

# STATUS OF THE RECHARGEABLE LI-ION BATTERY INDUSTRY 2021

Market & Technology Report - July 2021

*Asia dominates the Li-ion battery supply chain, but Europe is on the rise, with more than 1,000 GWh battery production already announced by 2030.*

## WHAT'S NEW

- Expanded overview of the application trends driving future needs for battery characteristics and demand
- Insights into cost analysis of battery components
- Focus on the supply chain for battery and battery components
- Focus on low cobalt and nickel-rich battery technology
- Broader coverage of battery integrators in different applications
- Insights into battery recycling methods

## KEY FEATURES

- 2020 - 2026 battery demand (in GWh and \$M) for three main application segments: consumer electronics, electric mobility, and stationary energy storage
- Analysis of different Li-ion chemistries and their applicative potential
- Technology trends for Li-ion battery cells, cell components, and battery packs
- Li-ion battery supply chain, ranging from raw material supply, cell components, and manufacturing/testing equipment to battery integrators and battery recycling companies

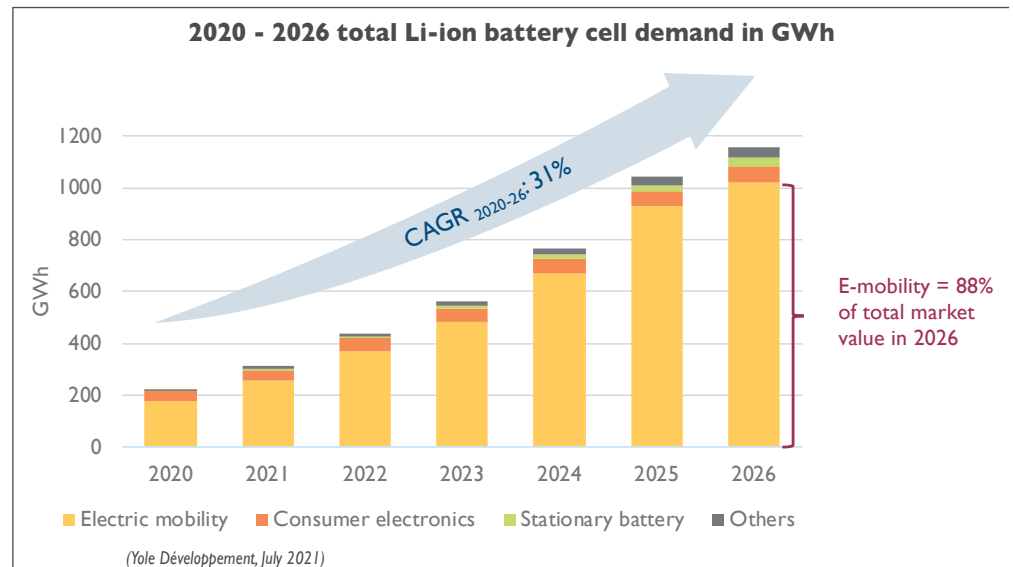
## WORLDWIDE LI-ION BATTERY DEMAND IS INCREASING ENORMOUSLY!

Global Li-ion battery demand continues its impressive growth and will reach a massive 1156 GWh of yearly demand by 2026. The main reason for this growth is the demand for electric and hybrid electric vehicles (EV/HEV) and other e-mobility applications. According to Yole Développement (Yole)'s analysis, e-mobility alone will represent about 88% of global Li-ion battery demand.

In the "Status of Lithium-ion battery 2021" report, Yole analyses three key battery market segments: consumer applications, e-mobility, and stationary battery storage. In addition, market and technology trends for the different

applications and their battery characteristic requirements are detailed.

The tremendous growth in demand for Li-ion batteries is due to various factors. First is the increasing demand for a given application. Second, in some applications (e.g., power tools), Li-ion battery's share is increasing via progressive replacement of "older" battery technologies like lead-acid and NiMH batteries. Third, and yet another factor fueling battery demand, is the new battery applications and a growing share of battery-powered power tools and consumer devices.



## THE SUPPLY CHAIN IS RESHAPING IN ORDER TO REDUCE COST AND GET CLOSER TO CUSTOMERS

Li-ion battery has become the technology of choice for many applications. As a result, it attracts numerous players: R&D labs, cell component manufacturers, cell and battery pack manufacturers, and system integrators.

Asia dominates the Li-ion battery supply chain, especially China, where Chinese Li-ion battery manufacturer CATL is the world leader in battery manufacturing. China's success results from its sizeable domestic battery demand, control of more than 70% of the world's graphite raw material refining, and massive cell and cell component manufacturing

capacity. Korea and Japan rank number two and three in the Li-ion battery supply chain. While both countries are among the leaders in battery and cell component manufacturing (LG Energy Solution, Samsung SDI, SK Innovation, Panasonic), they do not have the same influence in raw materials refining and mining as China.

Although Asia dominates the Li-ion battery supply chain, Europe is on the rise. As EV demand grows, there is an increasing need to establish cell manufacturing facilities close to the EV production site. To access the European EV market, Asian battery makers implement

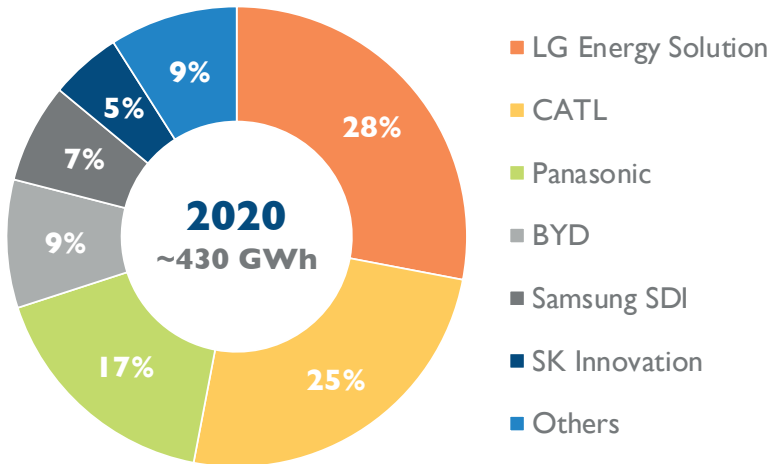
their factories in European countries. At the same time, European companies also invest in European

battery factories to catch the business associated with domestic battery demand.

Li-ion batteries for electric vehicles are in high demand, and in the future, battery supply may be an obstruction. Therefore, all carmakers have pursued different strategies to secure cell supplies. For example, many carmakers partner with battery manufacturers (e.g., BMW and Northvolt); many carmakers jointly establish a battery-manufacturing factory with cell manufacturers (e.g., GM with LG Energy; Renault with Envision AESC and Verkor); and many carmakers are in a race to develop in-house battery production (e.g., BYD, Tesla, Daimler).

As battery demand grows, the need for battery components (anode, cathode, electrolyte, and separators) also increases. To meet this demand, the companies manufacturing battery components (e.g., BTR, Asahi Kasei, SK Innovation) are increasing their production capacity rapidly.

2020 top battery manufacturers market shares in GWh



(Yole Développement, July 2021)

### BATTERY TECHNOLOGY: THE POTENTIAL EXISTS FOR PERFORMANCE IMPROVEMENT AND COST REDUCTION

As EV drives global battery demand, most technology innovations and development efforts focus on EV battery cells. Regarding battery cathode chemistry, there is a clear trend towards nickel-manganese-cobalt oxide (NMC) technology due to its «universal» characteristics that match the requirements of a large variety of products and applications. Within NMC technology, the trend is to reduce the cobalt content such as NMC811 and NMC721. At the same time, there is renewed interest in lithium-iron-phosphate (LFP) because of its lower cost, despite its relatively low energy density. A few carmakers have already confirmed

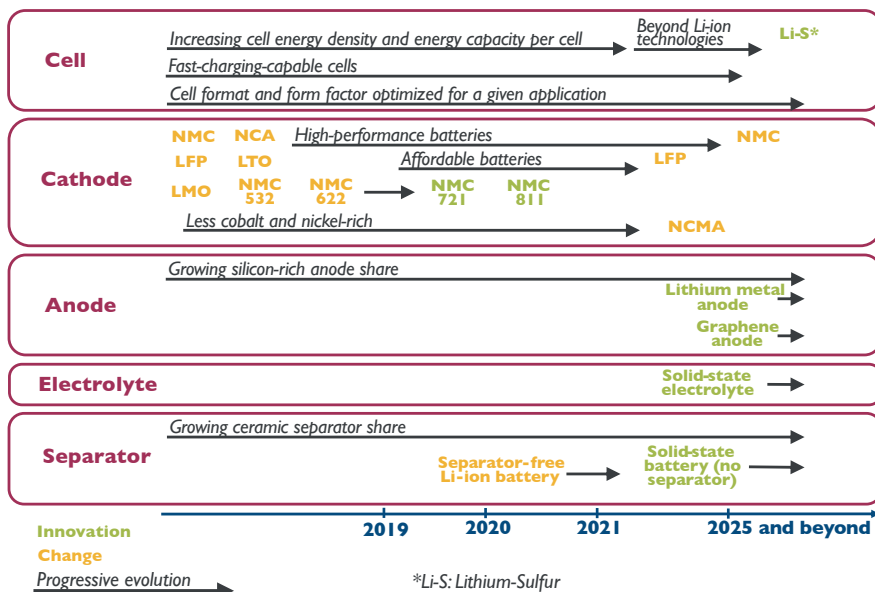
using LFP batteries to power their EVs, such as Tesla and BYD.

In the case of the anode, graphite is the primary anode material; however, the trend is moving to add silicon to the graphite material to increase the energy density of Li-ion battery cells.

In the past, carmakers commonly used a single battery chemistry for all their electric vehicles. However, with a growing number of car models per car manufacturer and a more extensive customer portfolio, two or more battery chemistries are used by each car maker. Most commonly, two different chemistries are used to satisfy the requirements of different EV users: a “high-performance” one and an “affordable” one. For example, Tesla is using NMC811 batteries for high-performance Made-in-China Model 3 and LFP batteries for affordable Made-in-China Model 3. Volkswagen and Renault also plan to use LFP and NMC batteries to power their upcoming EVs. Furthermore, to reduce the supply shortage issues and reach required volumes, car makers usually partner with several cell manufacturers. For example, Tesla uses NCA batteries produced by Panasonic, and NMC811 and LFP batteries produced by LG Energy and CATL, respectively, for its different EVs.

Although there is a strong development effort to find alternatives to existing Li-ion technologies, there will be no significant battery breakthrough in the coming years, according to Yole. Instead, battery improvements will be progress steadily. The focus will be on cost reduction and environmental, economic, and safety issues related to battery production and end-of-life battery handling.

Battery cell – 2019 to 2025 technology trends



(Yole Développement, July 2021)

## REPORT OBJECTIVES

- Offer deep insights into the rechargeable Li-ion battery market, covering the three main application segments: consumer electronics, electric mobility, and stationary energy storage
- Furnish 2020 - 2026 battery demand data (in GWh) and market value (in \$M) for various Li-ion battery applications
- Offer a thorough analysis of different Li-ion chemistries and their future applicative potential
- Discuss the cost analysis of various types of Li-ion batteries.
- Discuss main challenges associated with Li-ion batteries
- Discuss the main technology trends for Li-ion battery cell materials, formats, sizes, and cell components (cathode, anode, electrolyte, and separator), as well as battery packs
- Provide a detailed overview of the Li-ion battery supply chain, ranging from raw material supply, cell components, and manufacturing/testing equipment to battery integrators in different applications and battery recycling companies

## COMPANIES CITED IN THE REPORT (non exhaustive list)

3M, Ambatovy, Alabama Graphite, Accumotive, Altairnano, Alelion, Automotive Energy Supply Corporation, Akkuser, American Manganese, Advance Lithium Systems Europe, Akasol, ABB, Adstec, Albermarle, Asahi Kasei, ATL, ALL Cell, Ashok Leyland, Ampere Technology, ACC, AES, Aoyu Graphite Group, AMTE, Advano, BASF, Bitrode, Boston Power, Batrec, Brunp Recycling, BMW, BMZ, BAK, Bosch, Benergy Tech, BTR, BYD, Britishvolt, Battery Resourcers, Batrec, Cangzhou Mingzhu, CATL, CALB, Chilwee, Cealtech, Cenate, Capchem, Critical Elements, China Baoan Group, China Molybdenum, DOW, Dow Eco-system, Duesenfeld, Daikin, Dynapower, Dynanonic, Delvotec, Daimler, DESAY, DNP, Dongguan Shanshan Battery Material, Dinho Technology, Digatron Power Electronics, Dongguan Honbro Li-ion Battery Equipment Technology Co., Ltd., Electric Vehicle Power System, Enovix, Enevate, Entek, Eliiy Power, Envirostream, Elmarco, Europe Batteries, Envision AESC, Enphase, European Batteries, Engie, Elkem, Enwires, E-One Moli Energy, EAS, Electrovaya, Electric Power Research Institute, Eguana, Fortum, Forsee Power, F&K, Freyr, Fangda Carbon New Material, FDK, FMC, Freudenberg, Focus Graphite, Freeport-Cobalt, Freeport-McMoran, Furukawa Electric, Festo, Fronius, First Energy, Foshan Jinhui Hi-Tech Optoelectronic Material, Green Smith, GRST, Green Charge, Goutai-Huarong, Ganfeng Lithium, GE Energy, Galaxy, GEM, Golden Light Hi-Tech, GS Yuasa, Group14, Hanrui Cobalt, Henan Kelong New Energy, Hioki, Hitachi Metals, HBM, Honbro, Hefei Guoxuan Hi-Tech Power Energy Co. Ltd., Hesse Mechatronics, Hi Future, Huayou Cobalt, Iron Edison, IF, Inobai, Italvolt, Ingeteam, Jinchun, JFE, Jinhe, Japan Metals & Chemicals, JX Nippon Mining & Metals, Johnson Matthey, Jiangxi Special Electric Motor, KCFT, Kureha, Kanto Denka Kogyo, Keysight, Kokam, Kulicke & Soffa, LG CNS, Leclanché, Li-Cycle, LG Energy Solution, Lishen, Lithium Americas, Lithium South Development Corp., Leydenjar, Maison Graphite and more...



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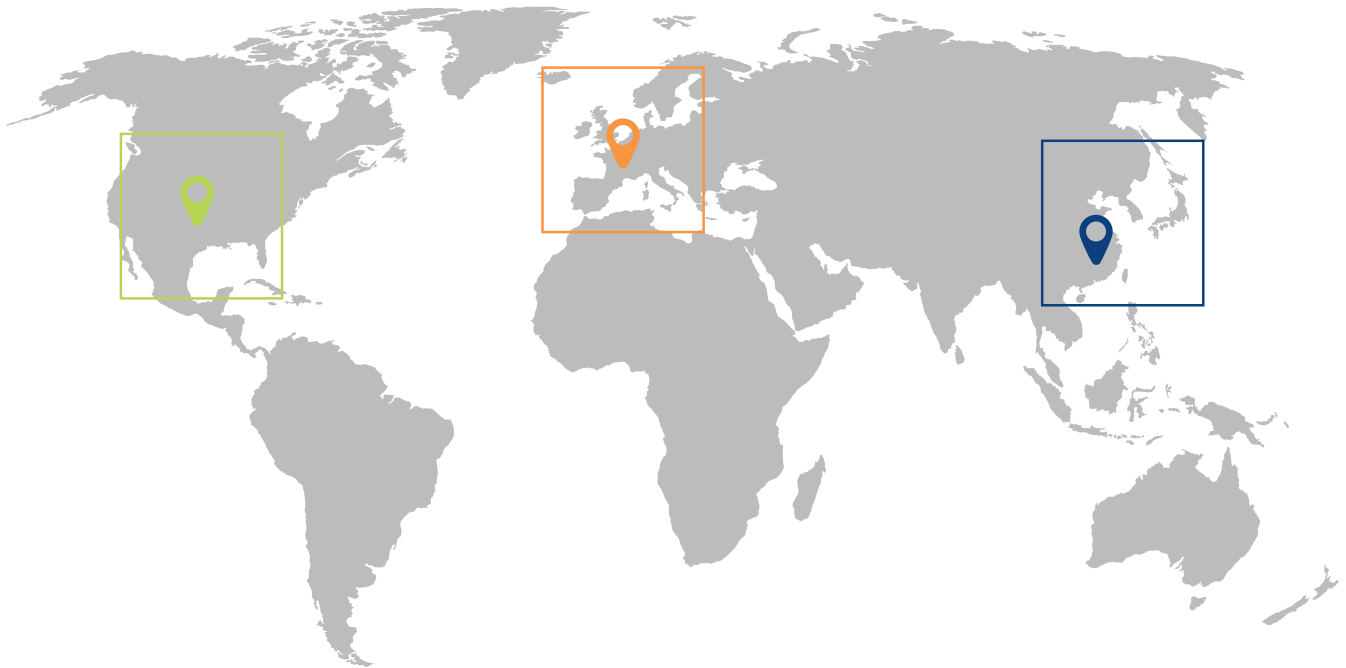
## RELATED REPORTS, MONITORS & TRACKS



- Solid-state Battery 2021
- Lithium-ion Battery Recycling Market & Technology Trends 2020
- Li-ion Battery Packs for Automotive and Stationary Storage Applications 2020
- Power Electronics for E-Mobility 2021
- DC Charging for Plug-In Electric Vehicles 2021

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## ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

### CONSULTING AND ANALYSIS

- Market data & research, marketing analysis
- Technology analysis
- Strategy consulting
- Reverse engineering & costing
- Design and characterization of innovative optical systems
- Financial services (due diligence, M&A)

More information on [www.yole.fr](http://www.yole.fr)

### MEDIA & EVENTS

- i-Micronews.com website, application & related e-newsletter
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- Market & technology reports
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- Marketing & Communication: Jean-Christophe Eloy ([eloy@yole.fr](mailto:eloy@yole.fr))

Definitions: **“Acceptance”**: Action by which the Buyer accepts these General Terms and Conditions of Sale in their entirety. It is done by signing the purchase order which states “I hereby accept Yole Développement’s General 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) placing an order pursuant to these General Terms and Conditions of Sale, with the exclusion of any individual consumer acting for his/her sole personal interest.

**“Seller”**: Headquartered in Villeurbanne (France), Yole Développement provides marketing, technology and strategy consulting, media and corporate finance services, reverse engineering/costing services as well as IP and patent analysis. With dedicated teams of technology & market analysts, Yole Développement operates worldwide with the key industrial companies, R&D institutes and investors to help them understand the market and technology trends.

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Reports are established in PowerPoint and delivered in a PDF format with an additional Excel file. 30 min of Q&A session with an analyst/author can be included for all purchased reports (except the ones bought as a one user license). More time can be allocated on a fee basis.

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1.1 Both Contracting Parties undertake to comply with these General Terms and Conditions of Sale.

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1.2 These General Terms and Conditions of Sale shall be deemed valid and enforceable between the Contracting Parties after acceptance of an order from the Buyer by the Seller pursuant to Article 1.3 below. For such purpose, the Buyer, when signing the purchase order which mentions “I hereby accept Yole Développement’s Terms and Conditions of Sale” is deemed to have fully and unequivocally accepted these Terms and Conditions of Sale.

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. In the absence of any confirmation in writing, no order shall be deemed to have been accepted.

#### 2. MAILING OF THE PRODUCTS

2.1 Products are sent by email to the Buyer after Seller’s confirmation:

- Within a few days from the Seller’s confirmation of the order for Products already released and paid; 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 The Seller shall by no means be responsible for any delay pursuant to Article 2.1 above, in particular in cases where a new event or access to new contradictory information would require the Seller analyst to dedicate extra time to compute or compare the data in order to enable the Seller to deliver a high quality Product.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in Article 3 above.

2.4. The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. The Buyer is responsible for ensuring that the Buyers platform has the required capacities and authorisations to receive the Product(s) emailed by the Seller. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that the Seller 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 with 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 written notification from the Buyer to the Seller, even in case of delayed delivery. Any Product returned to the Seller without the Buyer providing prior notification to the Seller as required under Article 2.5 above shall remain at the Buyer’s risk. In no event shall the Seller incur any liability for Products erroneously ordered by the Buyer, or for any request from the Buyer to replace a Product previously ordered by a different Product.

#### 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 deemed to be inclusive of all taxes applicable in the country where the Seller is based (except for France where VAT will be added). The prices are re-evaluated from time to time by the Seller. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, or made by 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 secure the payments due to the Seller, the Seller reserves the right to request down payments from the Buyer. In such case, the need for a down payment will be mentioned on the corresponding order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except as otherwise specifically agreed in writing by the Buyer and the Seller. If the Buyer fails to pay at the due date and fails to request and obtain from the Seller a payment extension, 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.

3.4 The Seller publications (reports, monitors, tracks...) are due for delivery only after receipt by the Seller of any payment due by the Buyer prior to delivery.

3.5 In the event of termination of the contract by the Seller attributable to Buyer misconduct during the contract, the Seller will have the right to invoice all work performed at the time of termination, 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 the choice of the Products purchased as well as for the use and interpretations the Buyer makes of the documents it purchases, of the results the Buyer obtains, and of the advice and acts the Buyer bases thereon .

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- b) Any claim attributable to errors, omissions or other inaccuracies in a Product or interpretations thereof.

4.3 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.

4.4 Any Product that the Seller sells may, upon prior notice to the Buyer from time to time be modified by Seller or substituted with a similar Product meeting the needs of the Buyer. Such modification shall not lead to any liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

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4.7 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 any 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 Products available, the Seller cannot guarantee that any Product will be free from infection.

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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 a Product, or any part of it to any other party other than employees of the Buyer Company (and only in the country of the Primary User for Multi-User Licenses). The Buyer shall have the right to use Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use any Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmittals 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 a Product or any derivative thereof.

6.3 If the Buyer would like to use data coming from a Product for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement’s Public Relations Director (info@yole.fr) to get an official authorization and confirm that the data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.

6.4 The Buyer shall be solely responsible towards the Seller for any infringement of the obligation described in Article 6.3 above, whether such infringement originates from the Buyer’s employees or any person to whom the Buyer has sent the Products. Furthermore, the Buyer shall initiate and personally take care of any related proceedings in coordination with the Seller, and the Buyer shall bear the related financial consequences in their entirety.

6.5 The Buyer shall define within its Company an identified user who shall serve as a contact person for the License purchased by the Buyer. This person will be the recipient of each new report. This person shall also be responsible on behalf of the Buyer, for compliance with all copyrights and other obligations relating to the protection of the Seller’s IP rights and general compliance with the terms of the License purchased by the Company. In the context of Bundle and Annual Subscriptions, the contact person shall decide within the Buyer which person(s) shall be entitled to receive the protected link that will allow the Buyer to access the Products.

6.6 It is acknowledged and accepted by the Buyer that whether purchased in the form of Bundles or Annual Subscription, all unselected reports will be deemed cancelled and lost after a period of 12 month following acceptance of the corresponding order by the Seller in accordance with provisions of Article 1.3 above .

6.7 It is further acknowledged and agreed by the Buyer that any investor in the Buyer Company, any external consultant of the Buyer Company or any joint venture done with a third party in which the Buyer Company is involved , is not entitled to use a Product, without paying to the Seller the full price for a license to the required Product..

#### 7. TERMINATION

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 incurred by the Seller, pursuant to such cancellation or postponement.

#### 8. MISCELLANEOUS

8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing and shall be effective upon receipt by the other Party.

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

#### 9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.