

IGBT

IGBT Markets and Application Trends Report

IGBT application growth will lead the market to \$6B+ by 2018

WHAT'S NEW COMPARED TO LAST ANALYSIS

- Complete analysis of every IGBT application
- Updated IGBT market forecast for six key applications: PV, Windmill, Rail, UPS, EV/HEV and Motor drives

REPORT OUTLINE

- Title: IGBT Markets and Application Trends
- Market & Technology Report
- PDF
- 240+ slides
- May 2013
- €5,990 - Multi user license

KEY FEATURES OF THE REPORT

- Market metrics split by players, applications and voltage
- Market forecast to 2018 (in \$ and wafer eq.)
- Analysis of new and existing players
- Exhaustive supply chain analysis
- Analysis of packaging solutions evolution
- Analysis of all applications using IGBTs
- Specific focus on six applications: EV/HEV, PV, Windmill, UPS, Motor drive and Rail traction

RELATED REPORTS

- SiC Market 2013
- Inverter Market Trends for 2013-2020 and Major Technology Changes
- Reverse Costing: Mitsubishi 6th Gen. CSTBT 1200V

Find all our reports on www.i-micronews.com

EV/HEV, RENEWABLE ENERGIES, MOTOR DRIVES, UPS AND TRANSPORTATION: THESE KEY APPLICATIONS WILL DRIVE IGBT GROWTH TO \$6B BY 2018

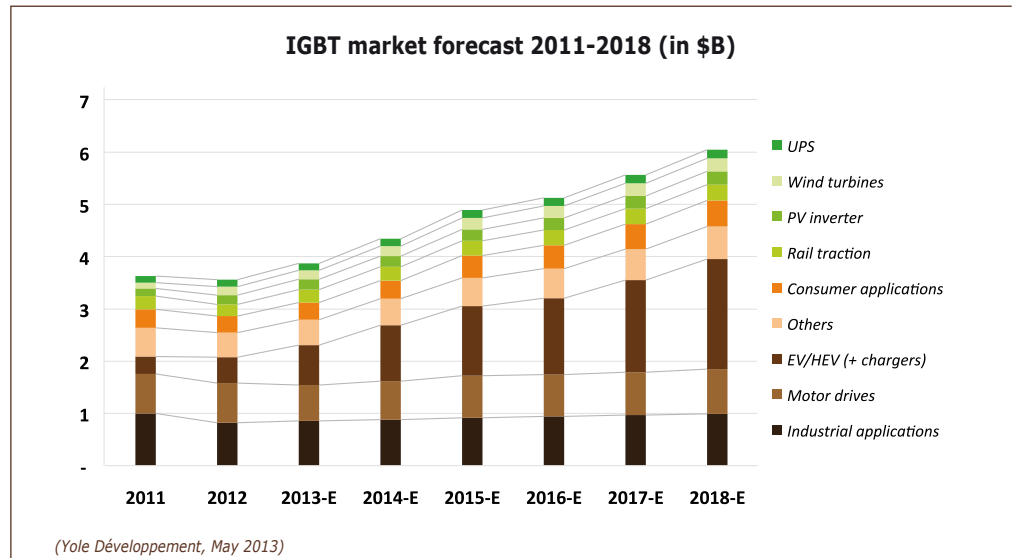
After a few hiccups in 2011 and 2012, we expect a return to steady growth for the IGBT market; specifically, from \$3.6B today to \$6B by 2018. Six key applications, which are extensively analyzed in this report, will fuel this growth: Motor drives is the largest one for IGBTs; in this report, we provide its splits for industrial, commercial and residential segments. Renewable energies (PV and wind) are also trending well. Since they rely on government investments, they can be

unpredictable, but Japan and several developing countries will make up for Europe's slow-down. Mass transportation and UPS are based on infrastructure needs; thus, the need for greater efficiency is pushing these markets. As for hybrid and electric cars, question marks remain. Market growth will occur, but nobody can predict to what extent. Our forecast is based on the latest Q1/2013 results and our own understanding of technology adoption.

IGBT IN EVERYDAY LIFE: CONSUMER AND HOME APPLIANCES ARE NOW PART OF THE EQUATION

In addition to the six key applications, every secondary application is analyzed in this report as well, and there are important trends not to be missed: the so-called "inverterization" trend is one of them. Home appliances increasingly require inverter-based motor drives, which

provide better performance, comfort and efficiency: all "musts" for high-end products. Consumers are also using more advanced home solutions, like induction-based plates for rice cookers. These new applications will contribute to IGBT's growth in consumer applications.



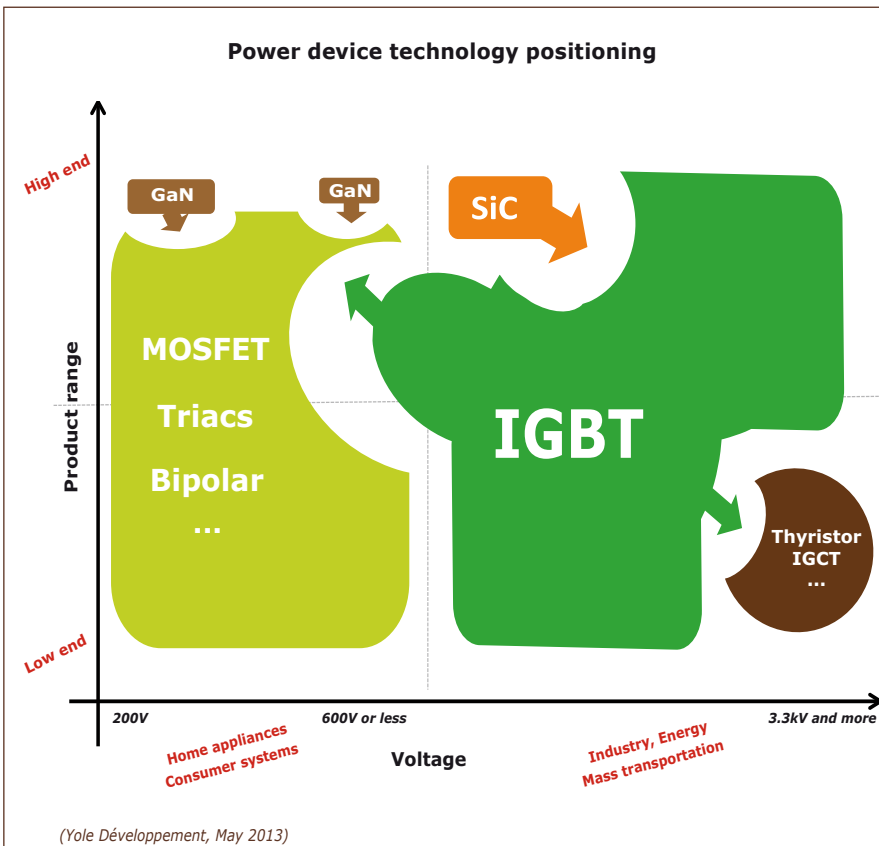
25% DROP IN 2012: MORE A MATTER OF CIRCUMSTANCES THAN AN ACTUAL CRISIS

In 2012 there was a crisis in the Power Devices markets, IGBTs in particular. This is explained by multiple factors:

- The slow-down of PV installations due to the reduction of feed-in-tariffs in Europe
- The slow-down of wind turbine installations in China
- The train accident in China that halted the high-speed train production line
- The fact that global economic recovery has been much slower than expected (thus affecting the consumer markets).

Also, we believe that the 2011 earthquake in Japan caused system makers to secure their orders. All these factors combine to explain 2011's overproduction, which was paid for in 2012 and early 2013.

IGBT FACES COMPETITION FROM THYRISTORS, SiC, GaN AND MOSFET



The IGBT market also faces competition from external, market-impacting trends. By following the component trends surrounding IGBT, we've observed many evolutions, all of which are explained in this report. In fact, IGBT drivers area has never been so active: there are a bunch of start-up companies proposing solutions offering more design flexibility and/or higher performance. Other companies are structuring offers at power stack level, and we've seen a lot of work put into power module packaging solutions.

IGBT is no longer the only high-end device solution. SiC devices are ready, and GaN devices are at sample stage. Adoption roadmaps are clearer now. We've seen the first full SiC PV inverters based on MOSFETs or JFETs. IGBT is slowly moving to medium and-low end solutions, allowing SiC to handle higher voltages, and GaN to capitalize on lower voltages.

The need for efficient energy solutions is stronger than ever, and IGBT devices are still undergoing developments and improvements: thinner wafers, more efficient production, integration of functionalities, etc. This is why we believe that IGBT is not on its deathbed, nor even declining. No, there are plenty of opportunities still to be had.

STRONG SUPPLY CHAIN EVOLUTION WITH ASIA ENTERING THE GAME



The IGBT supply chain is not steady either, and we've observed a growing number of Asian companies involved or willing to be involved in this market. Chinese and Korean companies are part of this trend, and we've listed them in this report. Among the biggest are CSR (who acquired Dynex), and of course BYD; both are moving towards a verticallyintegrated business model.

Also, foundries and fabless companies are targeting opportunities in the low-voltage, low-end market. As a first step, Asian players will probably remain with standard technologies and focus on production for local use.

On the other hand, European and U.S.-based players are pushing for innovation. Some, such as ON Semiconductor (with its division, Sanyo) and Alpha and Omega Semiconductor, are entering or re-entering the IGBT market.

OBJECTIVES OF THE REPORT

- Analyze and forecast IGBT markets and applications
- Provide a progressive point-of-view on future IGBT market evolution
- Provide an exhaustive analysis of IGBT's main applications
- Present and explain the main trends impacting the IGBT market



AUTHOR

Alexandre Avron is a full time analyst in power electronics at Yole Développement. He was granted a Master degree in Electrical engineering, with a major in power electronics and microelectronics processes, from Applied Sciences National Institute (INSA) of Lyon, France.

COMPANIES CITED IN THE REPORT

ABB, Agile Switch, Alstom, Amantys, AOS, ASMC, Bombardier, Covalent, CSMC, CSR, Danfoss, DEC, Delta, Dynex, Eaton, Electrovipryamitel, Emerson, Fairchild, Founder, Fronius, Fuji Electric, GRINM, HH NEC, Hitachi, Huajing, Infineon, Ingeteam, International Rectifier, IR Peri, Ixys, Kaco, Kawasaki, KEC, KEDA Semiconductor, Legrand, LS Power Semitech, Lytran, Macmic, Magnachip, Maplesemi, MEMC, Methode Electronics, MicroGan, Microsemi, Mitsubishi Electric, National Instruments, Nichicon, NXP, OKMETIC, ON Semi, Panasonic, Poseico, Power One, Powerex, PSMC, Renesas, Rohm, Sanken, Sanrex, Sanyo, SAS, SBE, Schneider Electric, Semikron, Shindengen, Shinetsu, Siemens, Siltronic, Siltronix, Silvermicro, Sirectifier, SMA, SMIC, Socomec, Solar Max, STMicroelectronics, Starpower, Sungrow, Techsem, TOPSIL, Toshiba, Toyo Denki, Toyota, Vincotech, Vishay, Xantrex, Yaskawa.

TABLE OF CONTENTS

• Executive summary	3
• Preliminary definitions	30
• Introduction	37
• Market metrics	43
> Market metrics	
> Players' production analysis	
• IGBT for motor drives	66
> Definition & application description	
> Market and players	
• IGBT for PV inverters	82
> Definition & application description	
> Market and players	
• IGBT for electric and hybrid cars	98
> Definition & application description	
> Market and players	
> EV/HEV charging stations	
• IGBT for rail traction	117
> Definition & application description	
> Market and players	
• IGBT for wind turbine	127
> Definition & application description	
> Market and players	
• IGBT for UPS	139
> Definition & application description	
> Market and players	
• Secondary IGBT markets	152
> Home appliances & consumer systems	
> Secondary industrial applications: HVAC, pumps, ...	
> Secondary transportation applications: avionics, marine, ...	
> Medical applications	
> Other applications	
• Technology and supply chain trends	175
> IGBT technologies and roadmaps	
> Power stack trend	
> IGBT driver innovations	
> Other IGBT devices	
> Wafer technology trends	
> ASP analysis and cost trends	
• IGBT packaging	207
• Si, SiC and GaN	230
• Conclusions	235

ORDER FORM

IGBT Markets and Application Trends

BILL TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country*:

*VAT ID Number for EU members:

Tel:

Email:

Date:

PAYMENT

BY CREDIT CARD
 Visa Mastercard Amex

Name of the Card Holder:

Credit Card Number:

Card Verification Value (3 digits except AMEX: 4 digits):

Expiration date: /

BY BANK TRANSFER
 BANK INFO: HSBC, 1 place de la Bourse,
 F-69002 Lyon, France,
 Bank code: 30056, Branch code : 00170
 Account No: 0170 200 1565 87,
 SWIFT or BIC code: CCFRFRPP,
 IBAN: FR76 3005 6001 7001 7020 0156 587

RETURN ORDER BY
 • FAX: +33 (0)472 83 01 83
 • MAIL: YOLE DÉVELOPPEMENT, Le Quartz,
 75 Cours Emile Zola, 69100 Villeurbanne/Lyon - France

PRODUCT ORDER

Please enter my order for above named report in multi user license* at euro 5,990.**

*For one user license sales conditions, please contact us.
 **For price in dollars, please use the day's exchange rate. All reports are delivered electronically at payment reception. For French customers, add 19,6% for VAT

Signature:

I hereby accept Yole's Terms and Conditions of Sale⁽¹⁾

SALES CONTACTS
 • North America: Michael McLaughlin - Mclaughlin@yole.fr
 • Greater China: Meiling Tsai - Meiling.tsai@yole.com.tw
 • Korea: Hailey Yang - Yang@yole.fr
 • Japan: Miho Ohtake - Ohtake@gii.co.jp
 • Europe & RoW: Yves Devigne - Devigne@yole.fr
 • General: info@yole.fr

⁽¹⁾ Our Terms and Conditions of Sale are available at www.yole.fr/Terms_and_Conditions_of_Sale.asp
 The present document is valid 24 months after its publishing date: May 23rd, 2013.

SHIPPING CONTACT

First Name: Last Name:

Email: Phone:

ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media in addition to corporate finance services. With a strong focus on emerging applications using silicon and/or micro manufacturing, Yole Développement group has expanded to include more than 50 associates worldwide covering MEMS, Compound Semiconductors, LED, Image Sensors, Optoelectronics, Microfluidics & Medical, Photovoltaics, Advanced Packaging, Nanomaterials and Power Electronics. The group supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to develop their business.

CONSULTING

- Market data, market research & marketing analysis
 - Technology analysis
 - Reverse engineering & costing services
 - Strategy consulting
 - Patent analysis
- More information on www.yole.fr

FINANCIAL SERVICES

- Mergers & Acquisitions
 - Due diligence
 - Fundraising
 - Coaching of emerging companies
 - IP portfolio management & optimization
- More information on www.yolefinance.com

REPORTS

- Collection of technology & market reports
- Players & Market databases
- Manufacturing cost simulation tools
- Component reverse engineering and costing analysis
- Patent analysis

MEDIA

- Online disruptive technologies website: www.i-micronews.com
- Editorial webcasts program
- Six magazines: Micronews - MEMS Trends - 3D Packaging - iLED - Power Dev' - New in 2013: Image Sensors Industry
- Communication & Webcasts services

CONTACTS

- For more information about :
- Consulting Services: Christophe Fitamant (fitamant@yole.fr)
 - Financial Services: Géraldine Andrieux-Gustin (andrieux@yole.fr)
 - Reports: David Jourdan (jourdan@yole.fr)
 - Media & Communication: Sandrine Leroy (leroy@yole.fr)

TERMS AND CONDITIONS OF SALES

Definitions: "Acceptance": Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions "I hereby accept Yole's Terms and Conditions of Sale".

"Buyer": Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

"Contracting Parties" or "Parties": The Seller on the one hand and the Buyer on the other hand.

"Intellectual Property Rights" ("IPR") means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

"License": For the reports and databases, 3 different licenses are proposed. The Buyer has to choose one license:

- One user license: one person at the company can use the report.
- Multi-user license: the report can be used by unlimited users within the company. Subsidiaries and Joint-Ventures are not included.
- Corporate license: purchased under "Annual Subscription" program, the report can be used by unlimited users within the company. Joint-Ventures are not included.

"Products": Depending on the purchase order, reports or database on MEMS, CSC, Optics/MOEMS, Nano, bio... to be bought either on a unit basis or as an annual subscription. (i.e. subscription for a period of 12 calendar months). The annual subscription to a package (i.e. a global discount based on the number of reports that the Buyer orders or accesses via the service, a global search service on line on I-micronews and a consulting approach), is defined in the order. Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

"Seller": Based in Lyon (France headquarters), Yole Développement is a market research and business development consultancy company, facilitating market access for advanced technology industrial projects. With more than 20 market analysts, Yole works worldwide with the key industrial companies, R&D institutes and investors to help them understand the markets and technology trends.

1. SCOPE

- 1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.
- 1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivocal consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions "I hereby accept Yole's Terms and Conditions of Sale". This results in acceptance by the Buyer.
- 1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer's address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

2. MAILING OF THE PRODUCTS

- 2.1 Products are sent by email to the Buyer:
 - within ^[1] month from the order for Products already released; or
 - within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.
- 2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer
The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including incases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.
- 2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.
- 2.4 The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. If the Product's electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects. .

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer's risk.

3. PRICE, INVOICING AND PAYMENT

- 3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.
- 3.2 Yole may offer a pre release discount for the companies willing to acquire in the future the specific report and agreeing on the fact that the report may be release later than the anticipated release date. In exchange to this uncertainty, the company will get a discount that can vary from 15% to 10%.
- 3.3 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, credit card or by electronic transfer to the following account:
HSBC, 1 place de la Bourse 69002 Lyon France
Bank code: 30056
Branch code: 00170
Account n°: 0170 200 1565 87
BIC or SWIFT code: CCFRFRPP
IBAN: FR76 3005 6001 7001 7020 0156 587

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

- 3.4 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.
- 3.5 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

4. LIABILITIES

- 4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.
- 4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement
- 4.3 In no event shall the Seller be liable for:
 - a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;
 - b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.
- 4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.
- 4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.
- 4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.
- 4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of sale ability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER'S IPR

- 6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.
- 6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:
 - Information storage and retrieval systems;
 - Recordings and re-transmissions over any network (including any local area network);
 - Use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
 - Posting any Product to any other online service (including bulletin boards or the Internet);
 - Licensing, leasing, selling, offering for sale or assigning the Product.
- 6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.
- 6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.
- 6.5 In the context of annual subscriptions, the person of contact shall decide who within the Buyer, shall be entitled to access on line the reports on I-micronews.com. In this respect, the Seller will give the Buyer a maximum of 10 passwords, unless the multiple sites organization of the Buyer requires more passwords. The Seller reserves the right to check from time to time the correct use of this password.
- 6.6 In the case of a multisite, multi license, only the employee of the buyer can access the report or the employee of the companies in which the buyer have 100% shares. As a matter of fact the investor of a company, the joint venture done with a third party etc...cannot access the report and should pay a full license price.

7. TERMINATION

- 7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.
- 7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party. The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

- 9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.
- 9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.