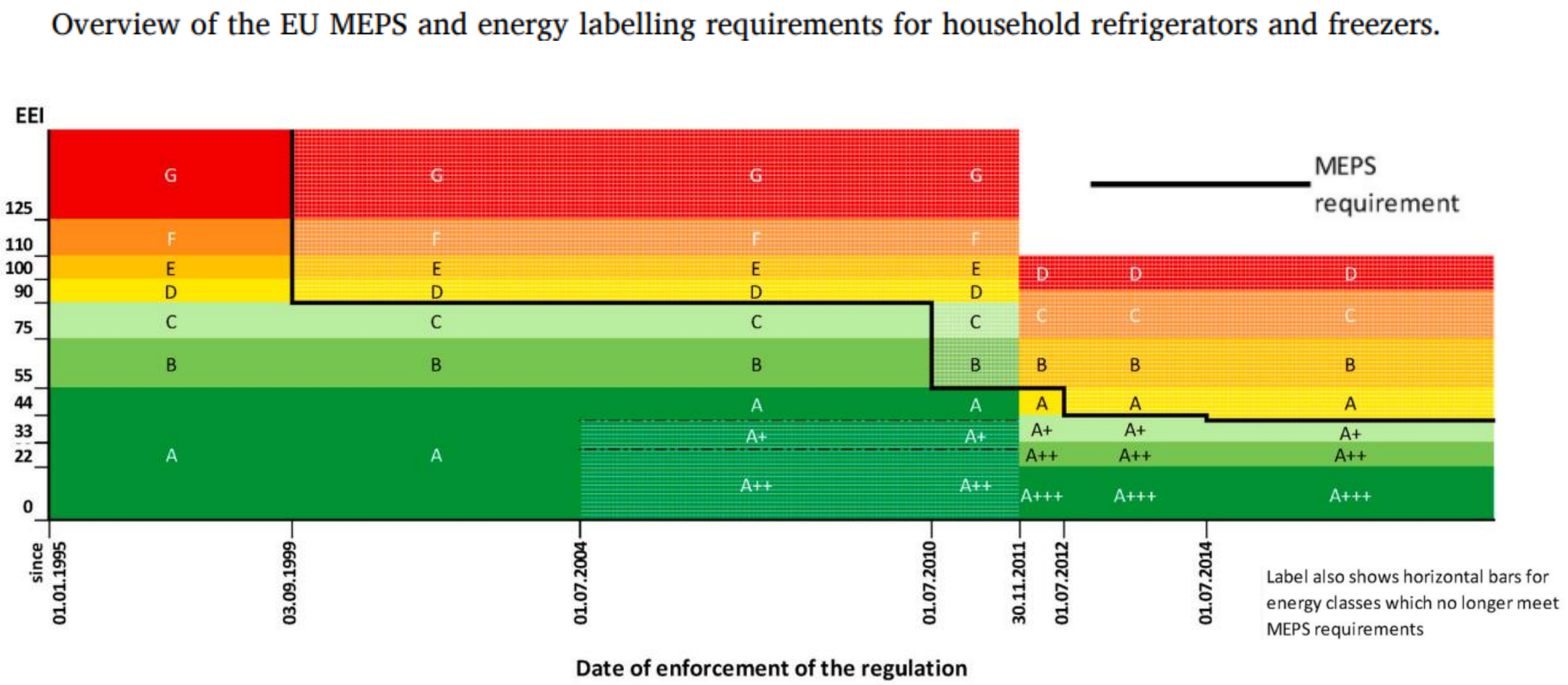
IEA 2021

Appliance energy efficiency is key to reaching net zero emissions in the electricity sector.

› **Next generation of appliances is broadening the scope of appliance efficiency policy**

– Home energy management system + more energy efficient equipment + a variety of smart automated appliances, sensors, controls and software to monitor and control appliance usage.

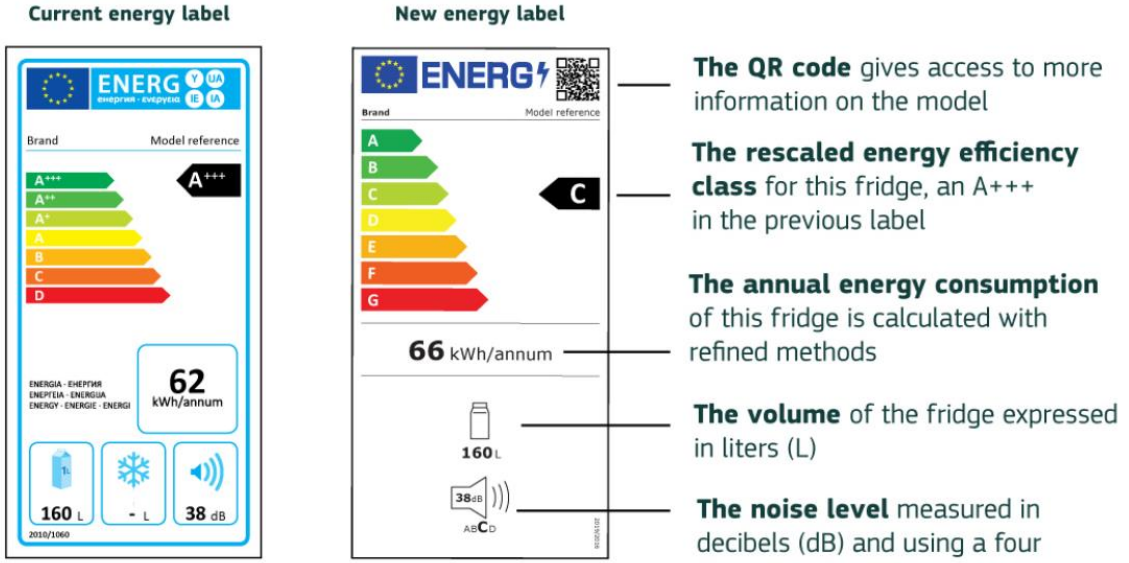
EU energy labels standard changes over time for refrigerators



J. Schleich et all, Energy policy 2021

EU energy label for fridges, freezers and wine storage renewed since **March 2021**

How to recognise a rescaled product ?



The energy labels for a fridge without freezer

$$EEI = AE/SAE.$$

= Annual Energy consumption/ Standard Annual Energy consumption

$$SAE = C \times D \times \sum_{c=1}^{n} A_c \times B_c \times [V_c V] \times (N_c + V \times r_c \times M_c)$$

= Appliance mechanical construction relevant

$$AE = 365 \times E_{daily}/L + E_{aux}$$

= average daily energy consumption relevant

Energy efficiency classes of refrigerating appliances	
Energy efficiency class	Energy efficiency index (EEI)
A	EEI ≤ 41
B	42 < EEI ≤ 51
C	51 < EEI ≤ 64
D	64 < EEI ≤ 80
E	80 < EEI ≤ 100
F	100 < EEI ≤ 125
G	EEI > 125

Source: European Commission

Fridge, Freezer, Wine Storage
EU performance distribution and ecodesign benchmarking

Legal framework is Regulation on energy labelling for refrigerating appliances (EU) 2019/2016 that repeals and replaces Regulation (EU) No 1060/2010

From 1 March 2021, the Regulation on ecodesign requirements of refrigerating appliances (EU) 2019/2019 repeals and replaces Regulation (EC) No 643/2009

COMMISSION DELEGATED REGULATION (EU) 2019/2016 with regard to energy labelling of refrigerating appliances

Distribution of the selected 27 585 models out of a total of 27 584 models

Class	Entries	%
A	20	0,1
B	68	0,2
C	489	1,8
D	1 853	6,7
E	8 147	29,5
F	14 463	52,4
G	2 545	9,2

Source: European Commission, European Product Registry for Energy Labelling (EPREL)

Refrigerator Benchmark		
Regulation	2019	2009
Volume	309 L	300 L
Annual E.	70 kWh/a	115kWh/a

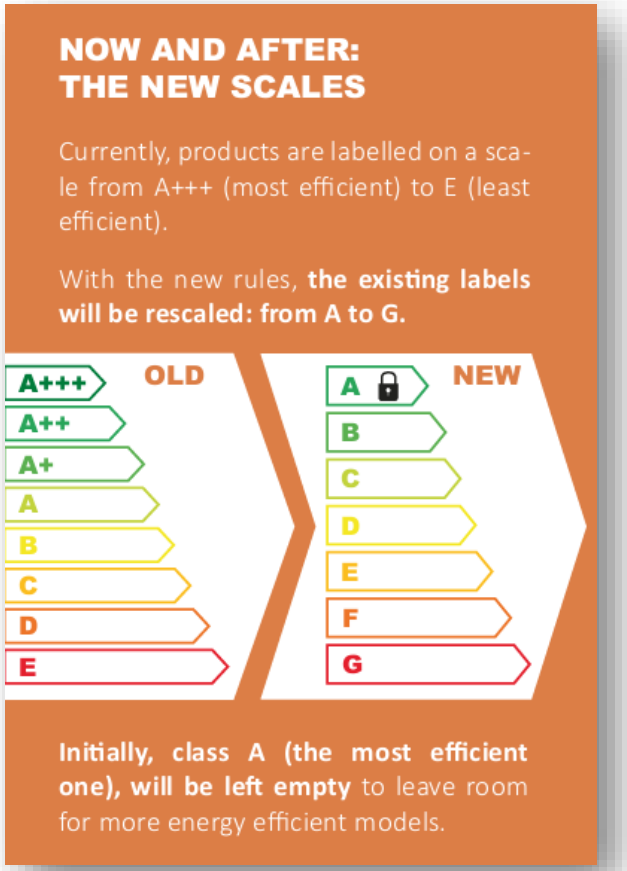
39% ↑

Refrigerator-freezers Benchmark		
Regulation	2019	2009
Volume	230 L	255 L
Annual E.	116 kWh/a	157kWh/a

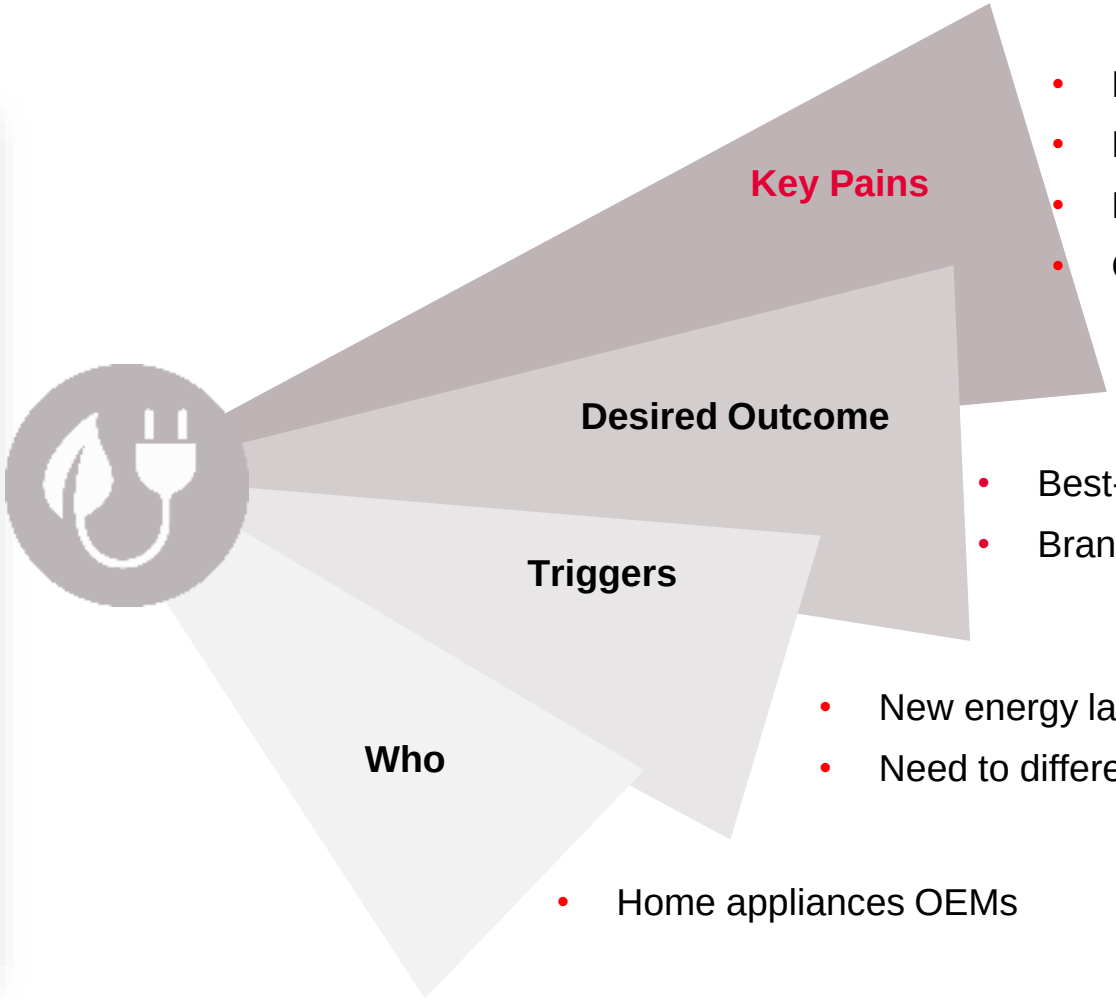
21% ↑

Efficiency

Appliance energy efficiency is key to reaching net zero emissions in the electricity sector



EU regulation 2017/1369



- High pressure to achieve ROI targets
- Limited cost-efficient options for innovation
- Long innovation cycles
- Global supply constraints

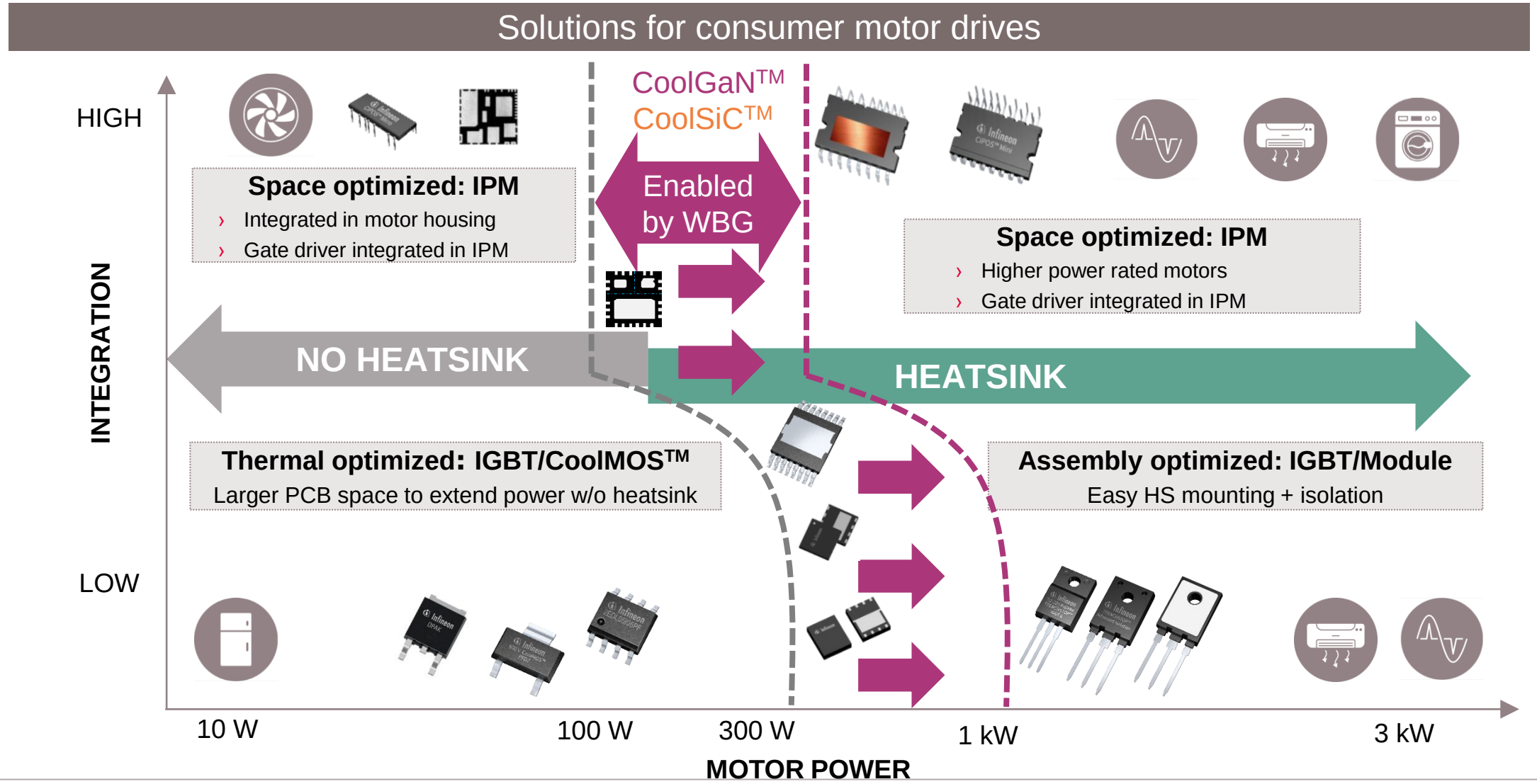
- Best-in-class energy efficient appliances
- Brand recognition & ESG* rating increase

- New energy labeling regulations
- Need to differentiating from global competitions

- Home appliances OEMs

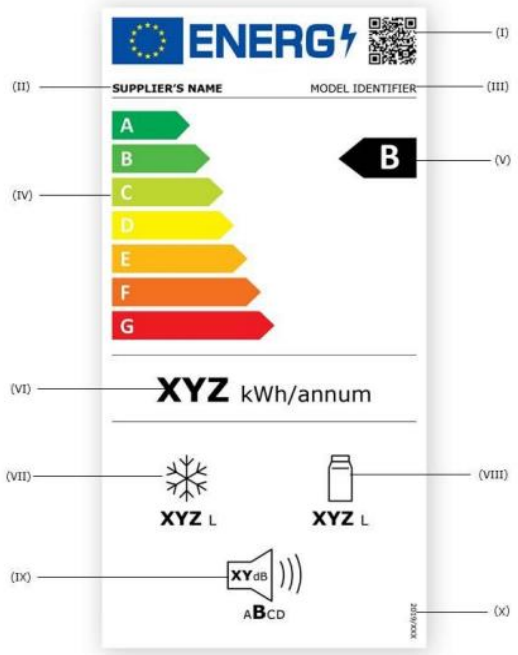
** ESG: Environmental, Social, Corporate Governance*

One method to support our customer is to tackle from power switches perspective, WBG can increase output power with same thermal system



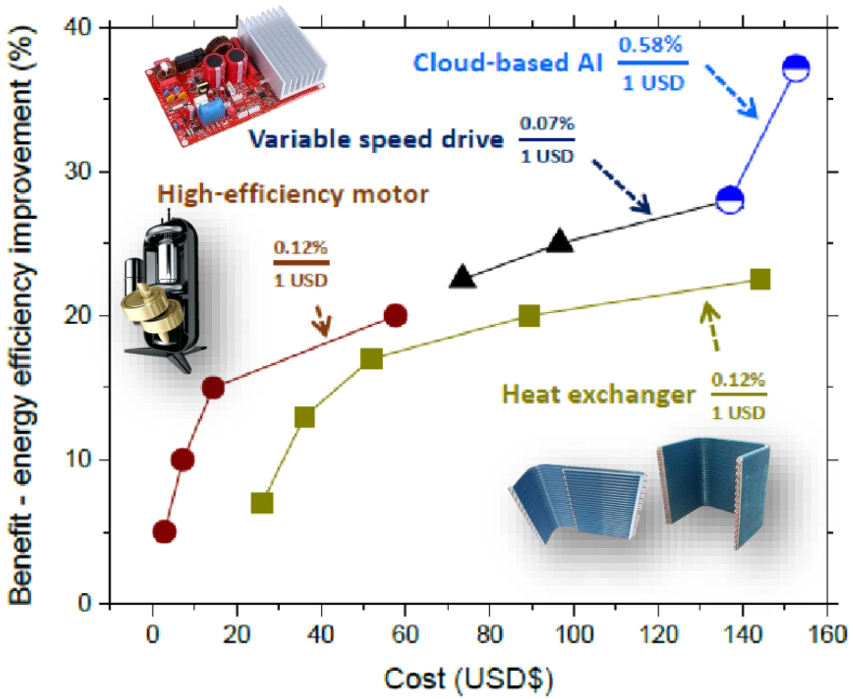
Another method to improve the system efficiency of a cooling appliances is by implementing cost efficient embedded AI solution

New 2021 EU fridge energy lable

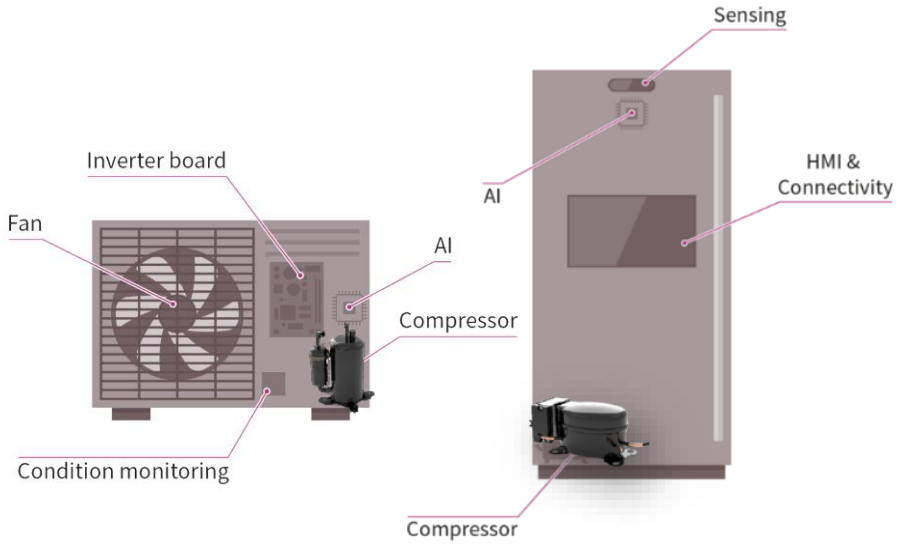


Minimum efficiency performance standard (MEPS) is becoming ever stringent for home appliances.

Study* showed AI assisted control is a cost effective measure, enabling further energy savings of an already very efficient & inverterized aircon system.

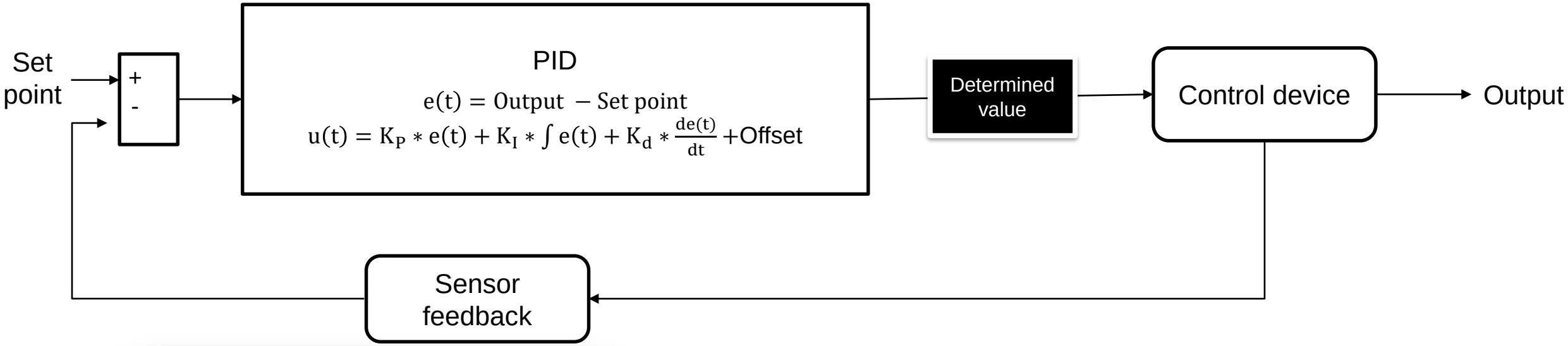


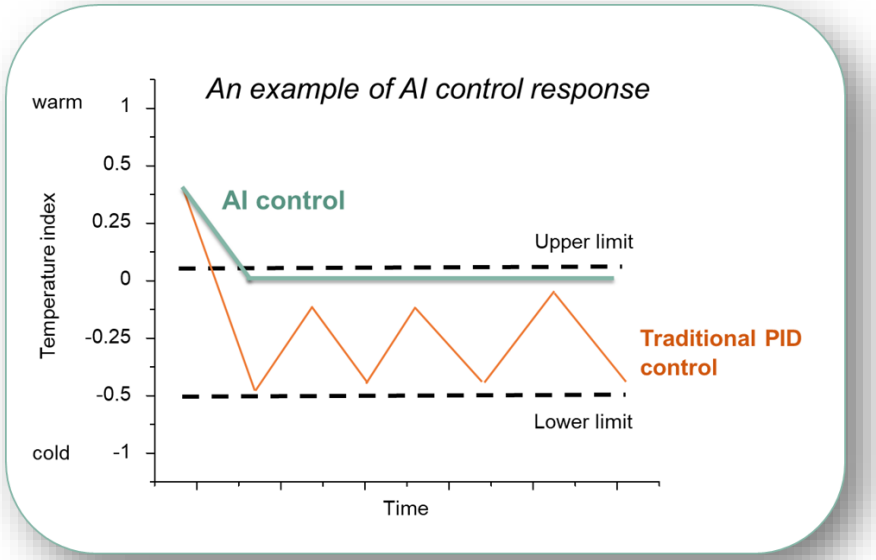
*Source: Air Conditioning Energy Saving from Cloud-Based Artificial Intelligence: Case Study of a Split-Type Air Conditioner (D. Lee et al., National Taipei University of Technology, Taiwan)



An embedded edge AI (SW+HW) solution monitors system condition, e.g., motor degradation, user habits/ preferences, then subsequently adapt operation timely to ensure lifetime efficiency performance.

Traditional PID System Control vs. Feed-forward





Tends to zero

Linear relationship to $R(t) \propto q_{ac}'$

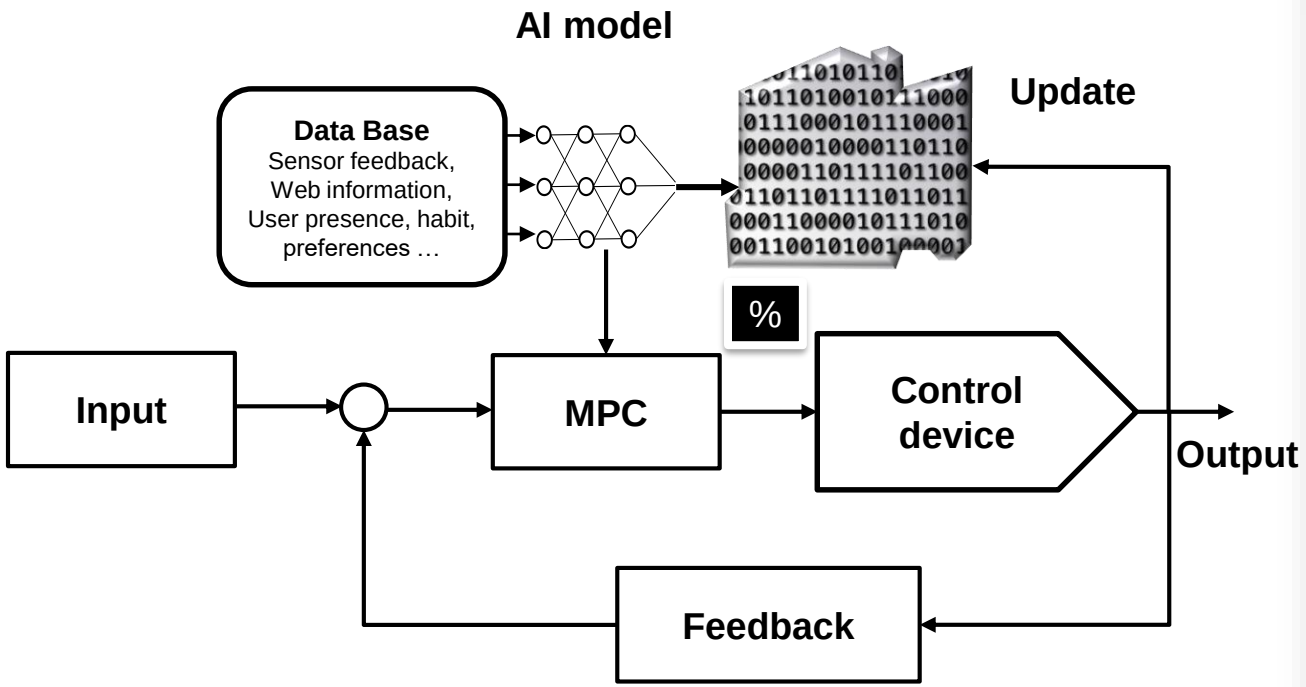
Minimum $q_{ac}' = mC_V \frac{dT_I(t)}{dt} + \frac{T_I(t) - T_O(t)}{R_{th}} + q_{occ}'$

Uncontrollable parameter but can be estimated by cloud-based AI

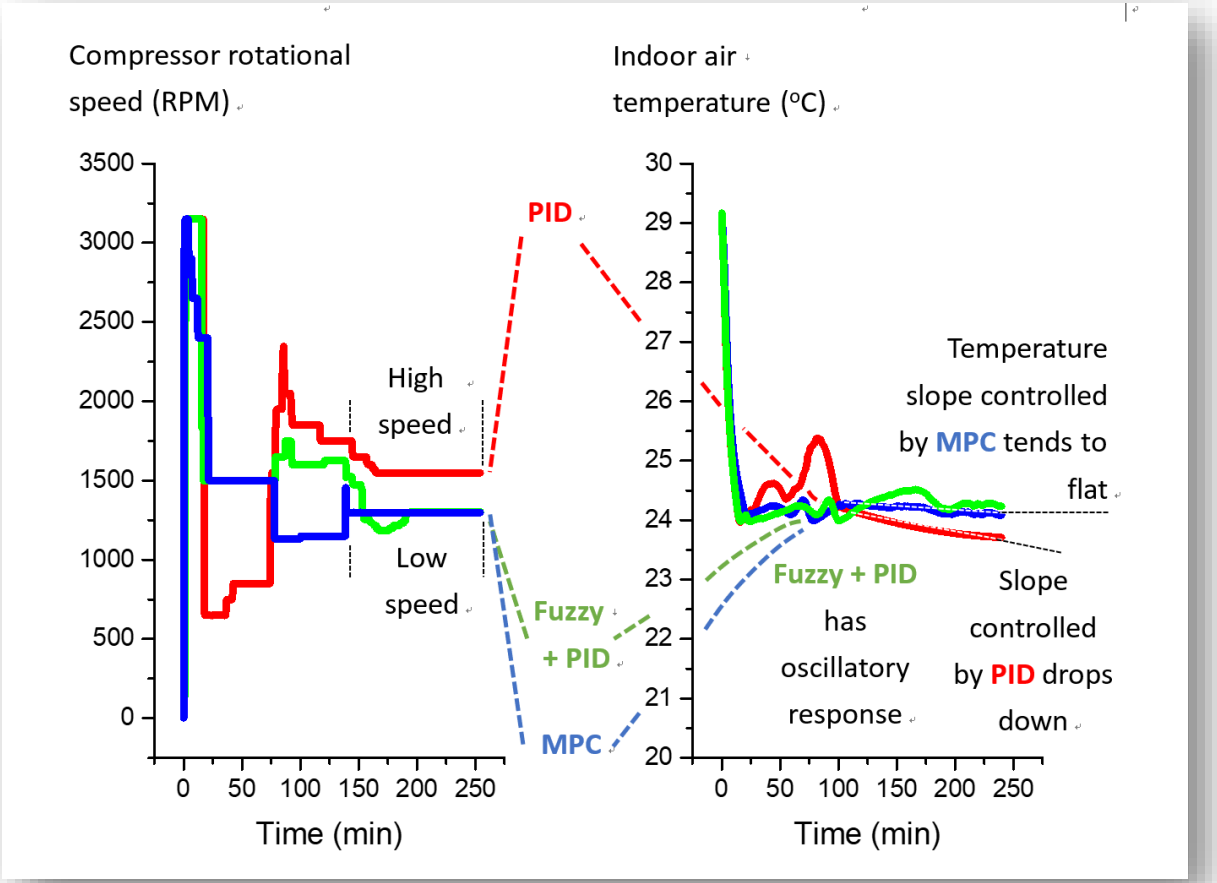
When $e(t) = T_I(t) - T_{set} = 0$, PID minimum q'_{ac} output = $\frac{T_{set} - T_O(t)}{R_{th}} + q'_{occ}$

q_{ac} cooling power provided
q_{occ} cooling load required

AI control strategy – Model based predictive control (MPC) average energy saving 17.4%



MPC uses different structures of NN & ML to learn history data and build the predictive model.



Source: Professor Da-Sheng Lee, National Taipei University of Technology

Market Study
Panasonic Econavi Fridge

https://www.panasonic.com/in/consumer/home-appliances/refrigerators/refrigerators-learn/article/efficient-econavi-inverter-technology.html

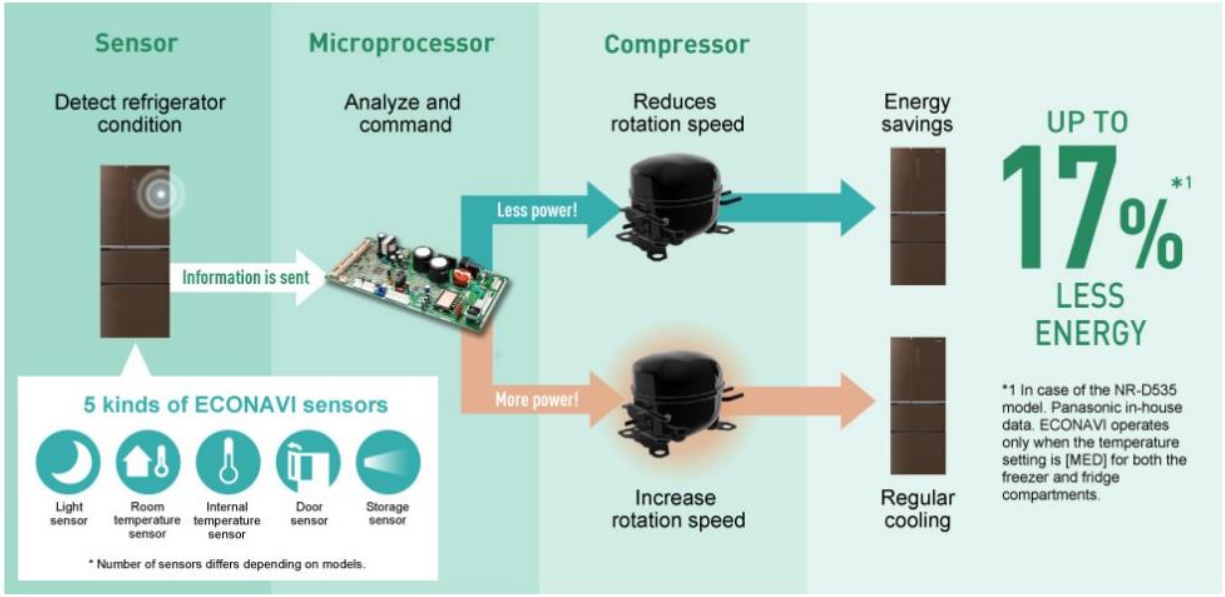
ECONAVI: Smart Cooling Technology

The ECONAVI INVERTER system is a unique Panasonic technology that provides optimum operation while saving energy. ECONAVI sensors detect conditions of use, and a microprocessor analyzes them. Using the results of this analysis, the INVERTER compressor adjusts the rotation frequency of the motor to optimize cooling performance. The ECONAVI INVERTER system memorizes the pattern of use for 3 weeks, and analyzes and predicts the conditions of use every hour of each day. Based on this prediction and actual conditions of use, it decides on the ideal operation to save energy.

INTELLIGENT ECO SENSORS
ECONAVI

Saving energy without doing anything

ECONAVI sensors detect conditions of use, and a microprocessor analyzes them. Using the results of this analysis, the INVERTER compressor adjusts the rotation frequency of the motor to optimize cooling performance.



Market Study
Arcelik partnered with ARM

https://www.arm.com/blogs/blueprint/ai-enabled-fridge

Arçelik Tackles Climate Crisis with AI-Enabled Fridge

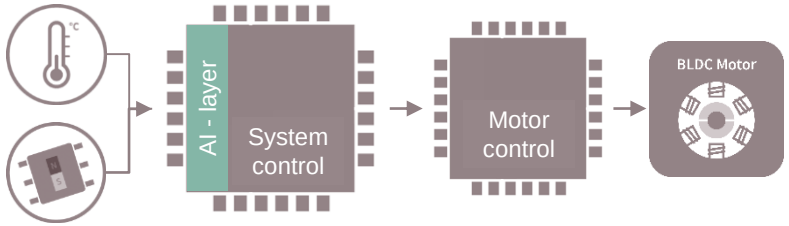
Our AI-enabled fridge, powered by Arm technology, can help slash your energy bill, drive down emissions and keep your food fresher for longer.

Posted on 10th August 2021

By Özgür Özkan, Senior Design Engineer, Arçelik Global

AI in motor control for home appliances - particularly fridge and aircon

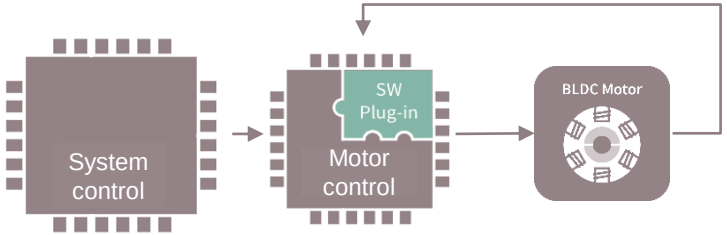
Edge AI in motor control



System level target optimization: Energy efficiency

A trained agent use system and sensor input and adapt the control quality to achieve a better efficiency of the system
- A feed-forward/look-ahead control.

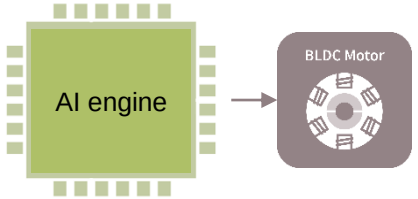
Cycle period	Cycle
Slow [some 10ms]	**Motor load cycle:** one mechanical turn of the motor
Slowest [as day, ….]	**Operational cycle:** in case of a fridge, different cycles as day, week, month….



Parameter self-tuning - initial, static, or adaptive

Tuning classical controllers using AI optimization algorithms to ensure optimal control performance at desired operating condition. Initial tuning at design-in phase as a tool or service, or at start to reduce offsets…,etc.

Cycle period	Cycle
Fast [ms]	**Motor commutation cycle** (1 electrical 360° period)



Adaptive self tuning agent

At start:
A trained AI agent optimize the parameters for the specific system unit at set up, adapting to singularity of each controlled system and unknown starting conditions in the field.

Later on:
A trained AI agent change parameter optimization adapting to changing conditions in the controlled system

Part of your life. Part of tomorrow.