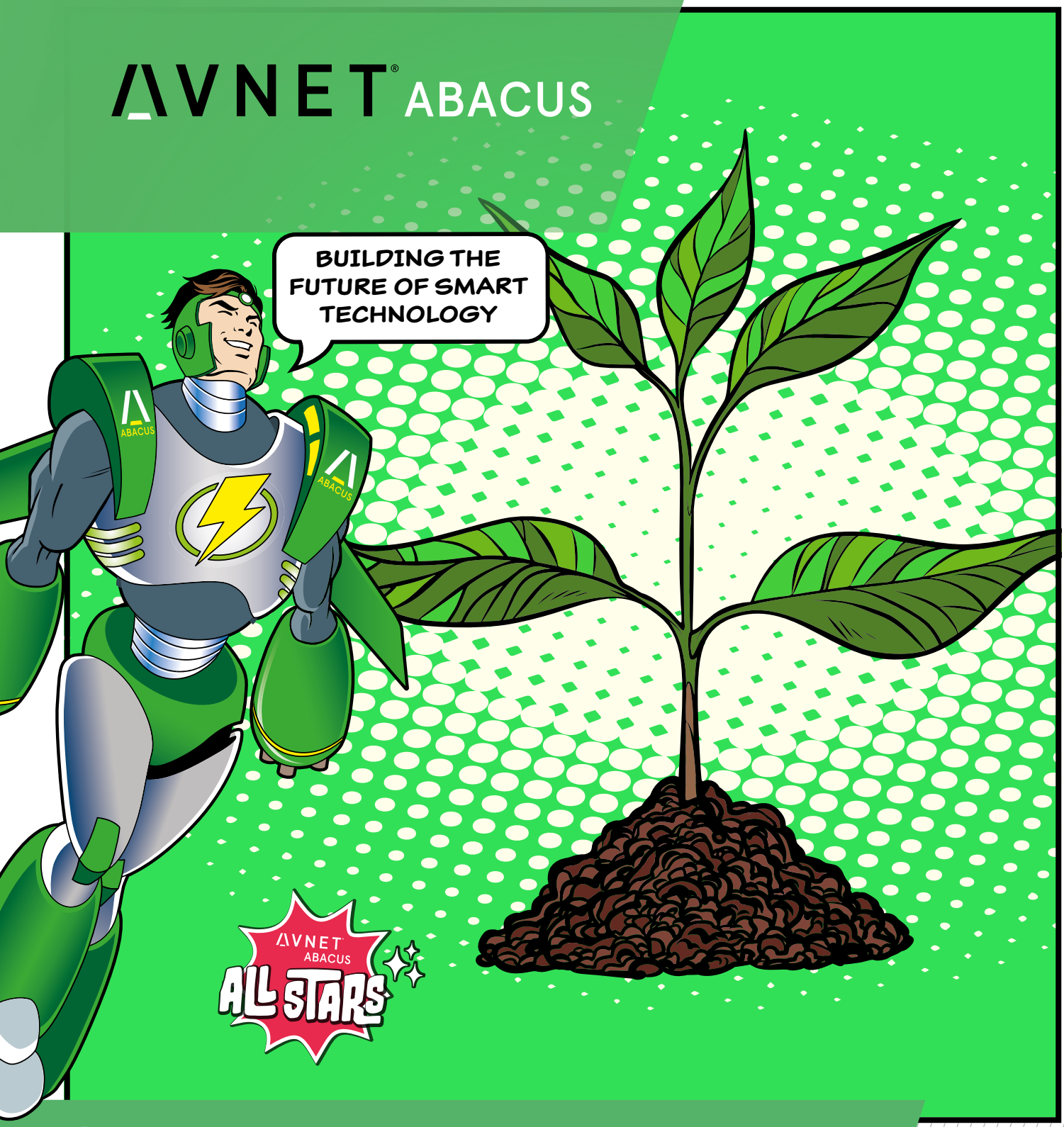
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/THE BIOENERGY IMPERATIVE

Today's fossil fuels are essentially ancient solar energy trapped in dead plant matter, compressed under rocks for thousands of years, and transformed into concentrated fuels whose embodied energy can now be released through burning or other chemical processes. But what if we could radically accelerate the 'sunlight to fuel' process and use contemporary crops to displace the increasingly unfavored fossil fuels? That's what the bioenergy sector of the renewable energy industry aims to achieve. However, this transition involves multiple trade-offs and has led to the discovery of numerous unintended consequences. Moreover, it is a transition that may soon face limitations due to its own success

To provide some context, the International Energy Agency (IEA) reports that the renewables sector is expected to become the largest source of global electricity generation by early 2025, surpassing coal. By 2027, renewables will account for over 90% of global electricity capacity growth. Biofuel demand is projected to grow by 22% during this period. This increase will be driven by a rise in the use of biodiesel in the US, Canada, Brazil, Indonesia, and India; a 35-fold increase in the use of biojet fuel since 2021; and the adoption of ethanol and biodiesel in emerging economies.

The following diagram (Figure 1), sourced from the International Renewable Energy Agency (IRENA), provides an illustration of the challenge the world faces in achieving net-zero emissions by 2050, and the role that bioenergy, created using biomass, is expected to play.

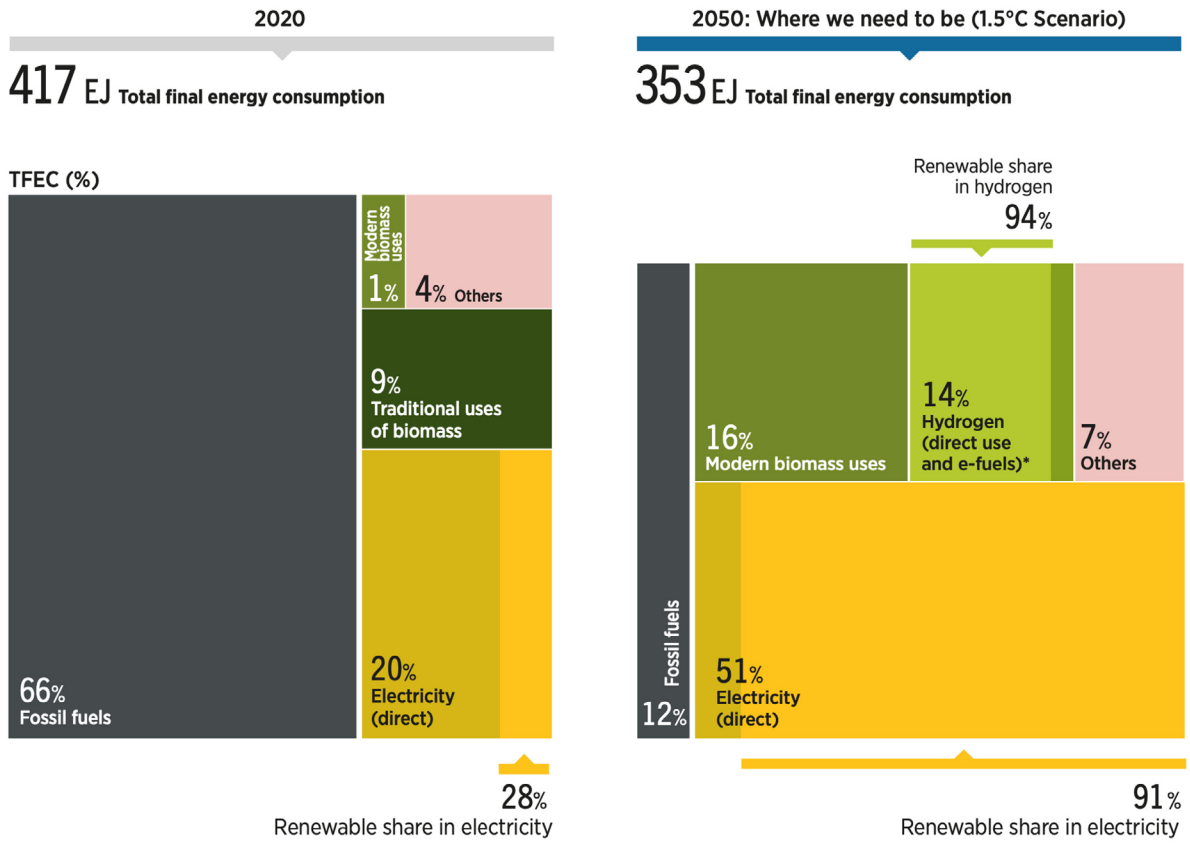


Figure 1: Biomass is expected to form an important part of the energy mix in 2050 (IRENA)

TYPES OF BIOENERGY

Terminology is important for understanding this renewable sector. The US Department of Energy's Bioenergy Technologies Office provides a set of useful definitions, as follows:

Biomass refers to a renewable energy resource derived from plant- and algae-based materials, which can include crop wastes, forest residues, purpose-grown grasses, woody energy crops, microalgae, and food waste. Biomass can be converted into liquid fuels that resemble gasoline, jet fuel, and diesel.

Biofuels encompass cellulosic ethanol, biodiesel, and renewable alternatives to hydrocarbon fuels. Biofuels are especially valuable because they are renewable, can seamlessly replace conventional fuels, and contribute to reducing the carbon intensity of various forms of transportation.

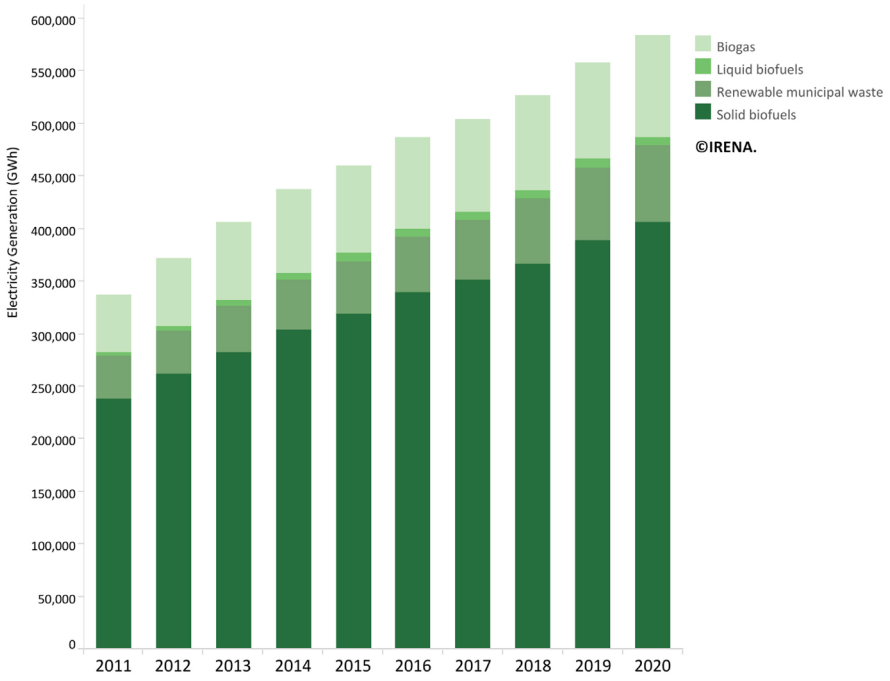


Figure 2: Growth in bioenergy electricity generation, by biofuel type (IRENA)

Biopower technologies involve converting biomass into heat and electricity. There are three primary methods for utilising biomass to produce biopower: combustion, bacterial decay, or conversion into gas or liquid fuel. Biopower can help to reduce the carbon intensity of electricity generation and is also 'dispatchable,' meaning it can be easily started up or shut down in response to the electricity grid's demand.

Biomass can also be used to make bioproducts like those usually made from feedstocks such as petroleum and natural gas. These include plastics, lubricants, industrial chemicals, and more. As in petrol refineries, bio-refineries can make bioproducts alongside biofuels. This makes more efficient use of biomass resources as well as offsetting the costs of biorefinery operations, reducing biofuel costs and so accelerating their uptake.

THE SUPPLY-CHAIN CHALLENGE

The increasing adoption of bioenergy is likely to create unintended consequences. For example, bioethanol and biogas were initially introduced on a large scale as alternatives to fossil fuels in transportation applications. It didn't take long before people started questioning the lifecycle benefits of these first-generation fuels in terms of carbon emissions, considering the energy costs involved in producing the necessary fertilisers. Additionally, there were increases in food costs in some regions as agricultural land was repurposed to grow bioenergy feedstocks.

Since then, developments have been made, and the IEA now predicts that waste and residues will fuel one-third of new biofuel production by 2027. This is, in part, attributed to policies, especially in the US and Europe, that favour fuels with lower greenhouse gas emissions - such as those produced from waste streams. In Europe, this particularly applies to renewable diesel and biojet fuels.

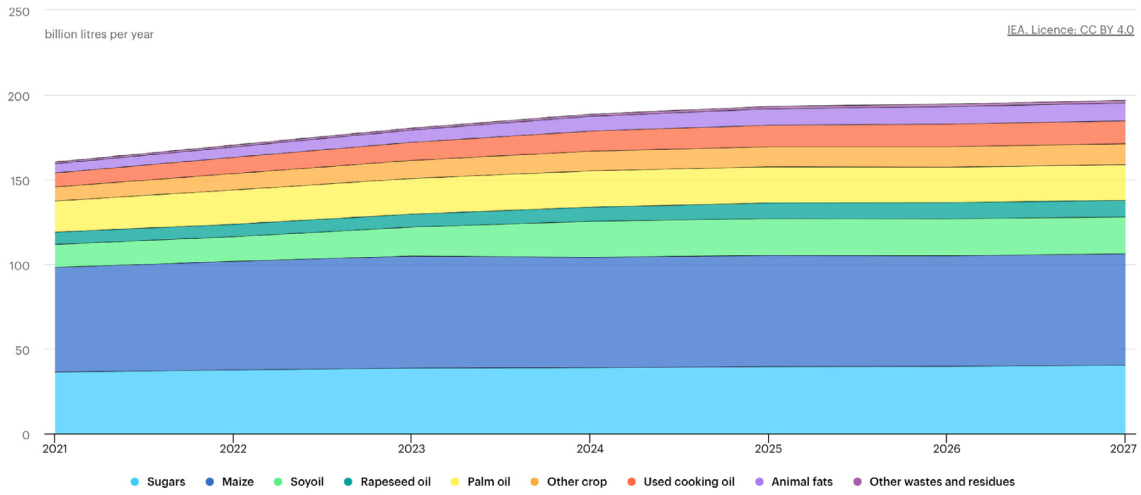


Figure 3: The uptake of bioenergy strategies may be limited by a lack of feedstocks (IEA)

However, the rapid adoption of bioenergy and biofuels is putting strain on supply chains. The IEA forecasts that the demand for waste and residue oils and fats is expected to nearly outstrip the supply of the most readily available sources by 2027. Supply constraints are also compelling biodiesel, renewable diesel, and biojet producers to turn to conventional vegetable oils, such as soybean oil and rapeseed oil. Figure 3 (below) projects relatively slow growth in bioenergy feedstocks such as maize and used cooking oils, according to the IEA.

THE ROLE OF AI AND ML

As the information above indicates, there is still plenty of room for discovery, development, and optimization in all forms of bioenergy. At a workshop convened in August 2022 by the US Department of Energy, bioenergy researchers outlined ways in which they believed they could leverage machine learning (ML) and other artificial intelligence (AI) strategies to accelerate their work. The consensus was that AI and ML techniques, coupled with automated experimentation systems, could help address some of the key challenges in bioenergy. These might include finding ways to engineer microbes or communities of microbes to meet specific criteria, developing closed-loop autonomous design and control capabilities for biosystems, and creating improved techniques for scaling up and automating successful bioenergy research outcomes to production status.

Among the obstacles to achieving these goals are a lack of high-quality, labelled data from which ML systems can learn, the absence of AI and ML tools tailored to bioenergy applications, and the challenge of automating experimentation systems and making them more autonomous. As is often the case at the forefront of research, there is also a shortage of individuals trained in these new techniques.

INNOVATION OPPORTUNITIES

Increasing the adoption of bioenergy will involve developing and deploying many of the same types of electronic systems used in other forms of renewable energy generation, as well as a few that are specifically adapted to the challenges of bioenergy development.

For instance, advanced control systems will be essential for optimising the performance, efficiency, and safety of bioenergy plants. These systems will require microcontrollers, sensors, actuators, and communication modules to monitor and control processes such as feedstock handling, combustion, gasification, and emissions control.

Power electronics will play a crucial role in bioenergy generation schemes. They will be needed to convert DC outputs into AC for direct use or for feeding into the grid, synchronisation circuits to align bio-generated AC with the grid phase, and transformers to adjust voltages as needed. Power electronics will also be integral in maximising the round-trip efficiency of large-scale storage systems for bioelectricity.

Automation and robotics may play a more significant role in bioenergy than in other forms of renewable energy generation. As suggested at the AI workshop described earlier, researchers need access to highly automated experimentation systems to explore a broader range of bioenergy options. Automation and robotics systems will improve the efficiency, safety, and reliability of bio-power plants by automating tasks such as feedstock handling, ash removal, and maintenance.

Similarly, bioenergy research will depend on the use of a wide array of sensor types to provide the rich datasets necessary for training ML systems to draw useful conclusions. Once sources and processes have been validated, full-scale bioenergy production plants will require sophisticated data acquisition systems that rely on a diverse set of sensors to collect, process, and analyse data from bioenergy systems.

All these data flows will originate from signals captured by rugged sensors, which will be conditioned and digitised for recording in data loggers, and then communicated, analysed, stored (and backed up) to enable the optimization of operations, maintenance, and decision-making through advanced analytics and ML algorithms.

The challenge of achieving net zero by 2050 can only be met through rapid innovation, development, optimization, and iteration. Avnet Abacus possesses the expertise, insights, tools, and components to assist electronics engineers in contributing effectively.



/ OFFICES

AUSTRIA
Avnet EMG Elektronische
Bauelemente GmbH
Grünbergstraße 15/1/4.OG,
A-1120 Wien
Phone: +43 (0)1 86642-0
Fax: +43 (0)1 86642-250
wien@avnet-abacus.eu

BELGIUM
De Kleetlaan 3
BE-1831 Diegem
Phone: +32 2 227 2000
diegem@avnet-abacus.eu

BULGARIA
c/o Avnet Abacus Romania
4 Gara Herastrau,
Building B, 2nd Floor
RO-020334 Bucharest
Phone: +4021 528 16 90
bulgaria@avnet-abacus.eu

CROATIA
c/o Avnet Abacus Slovenia
Dunajska Cesta 167
SI-1000 Ljubljana
Phone: +386 (0)1 560 97 54
Fax: +386 (0)1 560 98 78
croatia@avnet-abacus.eu

CZECH REPUBLIC
Amazon Court Karolinska 661/4
CZ-18600 Prague
Phone: +420 234 091 011
Fax: +420 234 091 010
praha@avnet-abacus.eu

DENMARK
Knudlundvej 24, DK-8653 Them
Phone: +45 86 84 84 84
Fax: +45 86 84 82 44
them@avnet-abacus.eu

Lyskær 9, DK-2730 Herlev
Phone: +45 86 84 84 84
Fax: +45 43 29 37 00
herlev@avnet-abacus.eu

EGYPT
c/o Avnet Abacus Turkey
Tatlısu Mahallesi Pakdil
Sokak No: 7 Kat: 2
TR-34774 Umraniye Istanbul Turkiye
Phone: +90 216 52 88 370
Fax: +90 216 52 88 377
egypt@avnet-abacus.eu

ESTONIA
Suur-Jõe 63, Pärnu,
EE-80042 Pärnu Maakond
Phone: +372 56637737
paernu@avnet-abacus.eu

FINLAND
Klovinpellontie 1-3
Tower 1, Floor 6
FI-02180 Espoo
Phone: +35 820 749 9220
Fax: +35 820 749 9240
espoo@avnet-abacus.eu

FRANCE
Le Copernic
12, rue Jean Bart
FR-91300 Massy
Phone: +33 (0) 1 6447 2929
Fax: +33 (0) 1 6447 9150
paris@avnet-abacus.eu

8 chemin de la Terrasse
Bat D 1er étage
FR-31500 Toulouse
Phone: +33 (0) 5 6247 4787
Fax: +33 (0) 5 6247 4761
toulouse@avnet-abacus.eu

16 C Rue de Jouanet
FR-35700 Rennes
Phone: +33 (0) 2 9983 7720
Fax: +33 (0) 2 9983 4829
rennes@avnet-abacus.eu

2 avenue Tony Garnier, 3rd floor
FR-69007 Lyon
Phone: +33 (0) 4 7877 1370
Fax: +33 (0) 4 7877 1391
lyon@avnet-abacus.eu

GERMANY
Kaiserin-Augusta-Allee 14
DE-10553 Berlin
Phone: +49 (0) 30 790 997 0
Fax: +49 (0) 30 790 997 51
berlin@avnet-abacus.eu

Industriestr. 16
DE-76297 Stutensee
Phone: +49 (0) 7249 910 149
Fax: +49 (0) 7249 910 177
stutensee@avnet-abacus.eu

Rhenus-Platz 2
D-59439 Holzwickede/Dortmund
Phone: +49 (0) 2301 2959 27
Fax: +49 (0) 2301 2959 29
dortmund@avnet-abacus.eu

Flughafenstraße 52a
DE-22335 Hamburg
Phone: +49 (0) 40 608 23 59 0
Fax: +49 (0) 40 608 23 59 20
hamburg@avnet-abacus.eu

Einsteinring 1
DE-85609 Dornach-Aschheim/
Munich
Phone: +49 (0) 89 388882 041
Fax: +49 (0) 89 388882 040
muenchen@avnet-abacus.eu

Lina-Ammon-Str. 19 b
DE-90471 Nuernberg
Phone: +49 (0) 911 244 250
Fax: +49 (0) 911 244 25 25
nuernberg@avnet-abacus.eu

Neue Ramtelstr. 4
DE-71229 Leonberg
Phone: +49 (0) 7152 3009 70
Fax: +49 (0) 7152 3009 96
stuttgart@avnet-abacus.eu

Rotenburger Str. 20
D-30659 Hannover
Phone: +49 (0) 511 336517 10
hannover@avnet-abacus.eu

GREECE
c/o Abacus Avnet Serbia
Milentija Popovića 5B,
Floors 6-8
Belgrade RS-11070
Phone: +381 11 4022302
Fax: +381 11 4049900
belgrade@avnet-abacus.eu

HUNGARY
c/o Avnet Abacus Slovakia
GreenPoint Offices,
Blok F Turcianska 2
SK-82109 Bratislava
Phone: +421 232 242 608
Fax: +421 2 32 1111 40
budapest@avnet-abacus.eu

IRELAND
c/o Avnet Abacus Bolton
Oceanic Building
Waters Meeting Road
Bolton BL1 8SW
Phone: +44 (0)1204 547190
Fax: +44 (0)1204 547171
bolton@avnet.eu

ISRAEL
1 Habrosh Street
Bney Dror IL-4581500
Phone: +972 9 778 0280
Fax: +972 3 760 0794
israel@avnet-abacus.eu

ITALY
Via Manzoni 44
IT-20095 Cusano Milanino/Milano
Phone: +39 02 660 921
Fax: +39 02 66092 332
milano@avnet-abacus.eu

Viale dell´industria 23
IT-35129 Padova
Phone: +39 049 7800 381
Fax: +39 049 7730 36
padova@avnet-abacus.eu

Via Scaglia Est. 31/33
IT-41126 Modena
Phone: +39 059 34891
Fax: +39 059 344 993
modena@avnet-abacus.eu

Via Panciatichi 40/11
IT-50127 Firenze
Phone: +39 055 436 1928
Fax: +39 055 428 8810
firenze@avnet-abacus.eu

Viale Luca Gaurico 9/11
IT-00143 Roma
Phone: +39 02 660 921
rome@avnet-abacus.eu

LATVIA
c/o Avnet Abacus Poland
Plac Solny 16
PL-50-062 Wroclaw
Phone: +48 71 34 205 99
Fax: +48 71 34 229 10
latvia@avnet-abacus.eu

LITHUANIA
c/o Avnet Abacus Poland
Plac Solny 16
PL-50-062 Wroclaw
Phone: +48 71 34 205 99
Fax: +48 71 34 229 10
lithiuania@avnet-abacus.eu

NETHERLANDS
Stadionstraat 2, 6th floor
NL-4815 NG Breda
Phone: +31 (0) 76 57 22 300
Fax: +31 (0) 76 57 22 303
breda@avnet-abacus.eu

NORWAY
Olaf Helsetsvei 6,
NO-0694 Oslo
Phone: +47 (0) 94 89 53 73
oslo@avnet-abacus.eu

POLAND
Plac Solny 16
PL-50-062 Wroclaw
Phone: +48 71 34 205 99
Fax: +48 71 34 229 10
wroclaw@avnet-abacus.eu

PORTUGAL
Tower Plaza, Rot. Eng. Edgar
Cardoso, 23,Piso 14, Sala E
PT-4400-676 Vila Nova de Gaia
Phone: +351 223 779502
Fax: +351 223 779503
portugal@avnet-abacus.eu

ROMANIA
4 Gara Herastrau, Building B,
2nd Floor
RO-020334 Bucharest
Phone: +4021 528 16 90
romania@avnet-abacus.eu

SERBIA
Milentija Popovića 5B, Floors 6-8
Belgrade RS-11070
Phone: +381 11 4022302
Fax: +381 11 4049900
belgrade@avnet-abacus.eu

SLOVAKIA
GreenPoint Offices,
Blok F Turcianska 2
SK-82109, Bratislava
Phone: +421 232 242 608
Fax: +421 2 32 1111 40
slovakia@avnet-abacus.eu

SLOVENIA
Dunajska Cesta 167
SI-1000 Ljubljana
Phone: +386 (0)1 560 97 54
Fax: +386 (0)1 560 98 78
ljubljana@avnet-abacus.eu

SOUTH AFRICA
Block 13, Pinewood Office Park
33 Riley Road Woodmead,
ZA-2191 Sandton, Johannesburg
Phone: +27 (0)11 319 8600
Fax: +27 (0)11 319 8650
avnet-abacus-sales-southafrica@avnet.eu

First Floor, Forrest House
Belmont Office Park, Belmont Road
ZA-7700 Rondebosch, Cape Town
Phone: +27 (0)21 689 4141
Fax: +27 (0)21 686 4709
avnet-abacus-sales-southafrica@avnet.eu

33 Shelbourne Avenue La Lucia
ZA-4051 Umhlanga
KwaZulu-Natal
Phone: +27 319 405 006
avnet-abacus-sales-southafrica@
avnet.eu

SPAIN
NyN Tower, C/Tarragona
149-157. Floor 19
ES-08014 Barcelona
Phone: +34 (0) 93 327 85 50
Fax: +34 (0) 93 425 05 44
barcelona@avnet-abacus.eu

Avenida Madariaga 1
Floor 3
ES-48014 Bilbao
Phone: +34 (0) 94 457 00 44
Fax: +34 (0) 94 456 88 55
bilbao@avnet-abacus.eu

Ronda de Poniente
(pq Empresarial Euronova),
4 - 2ª PLANTA, tres Cantos,
28760, Madrid
madrid@avnet-abacus.eu

SWEDEN
Avnet Nortec AB
Hemvärnsgatan 9
SE-171 54 Solna
Phone: +46 (0)8587 462 00
Fax: +46 (0)8587 460 01
stockholm@avnet-abacus.eu

Smörhålevägen 3
SE-43442 Kungsbacka
Phone: +46 (0)8 58746 200
Fax: +46 (0)300 140 15
gothenburg@avnet-abacus.eu

SWITZERLAND
Bernstrasse 394
CH-8953 Dietikon
Phone: +41 (0)43 322 49 90
Fax: +41 (0)43 322 49 99
zurich@avnet-abacus.eu

TURKEY
Tatlısu Mahallesi Pakdil
Sokak No: 7 Kat: 2
TR-34774 Umraniye Istanbul Turkiye
Phone: +90 216 52 88 370
Fax: +90 216 52 88 377
istanbul@avnet-abacus.eu

UK
Building 5, Waltham Park
White Waltham
Maidenhead Berkshire SL6 3TN
Phone: +44 (0)1628 512900
Fax: +44 (0)1628 512999
maidenhead@avnet.eu

St. Peter´s House
Silverwell Street
Bolton, BL1 1PP
bolton@avnet.eu

UKRAINE
c/o Avnet Abacus Poland
Plac Solny 16
PL-50-062 Wroclaw
Phone: +48 71 34 205 99
Fax: +48 71 34 229 10
ukraine@avnet-abacus.eu

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