

THERMAL IMAGERS AND DETECTORS 2020

Market & Technology Report - November 2020

Thermography is benefiting from COVID-19 mitigation attempts, pushing the thermal camera industry to \$6.6B in 2020.

WHAT'S NEW

This report is the complete analysis of the preliminary version done in May 2020. In this version the thermal imager and detector volumes, market value, market shares and associated forecasts are given. A more thorough overview of the COVID-19 effect on the thermal imaging market is presented together with Yole Développement (Yole) view for the future market and technology trends.

KEY FEATURES

- The report provides market data on key thermal detectors and thermal imagers, including market metrics and dynamics:
 - Thermal detectors and thermal imagers (and cameras) in units and revenue, split by market segment
 - Historical market data on 2018 and 2019, educated estimates for 2020 and market forecasts up to 2025
 - Market shares for thermal detectors and imagers
- It offers key technical insights into future technology trends and challenges
- It delivers an in-depth understanding of the thermal imaging value chain, infrastructure, and players:
 - Who are the industrial thermal sensor players and where are they positioned?
 - More generally, which are the key players to watch and how will the thermal detection/imaging market evolve?
- It also presents an in-depth analysis of thermal detectors and imagers for defense and commercial applications, including extra color on EBT/EST screening

THE ESTABLISHMENT OF FEVER DETECTION THERMAL CAMERAS

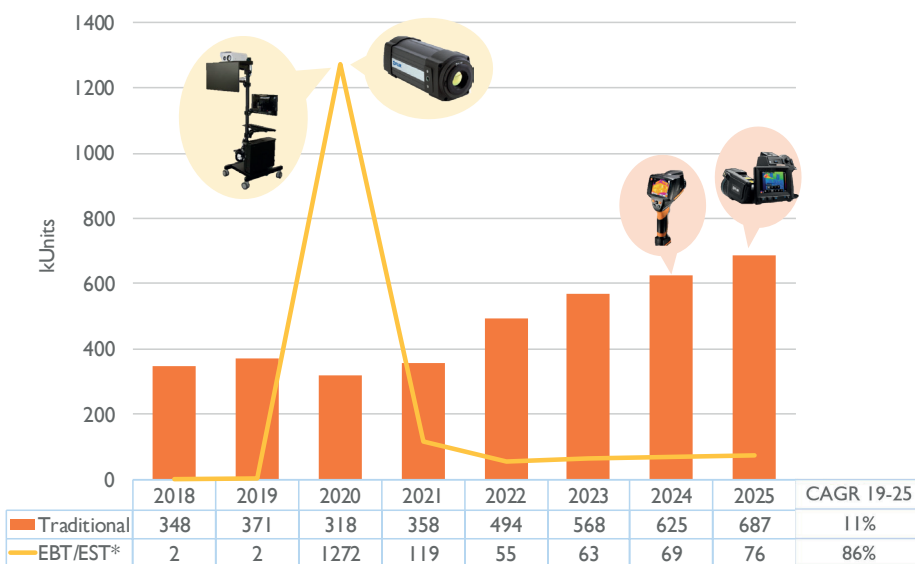
2020 was the year that turned the world upside down. As fears about COVID-19 erupted, various organizations rushed to get thermal cameras to monitor people's temperatures and detect possible fevers, one of the main symptoms. This made elevated body or surface temperature (EBT or EST) thermography surge unsustainably. Traditionally it was a very small market, created in 2002-2003 due to the SARS epidemic. It was sustained at very low volumes thereafter, only to get slightly boosted in years when other epidemics occurred, like H1N1 flu, Ebola and Zika.

Traditional thermography applications, such as building inspection and maintenance, suffered slightly in 2020. But the EST segment will compensate generously for this fall. The current situation will create a significant EST subsegment in the thermography market, which will continue to grow in the years to come. This could stem from the eventual realization of end-users that thermal camera systems can generally come in handy at various sites for isolating

sick febrile people, therefore decreasing cross-contamination. For example, people might have the simple flu or other infectious and non-infectious disease that causes a fever. For businesses this is very much needed, for example in minimizing sick leave.

However, one wonders what will happen next year and after that. Could this blip in 2020 go back to normal? It is likely, since demand has already drastically slowed down, as lots of sites are now equipped. Nevertheless, due to the imminent second and third waves and with no vaccine available, a possibility exists that the interest in this application will surge again. Finally, let's not forget that thermal imaging includes other interesting applications such as surveillance, firefighting, personal vision systems (PVS) and drones, which show promising growth. Together they will bring the total market value close to \$7.5B by 2025, at a 8% compound annual growth rate from 2019 to 2025 (CAGR₂₀₁₉₋₂₀₂₅).

The thermography blip in the thermal imager market



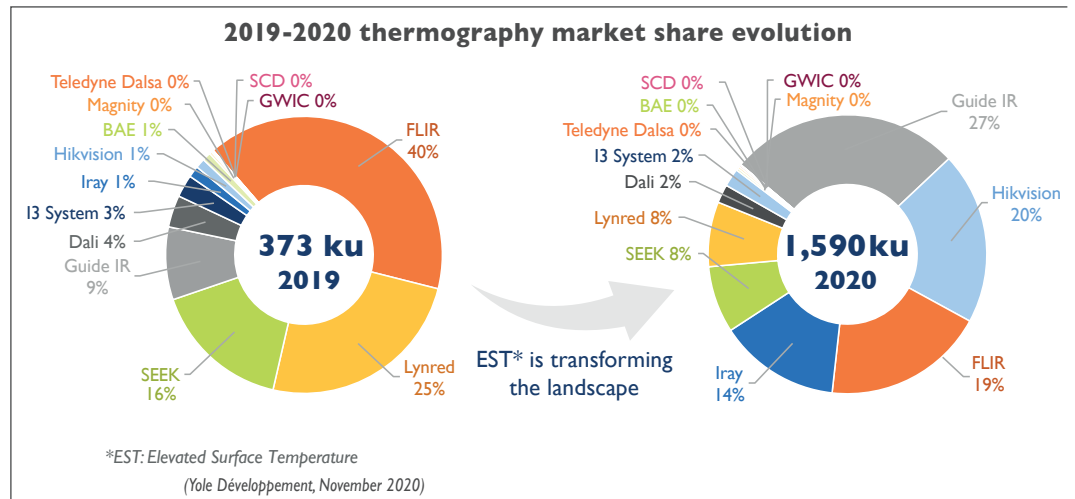
*EBT/EST: Elevated Body or Surface Temperature

(Yole Développement, November 2020)

THE MANUFACTURER LANDSCAPE IS TRANSFORMING

The current surge of EST applications has transformed the thermal imager manufacturer landscape, at least for thermography. In 2019, US and EU players (FLIR, Lynred, SEEK) were leading this market. Enter COVID-19, and Chinese players (Guide IR, Hikvision, iRay) have turned the tables, surpassing the market

leaders, at least in shipments. They rapidly addressed the great domestic demand for thermal imaging systems. Having acquired in the past few years technical competences in thermal imager manufacturing, these Chinese players ramped up their domestic production during the last 2 years, and the current situation



has fueled their path to becoming stars. As the epidemic spread across geographies to the west, the rest of the companies reaped the benefits from this hype. But western countries were slower in adopting thermal cameras en masse, due to privacy concerns.

In general, thermal imager production lines are not like other integrated circuit (IC) production lines that work at more than 90% of production capacity. Therefore, for some companies there was not a particular need for investment, besides some increase in consumables and possibly workforce. But for some Chinese companies, it is highly possible that the government has supported their production ramp ups. Moreover, this situation could push Chinese companies to chase investments for future growth, which could rapidly develop the market in the future. But what could happen next year? Chinese manufacturers have enormous production capacity

which risks being left unused. We could be spectators to huge changes in strategy where they could:

- Revert back to applications such as traditional thermography and surveillance. For example, companies with existing strong sales channels in traditional non-thermal surveillance can push forward thermal imaging technology. This could potentially lead to big price wars.
- Find new growth drivers, for example from big markets that are still left untapped. These include consumer applications such as smartphones and smart homes, industrial applications including smart buildings. They could enter the Internet of Things (IoT) world by leveraging megatrends such as 5G and artificial intelligence (AI) in an ultra-connected, intelligent world.

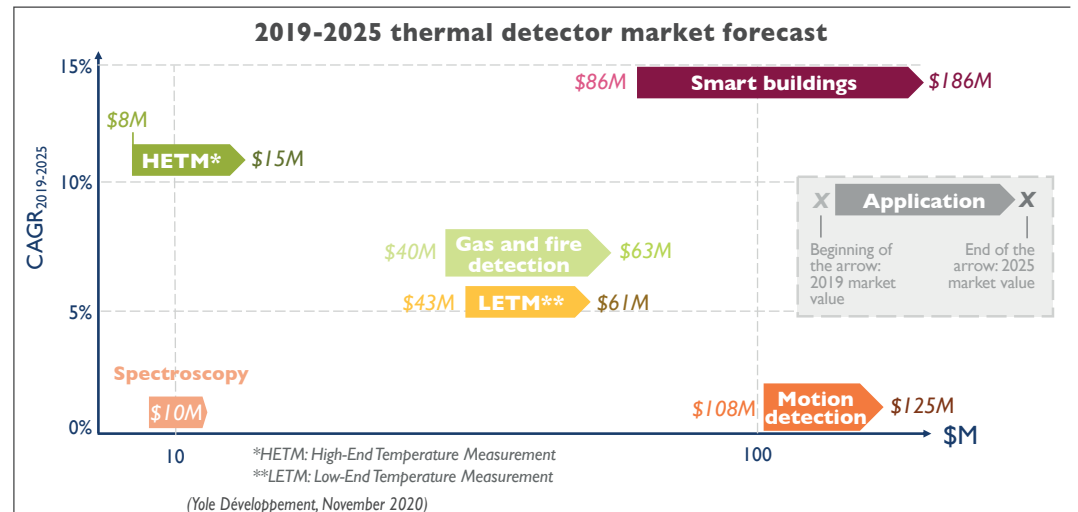
At this point, many uncertainties exist. One thing is sure: exciting times lie ahead for the thermal imaging industry.

WHAT IS THE STATUS OF THE SMALL THERMAL DETECTOR MARKET?

Beyond thermal imagers, small thermal detectors with no imaging functions comprise another interesting market. These thermal detectors are used for basic applications such as motion detection in security and energy savings in lighting and appliances, a stable market that grows slowly. Spectroscopy is another small and stable application, while gas and fire detection is getting more attention from smart home use-cases, growing faster than the rest.

Smart buildings have got a lot of attention in recent years due to the increased functionality that bigger

thermal detector arrays could offer. Comprising sizes of 8x8 pixels up to 64x64 pixels, these could be used in heating ventilation and air conditioning (HVAC), people counting and other use-cases for energy conservation and savings in buildings and infrastructure occupation management. The market is still growing, albeit slower than before and has not surged as expected. A limiting factor is the narrow Field of View (FoV) optics as well as price, with manufacturers facing strong average selling price (ASP) pressure from integrators.



Temperature measurement, while previously being a slowly growing market, has some opportunities for more thriving evolution due to the traction it gained from COVID-19. At the low-end, single, dual or quad element thermal detectors were used in temperature guns and contactless thermometers. At the high-end, thermal detector arrays are increasingly used in tablets and other access control terminals for human temperature measurement, offering cheaper solutions than thermal cameras.

Finally, we saw a glimpse toward consumerization of thermal detectors by their integration in Honor Play 4 Pro smartphones. The sought-after

smartphone application that Yole envisioned in the past is now a reality. However, is it a one-off opportunity or will it create a trend? For sure, various traditional camera module makers are becoming interested, but the use-case is still not clear. This particular human temperature measurement use-case is a very demanding one, with medical-grade thermal detectors needed and one must make sure that it is following established protocols and functioning reliably in all conditions. The future of this application, while always exciting, still remains uncertain.



AUTHORS

Dimitrios Damianos, PhD joined Yole Développement (Yole) as a Technology and Market Analyst and is working within the Photonics, & Sensing division. Dimitrios is daily working with his team to deliver valuable technology & market reports regarding the imaging industry including photonics & sensors. After his research on theoretical and experimental quantum optics and laser light generation, Dimitrios pursued a Ph.D. in optical and electrical characterization of dielectric materials on silicon with applications in photovoltaics and image sensors, as well as SOI for microelectronics at Grenoble's university (France). In addition, Dimitrios holds a MSc degree in Photonics from the University of Patras (Greece). He has also authored and co-authored several scientific papers in international peer-reviewed journals.



With more than 25+ years' experience within the semiconductor industry, **Eric Mounier** PhD. is Director of Market Research at Yole Développement (Yole). Eric provides daily in-depth insights into current and future semiconductor trends, markets and innovative technologies (such as Quantum computing, Si photonics, new sensing technologies, new type of sensors ...). Based on relevant methodological expertise and a strong technological background, he works closely with all the teams at Yole to point out disruptive technologies and analyze and present business opportunities through technology & market reports and custom consulting projects. With numerous internal workshops on technologies, methodologies, best practices and more, Yole's Fellow Analyst ensures the training of Yole's Technology & Market Analysts. Eric Mounier has a Semiconductor Engineering Degree and a Ph.-D in Optoelectronics from the National Polytechnic Institute of Grenoble (France).

REPORT OBJECTIVES

The COVID-19 outbreak has changed our world and will do so for years to come. Given the critical need for thermal detection and imaging systems to stem the spread of the virus by detecting the fever, this market has flourished. In this report, Yole Développement's analysts are trying to describe the global market, the effect of COVID-19, the changes that resulted and the possibilities for the future of this market.

COMPANIES CITED IN THE REPORT (non exhaustive list)

3M Scott, Adasky, Aeronvironment, Amphenol, Armasight, Aselsan, Athena, Avio, Avigilon, Axis Communications, BAE, Bosch, Bullard, Caterpillar, Convergent, Cosinuss, Cypress, Dahua, Denso, Device-ALab, DeWalt, Dexter, Dias Infrared, DJI, Dräger, Elbit Systems, Empatica, Excelitas (QiOptiq), FaceSense, Fisba, FLIR, Fluke, Flyability, Flybotix, Foresight, Fujitsu, Global Sensor Technology (GST), GreenWaves, GuidelR, Guide Smart, GWIC, Hamamatsu, Hanhwa Techwin, Heimann Sensors, Hensoldt, Hikvision, i3systems, Impossible, InfiRay, Infrared Cameras Inc, Infratec, InVid, IR&D, iRay Technologies, Irisys, Irllynx, Jenoptik, Kodenshi, Kyocera, L3 Harris, Leica, Leonardo DRS, LG Innotek, Lockheed Martin, Lucint, Lynred, Magnity, Melexis, Micasense, Mikrosens, Mitsubishi Electric, MKS Ophir, Mobotix, MSA, Murata, NEC, Nextvision, Nicera, Northrop Grumman, NXP, Omron, ON Semi, Opgal, OptoTherm, Orisystech, Parrot, Panasonic, Pyreos, Rafael ADS, Raytheon, Raytron, Safran, SATIR, SCD, Schneider Electric, Schott, Seek Thermal, Semitec, Senba Sensing Tec, Sierra Olympic, Sunell, Sunshine Technologies, Tamron, TE Connectivity, Teledyne Dalsa, Testo, Tetracam, Thales, Thermoteknix, TowerJazz, Umicore, Veoneer, Vital, Wahl, Wintec, Workswell, Xperi, Zeiss, Zhejiang Dali and many more...

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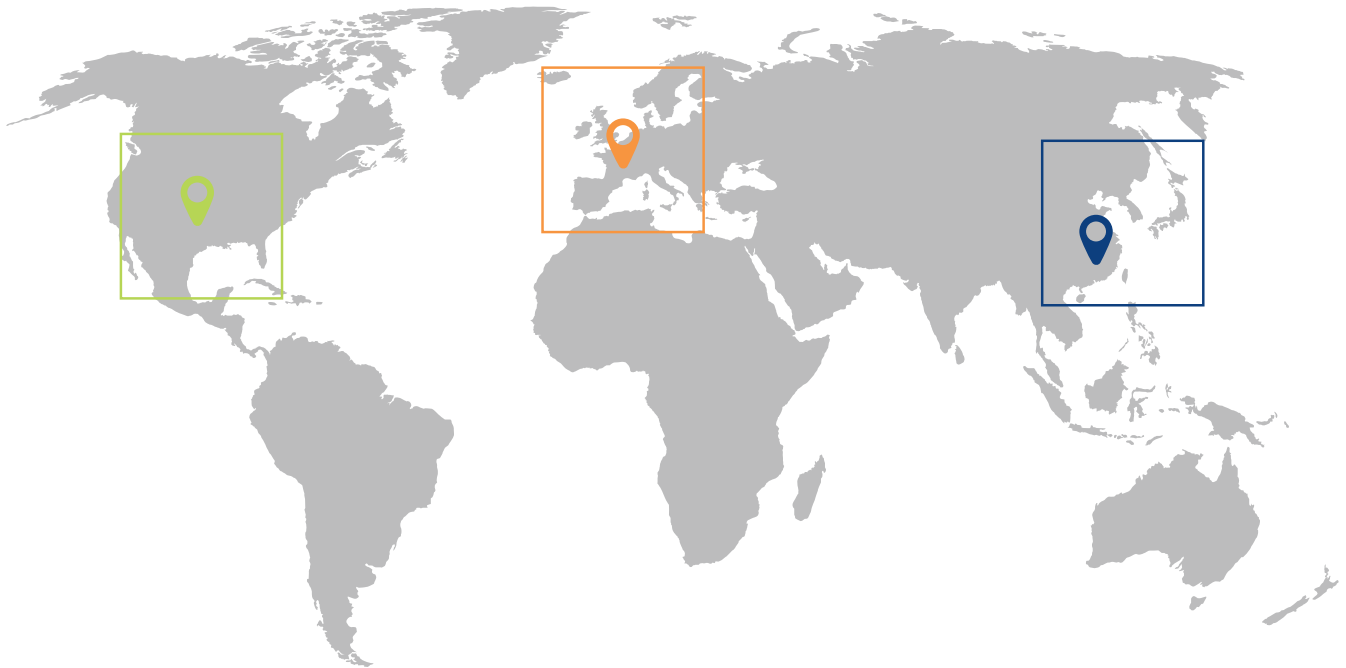
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ABOUT YOLE DEVELOPPEMENT

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.

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- Market data & research, marketing analysis
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- Financial services (due diligence, M&A)

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- Public Relations: Sandrine Leroy (sandrine.leroy@yole.fr)

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1.1 Both Contracting Parties undertake to comply with these General Terms and Conditions of Sale.
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1.3 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.

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- 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.

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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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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.