FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

ENERGY
Trials and deployment of fuel cells

heat and power production

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PRD 2018

14 November 2018

Agenda

PROGRAMME REVIEW DAYS 2018
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
14 - 15 NOVEMBER, BRUSSELS

11:30 - 11:50
11:50 - 12:10
12:10 - 12:30
12:30 - 12:50
12:50 - 13:10
13:10 - 13:30

TRIALS AND DEPLOYMENT OF FUEL CELL APPLICATION - TRANSPORT	NEXT GENERATION OF PRODUCTS - TRANSPORT	TRIALS AND DEPLOYMENT OF FUEL CELL APPLICATION - ENERGY	NEXT GENERATION OF PRODUCTS - ENERGY	HYDROGEN FOR SECTORIAL INTEGRATION	SUPPORT FOR MARKET UPTAKE
H2ME HAWL HYFIVE HYLIFT-EUROPE HYTRANSIT JIVE SWARM H2ME 2	AUTO-STACK CORE COBRA COSMHYC DIGIMAN Fit-4-AMandA H2REF HYCARUS INLINE INN-BALANCE INSPIRE MARANDA NANO-CAT SMARTCAT VOLUMETRIQ COMPASS Giantleap	ALKAMMONIA AUTORE CH2P CLEARGEN DEMO D2SERVICE DEMCOPEM-2MW DEMOSOFC ENE.FIELD ONSITE PACE PEMBEYOND POWER-UP STAGE-SOFC	Cell3Ditor DIAMOND ENDURANCE FLUIDCELL HEALTH-CODE HEATSTACK INSIGHT MATISSE NELLHI PROSOFC qSOFC SCORED 2:0 SECOND ACT SOSLeM INNO-SOFC	BIONICO BIOROBURplus Demo4Grid DON QUICHOTE Eco ELECTRA ELY4OFF ELYntegration GrInHy H2Future HELMETH HPEM2GAS HyBalance HYDROSOL-PLANT HyGrid INSIDE MEGASTACK PECDEMO PECSYS QualyGridS SElySOs SOPHIA BIG HIT MEMPHYS	HYACINTH HYCORA HyLAW HYPACTOR HySEA HYTECHCYCLING KNOWHY NET-Tools SOCTESQA

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for

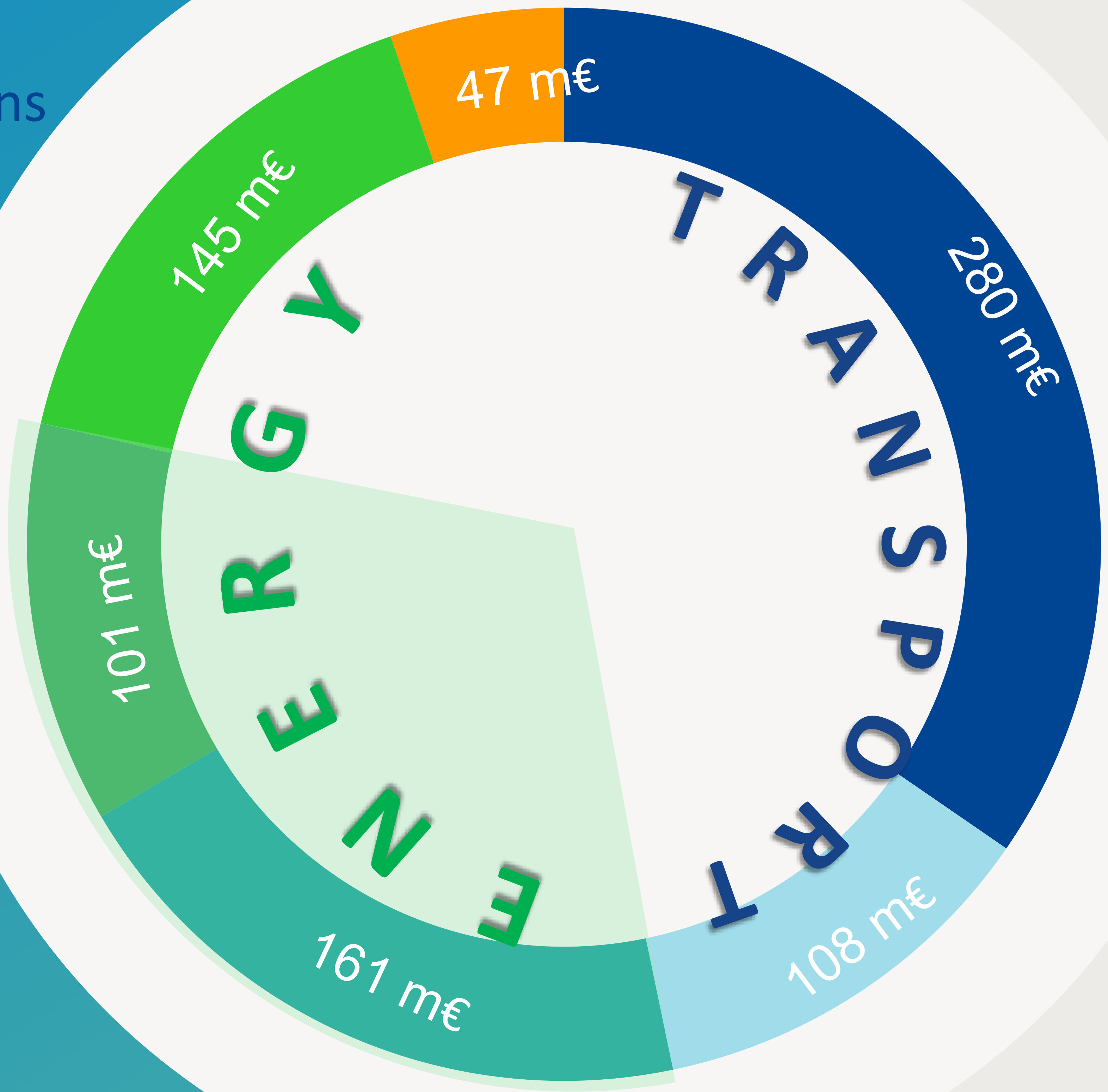
Trials and Deployment of Fuel Cell Application-Energy

Sustainable heat and power with fuel cells

Related FCH JU objectives

lications

Increase the efficiency and the durability of fuel cells for power production, while reducing costs



Stationary - Total

31 %

262 M€

76 Projects

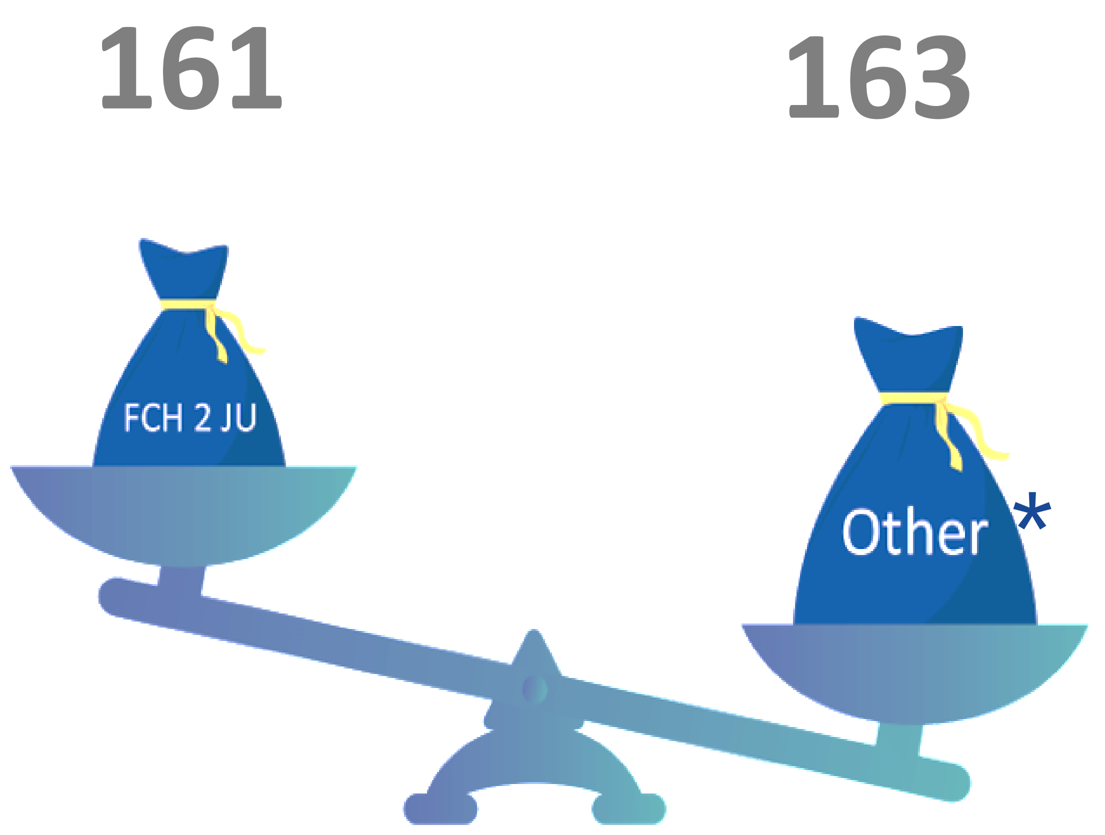
Trials & Deployment

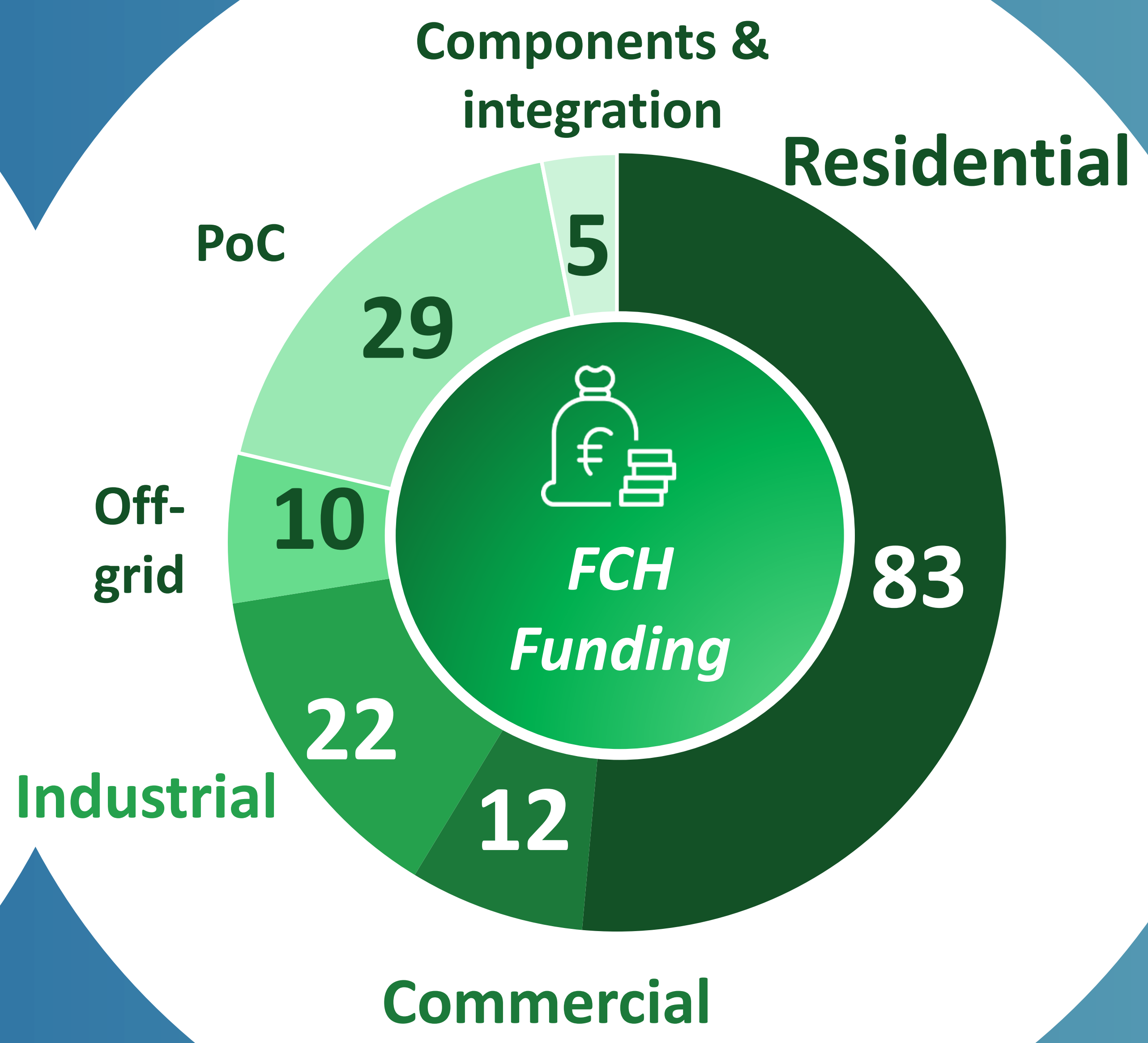
161 M€

30 Projects

Demonstrating low carbon and clean heat & power solutions

30 projects – 324 M€





Domestic solutions: on-track for commercialisation

Clean solutions for commercial buildings are ready

Exporting industrial CHP

DEPLOYING:

3,800 µ-CHP units

1 MW_e commercial

3 MW_e industrial

>500 kW_e off-grid/backup

** Other resources including private and national/regional funding*

Demonstration portfolio

~ 25% of the energy in the EU is consumed in the household sector

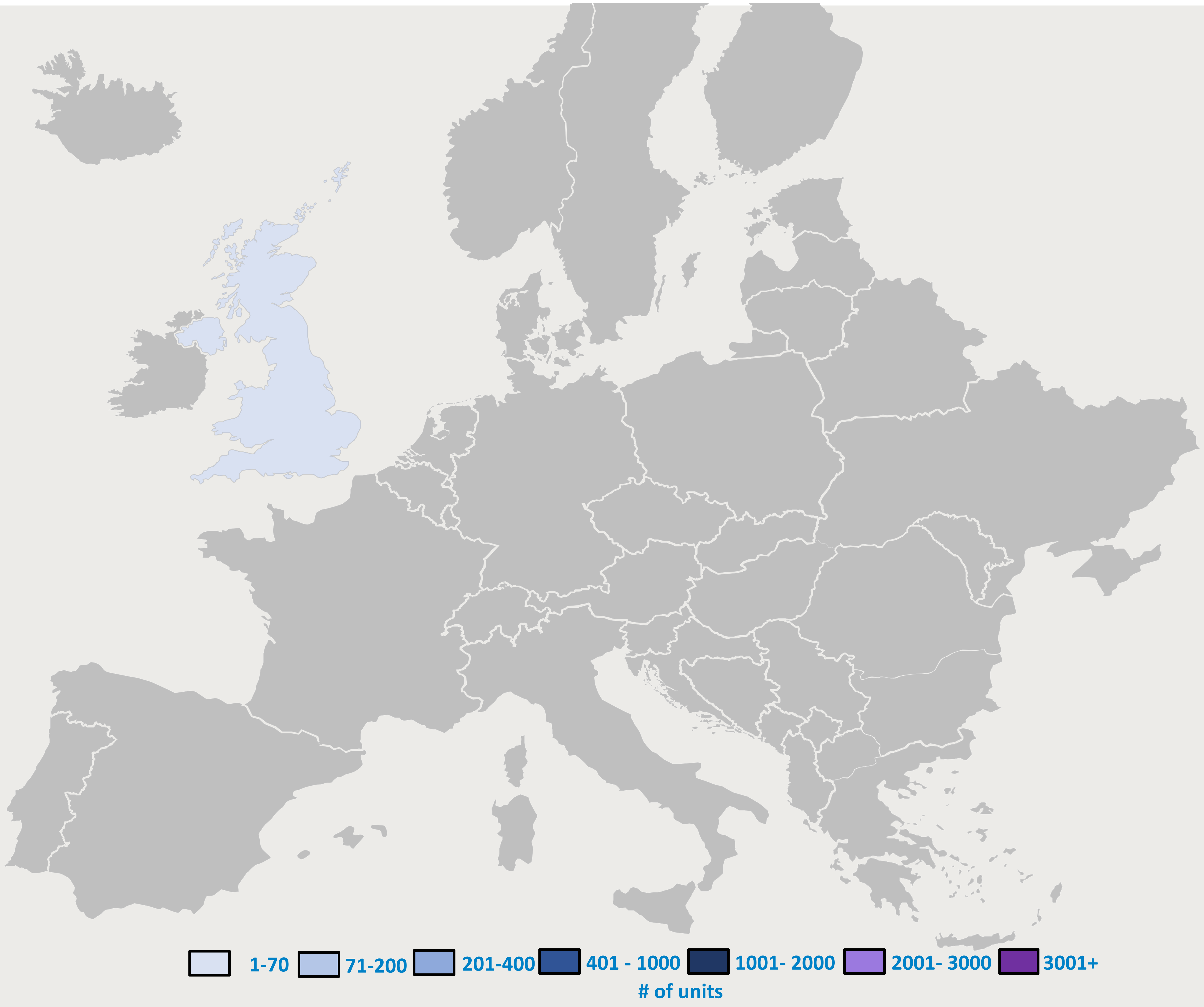
From research to small scale field trials

Following early research small field trials supported the validation of the technology

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

NATIONAL PROJECTS



Germany taking the lead

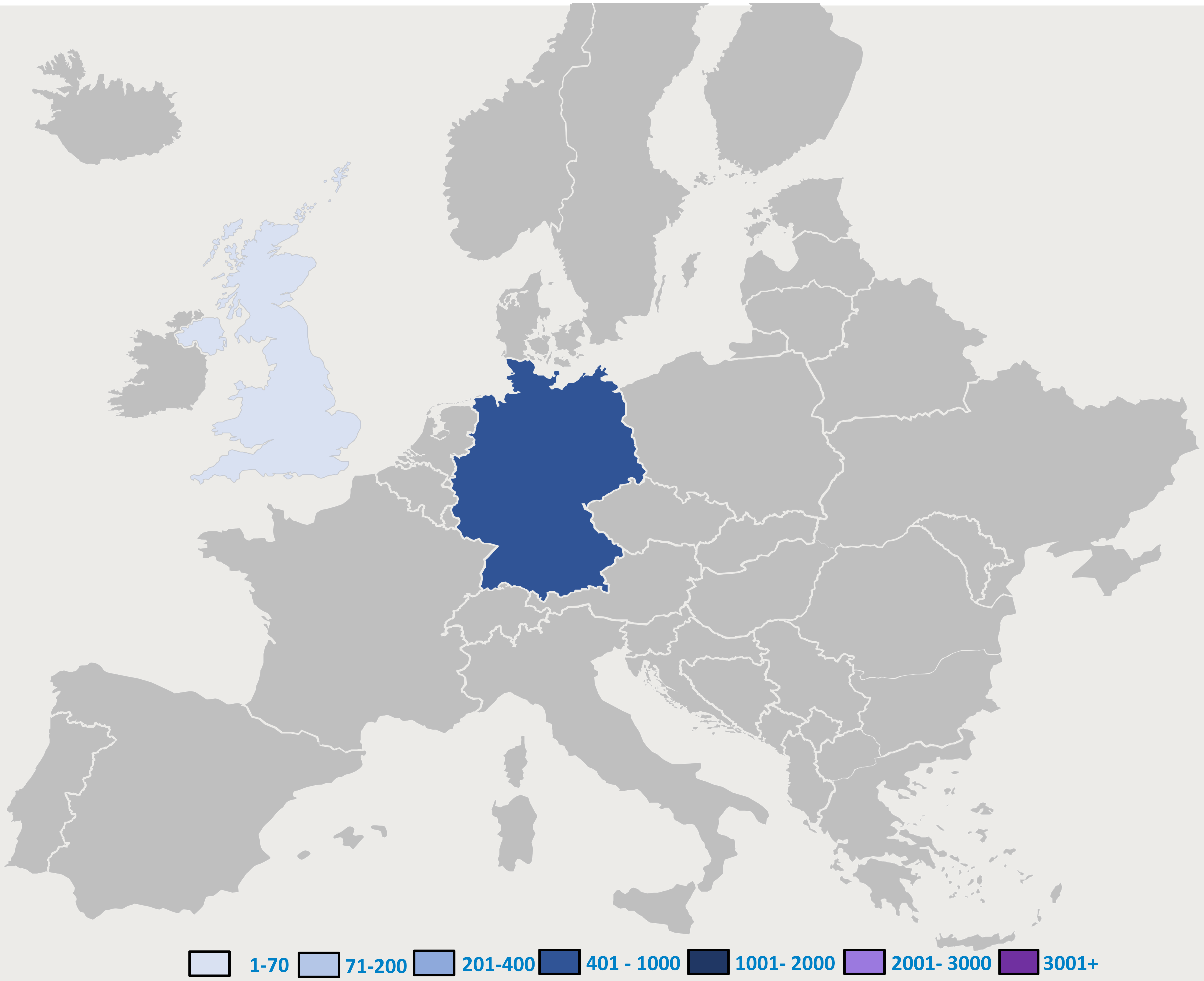
Large scale national demonstration programme CALLUX in Germany

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed



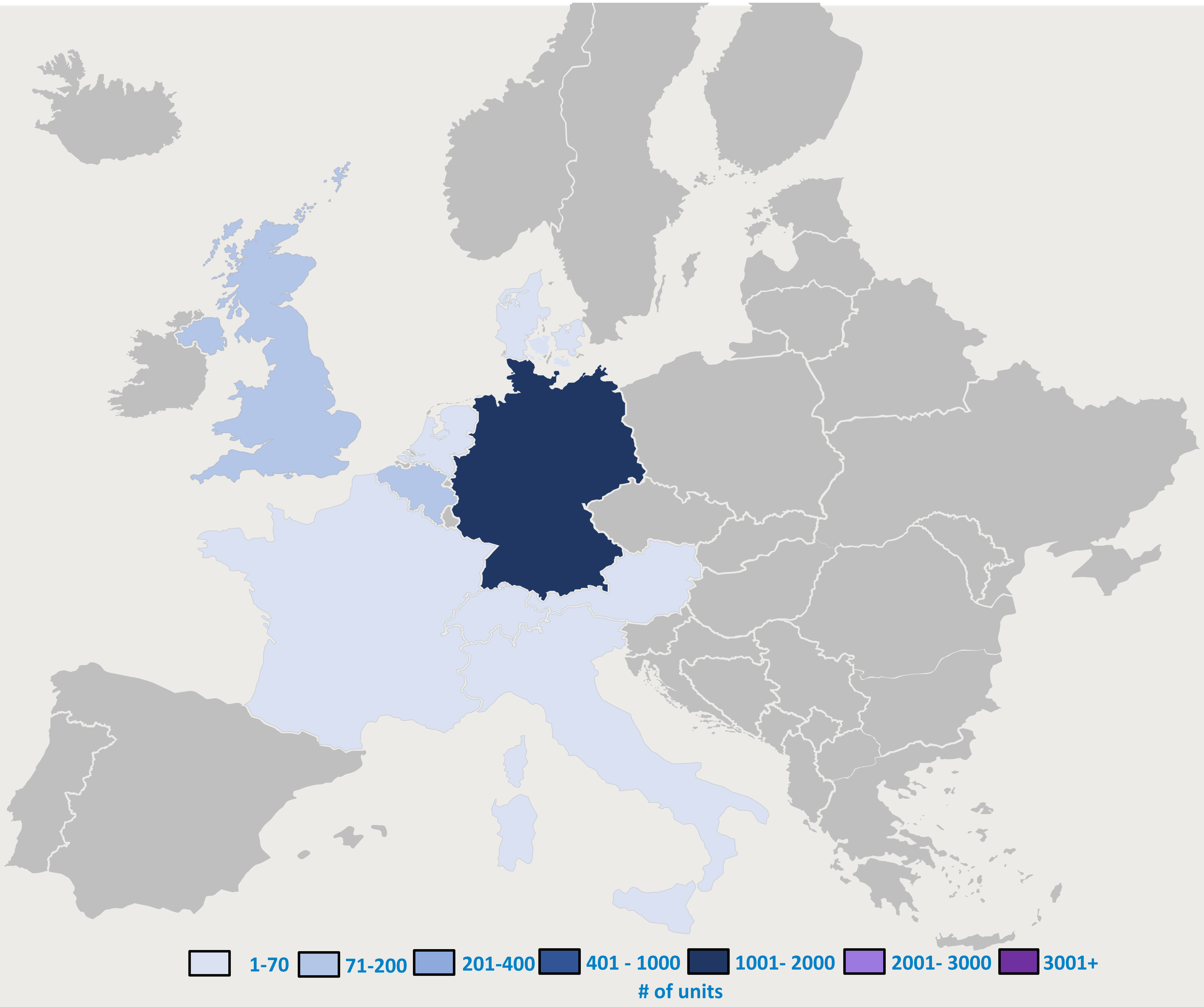
First large scale European wide field trial for domestic fuel cells

Gaining experiences and increasing consumer trust

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

ene.field
2012/2017
#1047 installed



NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed

Over 1000 fuel cell systems installed across Europe

Track record of domestic heat and power fuel cell solutions created

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

ene.field
2012/2017
#1047 installed

Field trials results*

- ✓ Over 1000 units installed (PEM and SOFC)
- ✓ 10 countries
- ✓ 5.5 million hours of operation
- ✓ 4.5 GWh of electricity produced
- ✓ 600 installers trained
- ✓ End-user satisfaction very good

NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed

*Source: 2017 FCH JU Data Collection and Analysis Exercise, see also https://goo.gl/GEqsoj and https://goo.gl/74Ffyc and Learnings from the ene.field project https://goo.gl/s3TmCZ

Over 1000 fuel cell systems installed across Europe

2017 objectives achieved

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

ene.field
2012/2017
#1047 installed

MAWP 2017 KPIs achieved

CAPEX, €/kW	13,000
Lifetime (y)	12
Availability (%)	97
Durability stack (h)	40,000
Reliability (h)	10,000
Elect. Ef.	30-60

NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed

On the road to mass market deployment

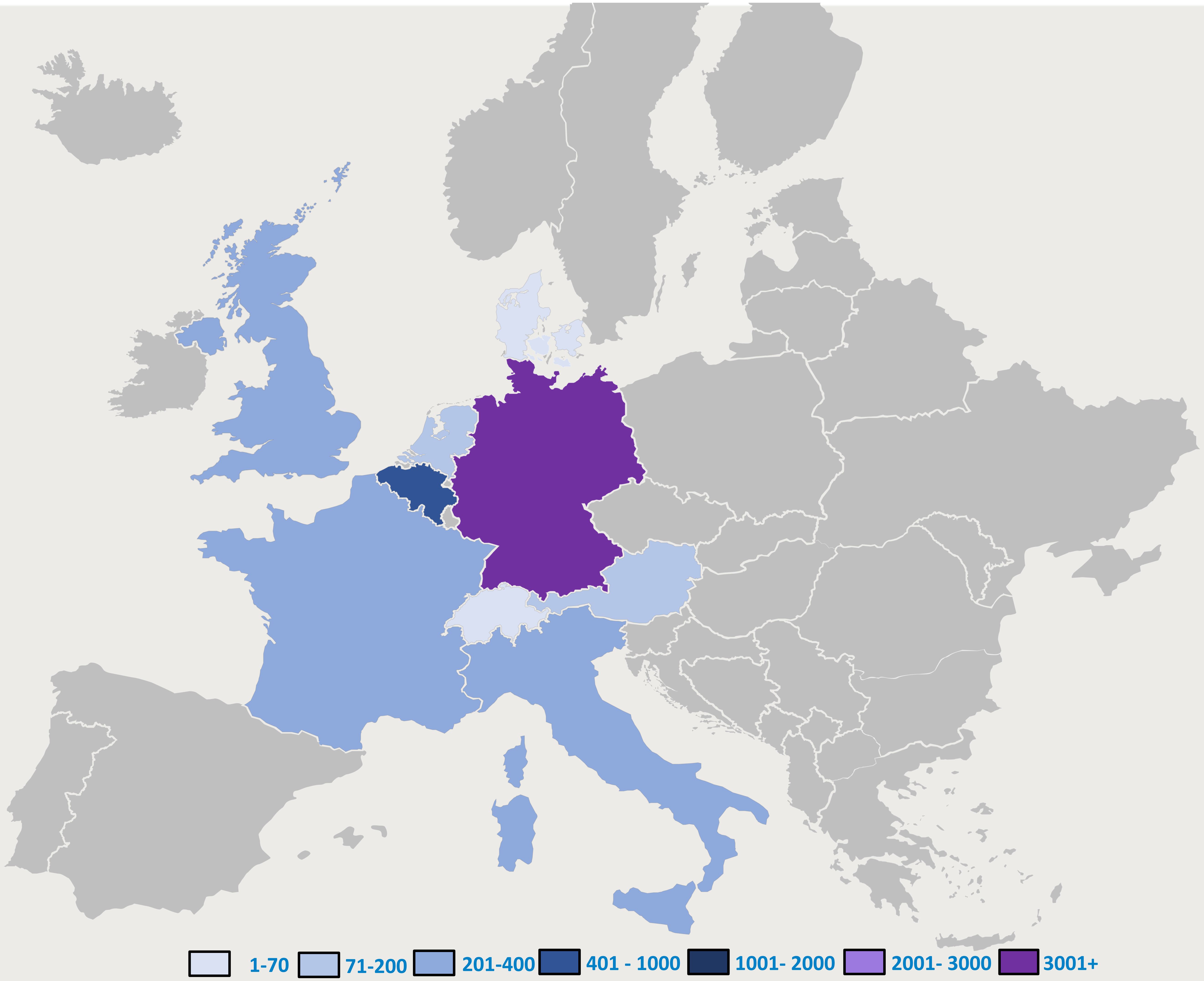
FCH JU PACE project supports OEMs for the development of the next generation of systems

EU PROJECTS

SOFTPACT
2011/2015
#65 installed

ene.field
2012/2017
#1047 installed

PACE
2016/2021
#2800 planned



NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed

On track and beyond targets…

68 systems with incremental improvements installed in PACE

KPI	MAWP 2020 Objectives	MAWP 2024 Objectives	MAWP 2030 Objectives
CAPEX, €/kW	10,000		
Lifetime (y)	**13** ✓		
Availability (%)	**97** ✓		
Durability stack (h)	**50,000** ✓		
Reliability (h)	50,000		
Elect. Ef.	**35-60** ✓		
Maintenance cost (EUR/kWh)	5		
Tolerated H2 content in NG (100)	100		

On track and beyond targets…but further improvements needed

68 systems with incremental improvements installed in PACE

KPI	MAWP 2020 Objectives	MAWP 2024 Objectives	MAWP 2030 Objectives
CAPEX, €/kW	**10,000**		
Lifetime (y)	**13**		
Availability (%)	97		
Durability stack (h)	50,000		
Reliability (h)	**50,000**		
Elect. Ef.	35-60		
Maintenance cost (EUR/kWh)	**5**		
Tolerated H2 content in NG (100)	**100**		

On the road to cost-competitiveness…

(1)…next generation systems: improved performances and designed for mass manufacturing

Source: Solid Power ©

Next generation systems being finalised and deployment in PACE will start end 2018

Source: Viessmann Group ©

On the road to cost-competitiveness…

(2) …volumes: German KfW 433 aims to support deployment in the order of 100,000’s by 2025

EU PROJECTS

SOFTPACT
2011/2015
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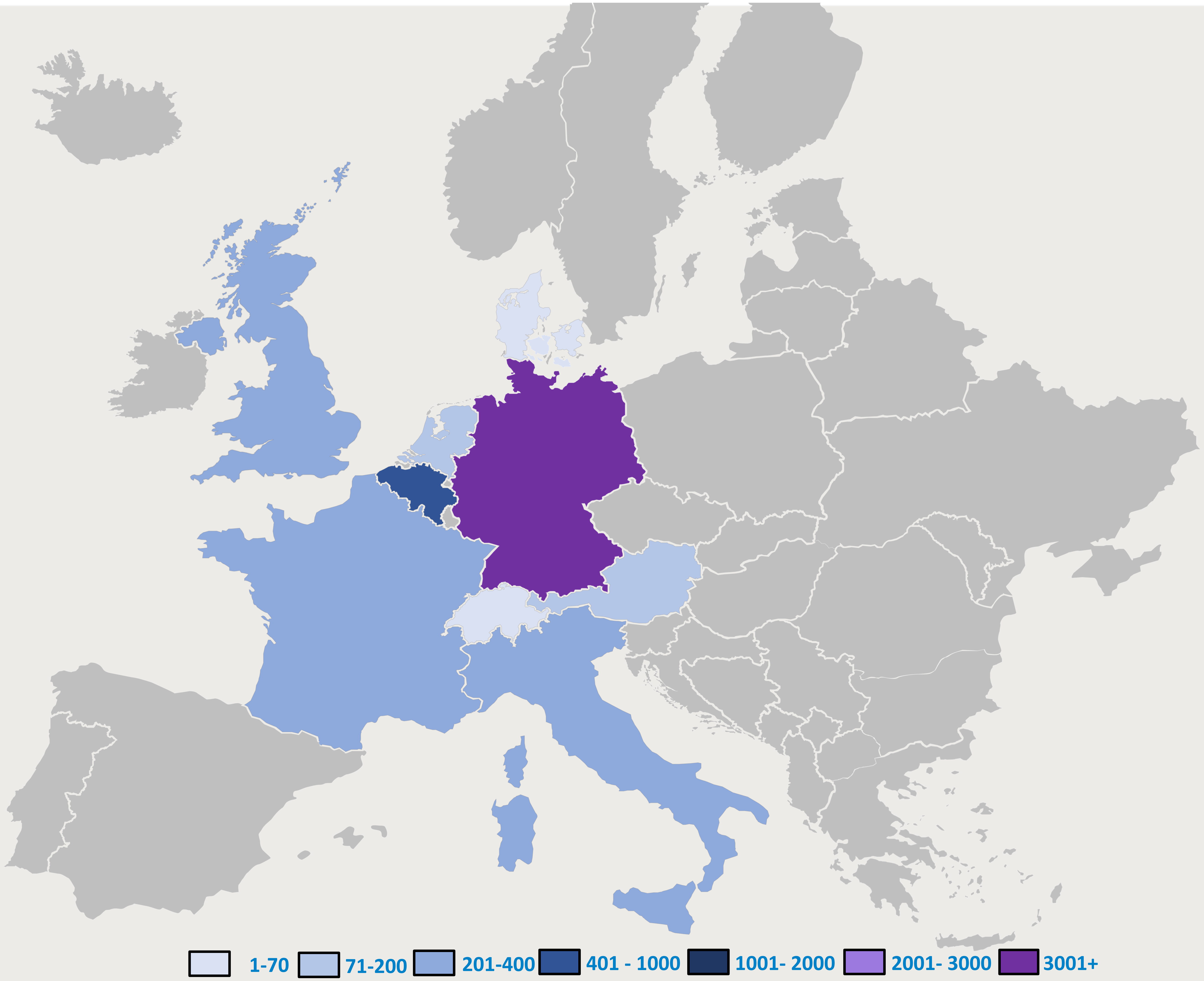


NATIONAL PROJECTS

CALLUX
2008/2015
#500 installed

KfW 433
2017/2025
~100,000’s

On the road to cost-competitiveness…

…achieving competitive products with no support

KPI	MAWP 2020 Objectives	MAWP 2024 Objectives	MAWP 2030 Objectives
CAPEX, €/kW	10,000	**5,500**	R&D **3,500**
Lifetime (y)	13	14	15
Availability (%)	97	97	98
Durability stack (h)	50,000	60,000	80,000
Reliability (h)	50,000	75,000	100,000
Elect. Ef.	35-60	37-63	39-65
Maintenance cost (EUR/kWh)	5	3.5	2.5
Tolerated H2 content in NG (100)	100	100	100

Next generation of products

Mass manufacturing

SLIDO Question

Project ene.field deployed over 1,000 domestic fuel cell systems across homes in Europe. End users reported savings in the energy bill of up to ….

A1: 250 EUR per year

A2: 500 EUR per year

A3: 1000 EUR per year

A3: 1500 EUR per year

Use your smartphone; go to www.sli.do and insert the code #PRD2018

Demonstration portfolio

~ 13% of the energy in the EU is consumed in the commercial building and services sector

Fuel cells in commercial buildings and service sector

PoC being developed show links between energy and transport sectors

PoC

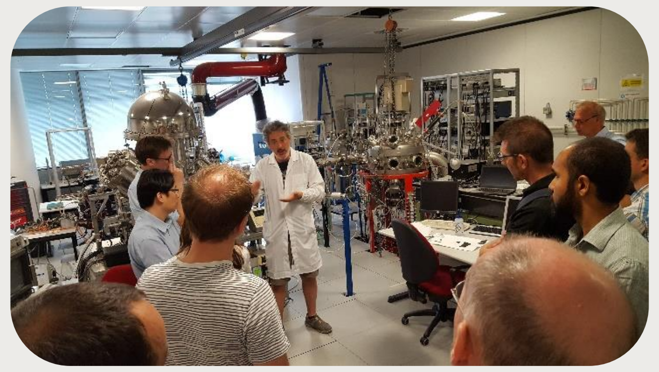
PEM

50 kW$_e$ automotive derived FC system

SOFC

58 kW$_e$ next generation FC system

Polygeneration of H_2, power & heat for distributed production on HRS



PEM

SOFC

H_2

Fuel cells in commercial buildings and service sector

Demonstrations in real installations have started

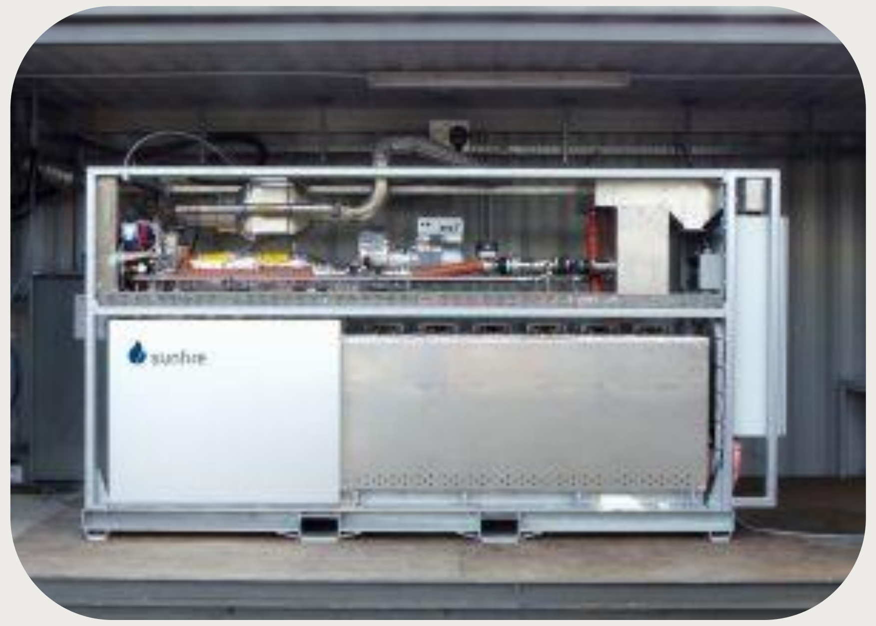
Performing well….costs remain an issue…next generation of systems being prepared

SOFC

PoC

Biogas 174 kW_e SOFC plant in a Waste Water Treatment Plant in Torino, Italy
53 kWe in operation for 1,200 hours in 2017 only
Elec. Effic. >50%
Big potential for replication
Cleaning of biogas too expensive -> new FCH JU research to decrease cost of biogas cleaning

23 systems in power range of 12 - 60 kW_e
Commercial buildings
Demonstrations to start soon



Demonstration portfolio

~ 25% of the energy in the EU is consumed in the industry sector

Industrial applications…greening big industry by using waste hydrogen

Exporting EU technology abroad…EU market conditions still not favourable

2 MW_e Fuel Cell in a Chlor-alkali plant, China

- H_2 by-product as fuel
- **Over 1 year operation**
- **~50% elec. eff. recorded**

1 MWe Fuel Cell in a Refinery, Martinique

- H_2 by-product as fuel
- Driven by high power generation costs in the island
- **To be commissioned Q2 2019**

International Collaboration

Starting point for emerging applications. e.g. maritime sector

Exporting EU fuel cell technology for industrial applications

Significant progress to date ….but further work is needed to achieve our targets

PEM

KPI	SoA (2017)	MAWP 2020 Objectives	MAWP 2024 Objectives
CAPEX, €/kW	3000-3500	2000-3000	1500-2500
Lifetime (y)	15	25	25
Availability (%)	98	98	98
Durability stack (khrs)	20-60	20-60	20-60
Reliability (hrs)	n/a	25,000	30,000
Elect. Ef.	45	45	45
Thermal. Ef.	20-40	22-40	22-40

PoC

Next generation of multi MW size Fuel Cell Power Plants

Reducing costs further

PoC

Uses **newly developed stacks, MEAs and BoP**

<u>Targets:</u>

- FC elec. efficiency > 55%
- Lifetime > 20,000 h
- Fast response, grid services capability
- **CAPEX < 1500 EUR/kW$_e$** at yearly production rate of 25 MW$_e$.

Pilot plan to be built mid 2019

- **2018/2020**
- **4.4M€ / 4.4M€**

Demonstration portfolio

Delivering reliable power supply

Industrial

Commercial

Off-grid / backup power

Residential

Research

Off-grid / backup power

Following successful PoC demos in real installation to start soon

Substituting dirty diesel solutions

PoC with promising results <7 kWe range:

- Limited operational hours
- 50% % elec. effic. proven
- Stack durability 10,000 h
- System lifetimes 10 years claimed
- CAPEX 4000 EUR/kWe at mass production claimed

Multi chemistry and fuels

PoC

SOFC

Demonstrations to follow as from next year for SOFC remote power applications

PEM

Containerised portable PEMFC gensets to be demonstrated soon

Fuel cells for micro cogeneration..a history of success

Strong European supply chain actors

- From early R&D to commercial product
- Proven to be a clean and efficient heat and power solution
- From hundreds to thousands
- OEMs meeting cost reduction curves
- Established EU heating companies include FCs in their product portfolio
- European leadership on Solid Oxide FC µCHP
- SOEs development builds on SOFC µCHP learnings

Applications extend to commercial and industrial sectors

Supporting the decarbonisation of the building and industry sectors…..and contributing to clean air for cities

- Fuel cells demos in commercial buildings and service sectors started
- Exporting EU fuel cell technology for industrial applications
- Large scale stationary sector supporting emerging maritime applications
- FC solutions displacing dirty diesel generation to be demonstrated soon

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