

Final report

1. Project details

Project title	IEA 4E PECTA 2022-2024
File no.	134-21033
Name of the funding scheme	EUDP
Project managing company / institution	Teknologisk Institut
CVR number (central business register)	56976116
Project partners	-
Submission date	02 May 2024

2. Summary

Project summary

- **The purpose of the project**

The purpose is to contribute actively, as alternate, to Denmark's participation in PECTA's management committee (MC). This involves participation in regular MC meetings and workshops, management of small projects initiated by the MC, quality assurance and dissemination/communication with the Danish Energy Agency and other Danish stakeholders.

- **Results, conclusions and perspective**

IEA 4E PECTA has achieved important results in making WBG technology for power electronics visible, as a means of achieving further energy savings in products:

- Expert panels have been established for universities and industry, which PECTA can draw upon;
- Workshops have been held with the experts to engage and involve them in PECTA's focus areas;
- Reports have been prepared, which address:
 - Efficiency potentials for different applications
 - Circular economy and life cycle perspectives for WBG
 - An overview describing when WBG technology is ready for different applications (ARM)
 - Various possible policy actions
 - Measurement standards and efficiency tests, especially for power supplies
 - Laboratory studies of PV inverters and EV charging stations

- Reliability of WBG technology
- Denmark has particularly contributed to life cycle perspectives including following IEC TC 111 (via S-611), policy actions, and reliability of WBG technology;
- Dissemination activities have been carried out including EPE 2023 conference in Aalborg, where PECTA was a special partner and over three days presented PECTA's results to a large global audience.

The results are continuously reported on the website <https://www.iea-4e.org/pecta/>. The network, the capacity building, and the dissemination successes will be built upon in a continuation of PECTA in a new 5-year period starting March 1, 2024. Denmark has leading researchers and companies in the field. Through PECTA Denmark is creating visibility about Denmark's strength positions.

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Projektrresumé

- **Formålet med projektet**

Dette projekts formål er at bidrage aktivt som "alternate" til Danmarks deltagelse i PECTA's styregruppe. Det indebærer deltagelse i regelmæssige styregruppemøder, deltagelse i workshops, styring af mindre projekter igangsat af styregruppen, kvalitetssikring og formidling/kommunikation med Energistyrelsen og andre danske interessenter.

- **Resultater, konklusioner og perspektiv**

IEA 4E PECTA har opnået en række vigtige resultater i synliggørelsen af WBG-teknologi i effektelektronik, som middel til at opnå yderligere energibesparelser i produkter:

- Der er etableret ekspertpaneler for universiteter og industri, som PECTA kan trække på
- Der er afholdt workshops med eksperterne for at engagere og inddrage dem i PECTAs fokusområder
- Der er udarbejdet rapporter, som adresserer:
 - Effektivitetspotentialer for forskellige applikationer
 - Cirkulær økonomi og livscyklusperspektiver for WBG
 - En oversigt der beskriver, hvornår WBG-teknologien er klar for forskellige applikationer (ARM)
 - Forskellige mulige politiktiltag
 - Målestandarder og effektivitetstest særligt for strømforsyninger
 - Laboratoriestudier af solcelleinverter og elbilladestandere
 - Pålidelighed af WBG-teknologi
- Danmark har bidraget særligt på livscyklusperspektiver inklusiv at følge IEC TC 111 (via S-611), politiktiltag og pålidelighed af WBG-teknologi
- Formidlingsaktiviteter er gennemført fx konferencen EPE 2023 i Aalborg, hvor PECTA var særlig partner og over 3 dage præsenterede PECTAs resultater for et stort globalt publikum.

Resultaterne er løbende rapporteret på hjemmesiden <https://www.iea-4e.org/pecta/>. Netværket, det faglige arbejde og formidlingssucceserne vil der blive bygget videre på i en fortsættelse af PECTA i en ny 5-årig periode med start 1. marts 2024. Danmark har ledende forskere og førende virksomheder indenfor området. Danmark har derfor fordel af PECTA for derigennem at skabe synlighed om Danmarks styrkepositioner.

3. Project objectives

The Power Electronic Conversion Technology Platform (PECTA) is one of four Platforms (EDNA, EMSA, SSL and PECTA) within the IEA 4E TCP (Technology Collaboration Program of Energy Efficient End-Use Equipment). The overall goal of PECTA includes collecting and analysing information about new wide band gap (WBG) based power electronic devices, coordinating internationally acceptable approaches that promote WBG-based power electronics and developing greater understanding and action amongst governments and policy makers.

4. Project implementation

N/A

5. Project results

N/A

6. Utilisation of project results

N/A

7. Project conclusion and perspective

The activities conducted by the Power Electronic Conversion Technology Platform (PECTA) over the past 5 years has provided valuable insights into the potential of Wide Band Gap (WBG) semiconductor technologies, particularly Silicon Carbide (SiC) and Gallium Nitride (GaN), to enhance energy efficiency across various applications. The evaluations revealed significant global annual energy saving potentials exceeding 120 TWh/year by adopting WBG devices in areas like data center power supplies, photovoltaic inverters, motor drives, electric vehicle charging stations, and consumer electronics. This amount is highlighted as being equivalent to twice the electric energy demand of Switzerland.

Experimental measurements corroborated the efficiency advantages of WBG-based solutions, with GaN chargers outperforming silicon counterparts by up to 2% at higher power levels, and SiC photovoltaic inverters demonstrating up to 2,7 % overall system efficiency improvements compared to traditional silicon IGBTs. While the efficiency gains may seem modest in some applications, the cumulative impact across millions of devices can translate into substantial energy savings.

However, the research also highlighted the importance of considering the entire life cycle when evaluating the environmental impacts of WBG technologies. While the manufacturing processes for WBG materials like SiC

are currently more energy-intensive than silicon, the potential energy savings during the use phase may offset this initial burden. Additionally, the incorporation of WBG semiconductors enables more compact and light-weight product designs, reducing material usage and distribution impacts.

Nonetheless, challenges remain in managing the supply risks associated with critical raw materials like gallium and improving end-of-life processes for recycling and reusing WBG materials. Overcoming barriers such as high costs, reliability concerns, and the lack of standardized WBG components and design knowledge will be crucial for broader adoption beyond early markets like automotive.

To drive wider implementation, PECTA proposed strategies like introducing stricter energy efficiency regulations, developing relevant standards for testing and reliability, and providing policy guidance tailored to specific applications. The Application Readiness Maps (ARMs) offer a valuable tool for tracking the market penetration of WBG devices across various sectors, informing decision-making by industry, policymakers, and other stakeholders.

The PECTA Management Committee has held monthly meetings, mostly as Teams-meetings, S-611 meetings have been half-yearly and in person, Denmark was present at the PECTA-session at the 4E ExCo meetings in Utrecht, 18 November 2022 and at the EPE 2023 conference in Aalborg 5 to 7 September 2023.

PECTA has started the second term of 5 years 1 March 2024 with the continued objective of assessing the efficiency opportunities of using WBG technology. As PECTA will continue focusing on both technical and policy topics as well as target audiences, the proposed activities for the second term are:

- Fine-tuning policy measures: Develop specific policy measures for appliances & equipment and prepare a policy guide for WBG technology.
- Improving EU regulation on PV converters: Analyze various PV converter topologies to support more precise EU regulations in the second term.
- Policy approaches for motors: Evaluate WBG efficiency in motor systems, in collaboration with 4E EMSA.
- Efficiency measurement standards: Initiate efficiency standards for WBG devices
- Update Application Readiness Maps (ARMs): Refine ARMs to reflect new semiconductor materials and WBG advancements.
- GHG emissions and sustainable use: Extend LCA work from the 1st term to quantify GHG emissions and compare WBG with Si-based devices.
- E-vehicle chargers: Monitor developments in charging technology to assess regulatory timing, leveraging advancements in WBG.
- Product reliability and market data: Gather field data on WBG devices to assess reliability. Reliability of the products, and particular the embedded power electronic, is one of the challenges that manufacturers face once a product is on the market.
- PECTA will carry out technology trend analysis with focus on e-mobility's influence on WBG technology, to gain insights and learnings that could be relevant for other end-use appliances/equipment. PECTA is fostering dialogue with ECPE and particular industries about this subject.
- From 2024, PECTA will continue to expand a relevant body of data and in-depth knowledge about WBG. The aim is that this know-how continues to be published and disseminated to target audiences.

8. Appendices

N/A