DIESEL international

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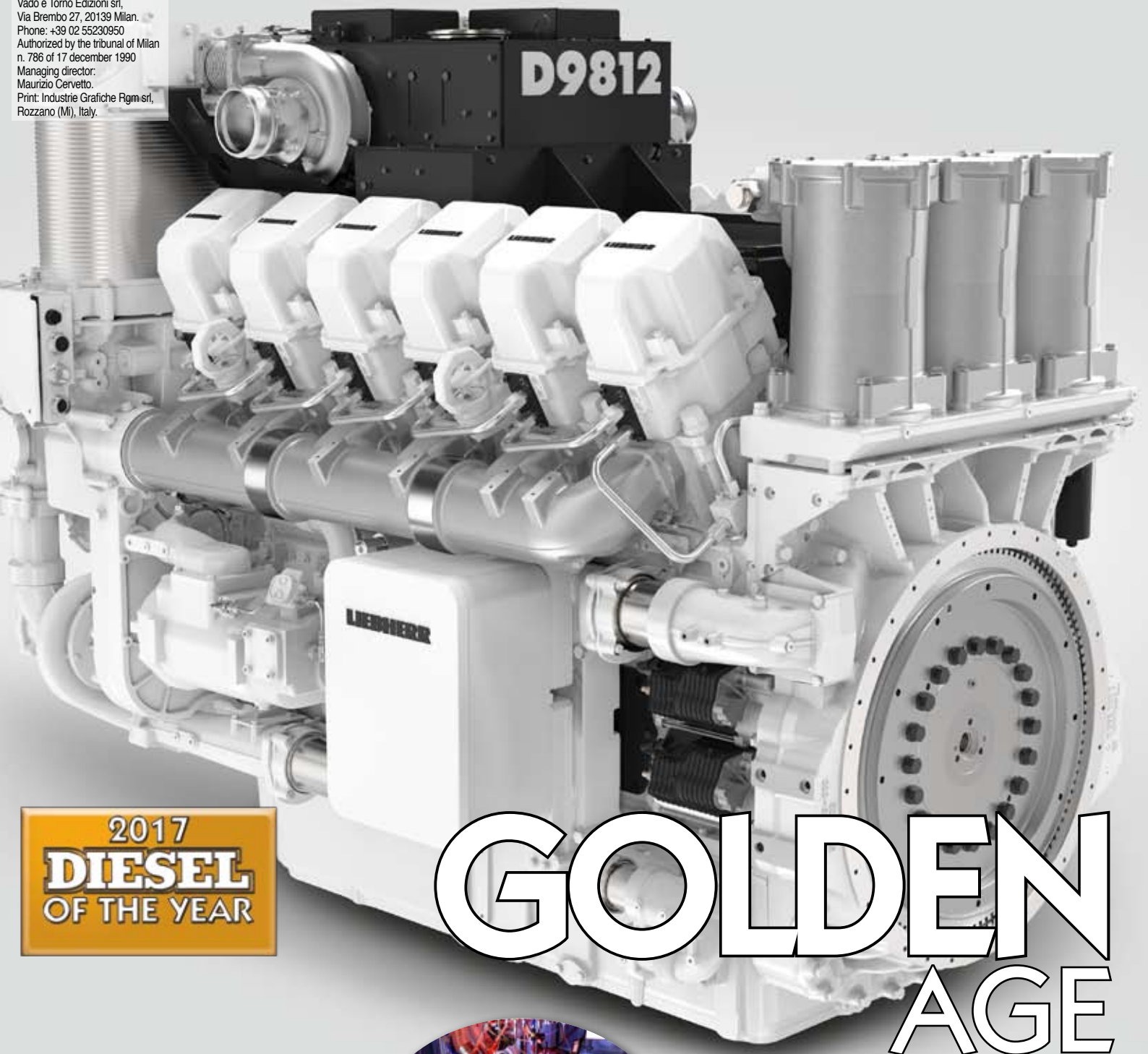

2017 DIESEL OF THE YEAR

GOLDEN AGE

DIESEL OF THE YEAR 2017:
Liebherr D98: 62, 83 and 103 liter for the 'Biggest One'

AND...
Exhibitions (Conexpo, Mee, Samoter, Sima, Omc), Energy report, News, Interviews, Power Generation, Comparisons

DIESEL international

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2017 DIESEL OF THE YEAR

GOING BIG

Liebherr invested in technology, gaining independence from Bosch and large displacements, becoming a supplier in the free market. The D98 starts with 12 cylinders and 62 liters for mining applications and is going to evolve to other applications along with 16 and 20 cylinders

The motivation for an award: the courage to dare where few others did in terms of displacements; breaking free from the embrace of technology providers to become a player in the free market; the compactness and flexibility in delivering power and torque curves, thanks to the synergy with the electronics of domestic propulsion systems. Diesel of the Year 2017 lies under the shadow of the most massive displacement in its history, that of 5.17 liters per cylinder of Liebherr D98.

A prize to a global effort

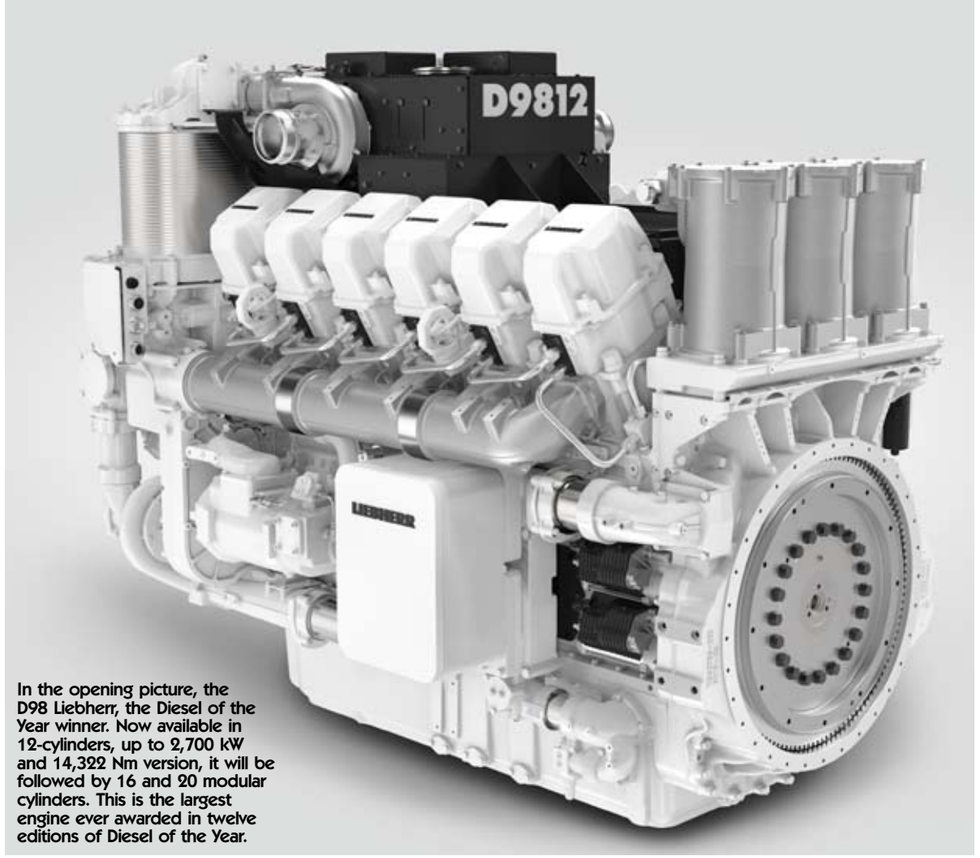
This is an award that legitimizes the long way bringing Liebherr to become a captive manufacturer and its strong ambitions in the free market, in a still relatively little explored range such as very large displacements. The award focuses in fact on the potential of D98, a 12-cylinders, 62-liter, officially introduced at MINExpo in Las Vegas, but embraces a broader horizon emphasizing all Liebherr efforts that impacted several aspects: the 95 series, Tier 4 Final/Stage IV compliant, with the original SCR-Filter system; the 96 series, which in its diesel version for power generation granted exclusive to Kohler-SDMO (see box on page 40) and in natural gas version testifies the credit of gas in Bulle; the G946 L1, which will include advanced electronics from 2019; the agreement with Deutz to make red painted engines (the Deutz color) in 200-700 kW range (box in comparison on page 36 and left here).

But let's step back to Diesel of the Year 2017 winner, the D98. This is a turning point in the history of the award, now in its twelfth edition, no engine has never been 'heretic' as the giant from Colmar, France, where the factory that designed and manufactured it is based.

Record displacement

Its 62 liters displacement, base of the 16 and 20-cylinders, 83 and 103 liters engines, is a hard to beat record in the palmares of Diesel of the Year. A six-year investment led the way here, an engine that is going to compete only with Cummins QSK 95 and the MTU Series 4000 at its top range, and also in the current 62-liters version knows few rivals, including the aforementioned Cummins and MTU and, in gensets, Isotta Fraschini and the great brands of power generation.

The 5.17-liters cylinder was specifically designed for mining, as evidenced by some solutions (i.e. an improved oil and cooling system and special wiring harness and connectors) and features that influenced the jury testifying the exceptional nature of this approach, although DIESEL believes that this engine can do much more outside the narrow quarry environment.

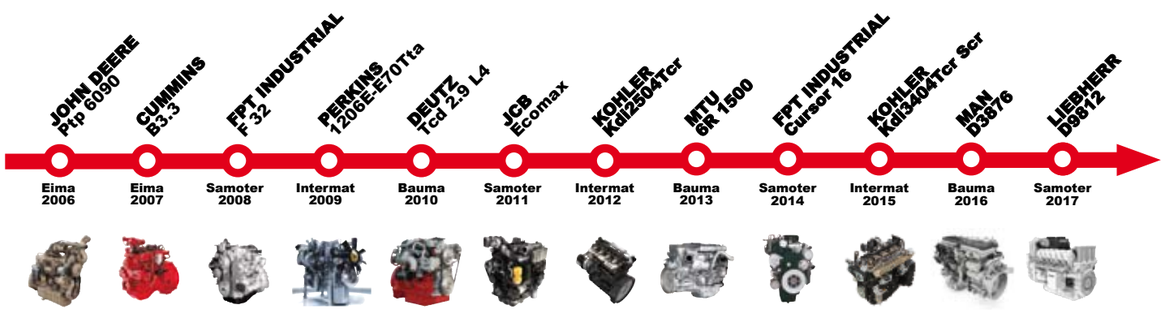


In the opening picture, the D98 Liebherr, the Diesel of the Year winner. Now available in 12-cylinders, up to 2,700 kW and 14,322 Nm version, it will be followed by 16 and 20 modular cylinders. This is the largest engine ever awarded in twelve editions of Diesel of the Year.

It could also replace MTU onboard Liebherr "sex symbol", the giant dump trucks, as well as migrating under the maxi excavator's bonnets; we also think it may have a future on commercial boats, mega-yachts and cruise ships and as a power generator for heavy duty applications with sustained energy requirements such as data centers and large residential complex, not to mention some semi-stationary and railway applications in construction. Currently its name in Kohler-SDMO range is K175 series as anticipated. True to the strategic line opened in 2013, also the D98 series uses Ecu and common rail designed and assembled in-house: the control unit draws on the power supply circuit for cooling, common rail takes advantage of some upgrades, working at 2,200 bar to optimize combustion. The 12-cylinders reaches up to 2,700 kW at 1,800 rpm and 14,322 Nm, 16 and 20 cylinders will reach up to 3,600 kW/19,096 Nm and up to 4,500 kW/23,870 Nm. This Tier 4 Final/Stage IV compliant engine is also suitable for less regulated markets thanks to its power rate, and it will also available in Stage V in the near future.

FB

Brand Model	LIEBHERR D9812	LIEBHERR D9816	LIEBHERR D9820
I.D. IN PILLS			
B x S mm - S/B		175 x 215 - 1.23	
N. cylinder - dm^3	12 - 62.025	16 - 82.7	20 - 103.37
Max power kW	2,700	3,600	4,500
Torque at max power Nm	14,322	19,096	23,870



D96 – G96 SERIES

Designed for stationary applications, the G96 is another piece of Liebherr evolution. In the near future, there will be a plate heat exchanger, three-way valve, canbus control, new blowby. As evidenced by G initial, this is a gas unit derived from the original diesel version. By the way, the D96 is a 20-cylinders, 2.25-liters cylinder (BxS 135 x 157 mm) intended for multiple applications (railway, construction, oil&gas, power generation), delivering 1,700 kW and 9,800 Nm.

D95 SERIES - SCR - COMMON RAIL

Tier 4 Final/ Stage IV compliant thanks to urea, the D95 series ranges from 7 to 24.2 liters. Stage V is being targeted thanks to SCRFilter, a DPF which also performs as a catalytic selector. An extruded ceramic honeycomb is used for SCR coating in order to combine soot filtration and NOx conversion. Coming to components, a mandatory quote for 11.2 common rail available both in Top Feed and Side Feed version for 120 to 800 kW applications and, in some cases, up to 1000 kW. The 2-cylinders, oil lubricated in-line pump provides up to 300 liters of fuel per hour flow of at 2,200 bar.

LIEBHERR AND DEUTZ

As you can see in the box of the comparison on page 36, the 9 liters introduced at Bauma Shanghai is the first piece of the agreement with Deutz, which will see Liebherr covering the 200 to 700 kW range made in Koln, which in turn will have more place on Liebherr compact machines, currently using a number of suppliers including FPT Industrial and John Deere. Ultra-compact dimension (LxWxH 1.015x838x1.116 mm), 4 PTO on the flywheel side, no recirculation and DPF-SCR with common rail and Liebherr control unit are some of TCD9.0 features.

MY GENIUS: THE 'SAVING' CONSOLE

Agricultural and construction machines need more and more efficient performances both in terms of productivity and fuel savings. These goals can be achieved by increasing torque delivery through the engine management remapping. My Genius is a serial read/write console for end users that can store up to 10 different mappings (powered both @12V/24V). The activation of My Genius is very simple. The first step is to connect the console to the diagnostics socket via specific connectors (included) and read the data of the machine. Data are then optimized and made accessible through the Internet. Once uploaded the new mappings to My Genius the user just have to connect the device to the diagnostics socket and choose one of the available mappings, depending on the desired performance.

CONEXPO-CON/AGG LAS VEGAS

USA on show

"Imagine What's Next" is the central idea of the next Conexpo, scheduled from March 7th to 11th. A source of inspiration for engine manufacturers that are competing on Stage V ground, bringing overseas regulations stricter than those of EPA for the first time

The American alter ego of Bauma will have technology at its core more than ever: "Imagine What's Next" is the main theme of 2017 edition. Facing this unknown factor and including it in the agenda of off-road propulsion will be the task of a large number of manufacturers, very similar to those seen in Munich. The number of exhibitors of the previous 2014 edition was 2,100. Despite the absence of Yanmar America, many Others will spice up the engine agenda at Conexpo. **Mtu** will introduce a pair of generators, the 4R0120 and the 6R0120, powered by two Mercedes-Benz Om924La and OM926LA delivering 80 to 200 kWe. Also the 1000, 1300, 1500, 1600 and 4000 series will be on display, besides the Tier 2 and Tier 3 approved S60 series for mining. **Liebherr** makes an encore in Las Vegas: after The MINExpo the company will show the D98 series, the D96 series and its whole Tier 4 Final range. **Cummins** will introduce its new Stage V range, with a new nomenclature, increased efficiency in line with EPA and no egr. **Man** will be another main player, introducing to the American market the Diesel of the Year 2016, the D3876. 2017 will be the year of the off-road consecration of its 15.2 liters. **Doosan Infracore** will attend the show in style with its D series, mounted on Bobcat machines, and its 6 cylinders. The main players of construction market will clearly leverage on corporate synergies, starting with the number one and master of the house **Caterpillar** followed by **FPT Industrial**, **JCB**, **John Deere** and **Volvo Penta**. Also **Scania** is comfortable in this area, providing engines for Doosan maxi excavators and dumpers, as well as **Isuzu**, which has a particular expertise in engines for construction and mining in America, Asia and Africa. **Kohler** will be represented by the American parent company. Last but not least, also **Kubota Engine America** in Las Vegas feels like home.

VOLVO FIGHTS FROST

Gener preserves fruit trees from frost with Volvo Penta engines. The turkish manufacturer of protection devices against frost, which entered the market just a year ago, relays on Swedes thanks to two 5 liters engines used on its FrostGuard VI system, a successful solution in Anatolian peninsula. The device consists of a 10.5 meters pillar carrying a 6 meters diameter propeller; its rotation spreads the air generated by an engine, increasing the temperature over a 60 thousand square meters area. The above mentioned engine is the TAD541VE, a 4-cylinders, 5.1-liter (BXS 110x135 mm) delivering 129 kW at 2,200 rpm, with fixed turbo turbocharging, common rail injection without egr, allowing the engine to tolerate fuels with high sulfur levels. «We decided to enter this market because there is a great demand for these machines and there are no other reliable manufacturers in Turkey. We wanted to assure our potential customers an immediate positive feedback from our products; that's why we chose Volvo Penta», stated Ongen Abdullah, one of Gener owners.

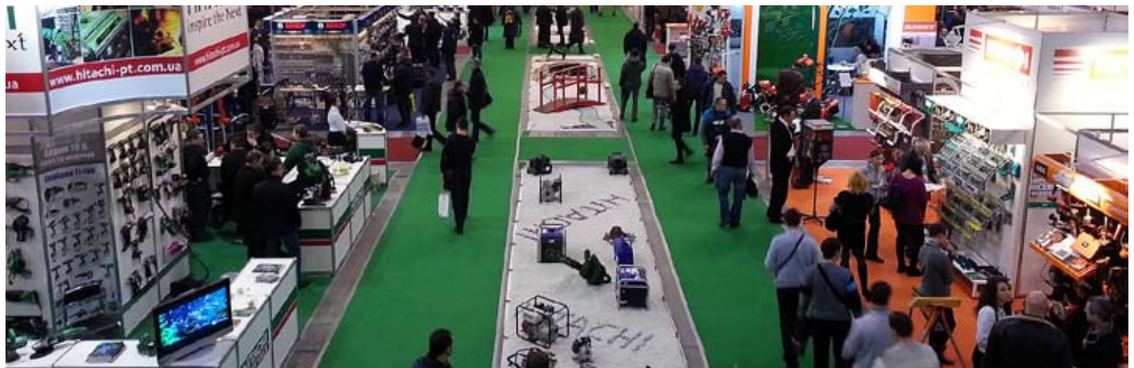
MIDDLE EAST ELECTRICITY DUBAI

Operation Smart City

Middle East Electricty focuses on integrated formulas for heating and energy management, betting on different energy sources as a key for success. Power generation involves a third of the audience. Yanmar makes its debut. Isotta Fraschini will take part at the fair in style

The spot is on the forty-first edition of the Middle East Electricity, scheduled from February 14th to 16th at Dubai World Trade Center, that chose the 'Smart Cities' as its main theme. Mee forecasts announce a 15 percent increase of exhibitors and visitors. Let's take a look at the most significant figure of the last edition, the number of exhibitors: 1,506 spreaded on 62,772 square meters, making Dubai the the most prestigious stage for power generation.

The elite of engine world will be on display, a pack that now includes also Yanmar, that makes its debut under the sun of the Emirates. Cummins, Deutz, Doosan, FPT Industrial, John Deere, Isotta Fraschini, Lovol, Mahindra Powerol, MTU, Perkins, Scania, Volvo Penta, Yuchai, Weichai. Among the main topics, the consequences of Stage V, the evolution of Tier 3, the instances of TLC which still rely on the efficiency of small and medium power generators, the prospects opened by the spread of data centers and smart grids. Power generation involves about 35 percent of the visitors. Last year the Cursor 16 Taa was one of the main protagonists, a stationary evolution of Diesel of the year 2014 winner delivering 600 kVA. The last two years have seen under the spot Caterpillar with its Compact International series, Cummins with its Qsk95 and alternators range, Deutz with its Td 2011 L4 Telco, John Deere, which made its debut in 2015 with its Gspu full line, **Peterborough with the newest** models of its 4000 series - the 4008-30Tag ElectropaK and the 404A-22Sg1 LPG, Scania with its 16 liters 8 V, Weichai and the synergy with Baudouin. Isotta Fraschini is back in style in power generation market with its G-Drive, two modular cylinders in 8 and 12 cylinders versions and a third one at the top of its range. All models are available in 50 Hz and 60 Hz version.



MICHELIN REMOTELY MEASURES THE PRESSURE

Michelin Tire Care has launched the Pressure Advisor website, designed for earthmoving machines. The system requires to input the brand and the model of the machine on the first page. The second page allows the operator to determine the correct pressure depending on the operating conditions by entering speed of the machine (both empty and at full load), tipping load and load per axle. On that base Pressure Advisor sets a quick estimate of the optimal tire pressure for each axle. Among the advantages, longer tire life, better productivity due to less breakdowns, less tire expenses. A correct inflation pressure can prolong the tire life because an optimum pressure reduces the wear rate and improves the strength of the tire. In terms of safety, tires operating at optimum pressure offer greater maneuverability during transport and greater stability with raised loads. Optimum pressure also reduces the risk of internal structural damage in case of overheating or bending.

SAMOTER ASPHALTICA TRANSPOTEC IN VERONA

One body, three souls

This edition is the basis for the revival of Verona as the Italian core of construction industry thanks to a three-in-one show: Samoter, Asphaltica and Transpotec. Timing seems to be right: after several years of recession we are seeing a rebound effect that should last until the next two years

The three-year rotation of European construction fairs sees Samoter under the spot in 2017 (being the others Bauma in Munich and Intermat in Paris). The fair experienced in 2014 its worst phase but is now setting up its definitive relaunch for 2020. Today, Man is the main player on the engines side. The engine world will be in fact represented by the Italian distributor Ets, showing models for stationary and mobile applications, while **the last edition was attended** by Geminiani, Hatz and Kohler. Three shows living together - Asphaltica (road construction technologies), Transpotec Logitec (transport and logistics) and Samoter congregate the entire construction industry, taking advantage of a market revival after very tough years. In Italy, a 37 percent growth is expected for 2017-2018 biennium, while 2016 first nine months are showing a 32 percent growth, a total of 7,551 machines sold and a very positive trend for mini excavators and loaders. Italian figures are a positive exception compared to the 1 percent loss of the global construction market (compared to 2015 first nine months) showing a random trend: China (+8 percent), India (+31 percent) Western Europe (+11 percent), USA (-3 percent) and Japan (-24 percent). Back to the exhibition, Case Ce, Doosan Bobcat, Euromac Sampierana, Hidromek, **Hyundai, Kobelco, Komatsu,** Kubota, Takeuchi, Venieri and Yanmar will attend the show. Ammann, Marini and Wirtgen will exhibit their products at Asphaltica, while Transpotec exhibitor's list is still under development. Daf, Isuzu, Iveco, Man, Mercedes and Volkswagen commercial vehicles confirmed the participation.

INTEC AND INDUSTRIAL STARTERS

A life spent among four wheels has brought Intec of Turin, the industrial district where automotive industry is the backbone infrastructure, to focus on the distribution of professional products, including in its product portfolio the new Lithium HD range of starters designed for agricultural, industrial and earth moving machines. The Lithium HD range includes 3 models of Lithium starters: Lithium 12V Super HD, Lithium 24V HD and Lithium 24V Super HD. Designed for high power, those starters are also suitable for machines over 500 HP such as harvesters or large articulated tractors. These new starters feature extreme lightness, weighing five time less than lead starters: Lithium 12V Super HD weighs only 5.5 kilos, Lithium 24V HD just 6 kilos and Lithium 24V Super HD 8 kilos. The range also provides superior life span and charge cycles compared to traditional lead starter and takes advantage of an innovative battery technology that eliminates any potential danger to the operator. All Intec starters feature overcharge, short circuit and reversed polarity protections.

SIMA PARIGI

Innovation wins

John Deere and Volvo represent the engine section of the Parisian event. Among the winners of Sima Innovation Awards we find JCB Dualtech, New Holland Hehrs, Case Autonomous Magnum and Sesam, the electric made in John Deere. DIESEL invites at the Machine of the Year award ceremony

56 years passed since "Paris Is Always Paris" movie but the quote has not lost its appeal. The Sima in fact opens in the sign of a stronger presence of international exhibitors (plus 8 percent) among the 1,770 attendees. We'll find waving the engines flag John Deere, playing at home, and Volvo Penta, focused more than ever on harvesting machines. There's so many ideas in Sima Innovation Awards. Let's start from powertrain. JCB won the silver medal with Dualtech Vt, an innovative dual technology transmission. **Specifically designed for agri**cultural telehandlers, this new solution combines the strengths of powershift and hydrostatic transmissions. Then there's New Holland with its high-efficiency cooling system (Hehrs). This device includes two heat exchangers instead of five and more of classic cooling groups. A heat exchanger is for engine cooling and one for low-temperature circuit: that is enough to a system that has its strongpoint in its compactness. A series of plate heat exchangers replace the air-to-air or air-liquid radiators. The exchangers are connected to a new cooling circuit with low-temperature liquid (around 50 degrees), that allows to locally cool the various tractor components as well as split cooling requirements and compact individual heat exchangers while an electric pump feeds with coolant the different circuits. **Let's move on to tractors. Case** IH won a silver medal for its Autonomous Magnum. Thanks to radar technology, lidar (light imaging, detection, and ranging) remote sensing and on-board cameras, the vehicle is able to detect stationary or moving obstacles on its path and automatically stop until the operator alerted by visual and audible warnings choose a new path. The vehicle also stops immediately in case of loss of GPS signal or position data, or when pushing the manual stop button. John Deere introduced Sesam (Sustainable energy supply for agricultural machines), a 300 kW electric tractor equipped with lithium-ion batteries. DIESEL is part of the jury of the Machine of the Year 2017 prize. The award ceremony is scheduled on February 27th.

OMC: OIL&GAS GATHERS IN RAVENNA

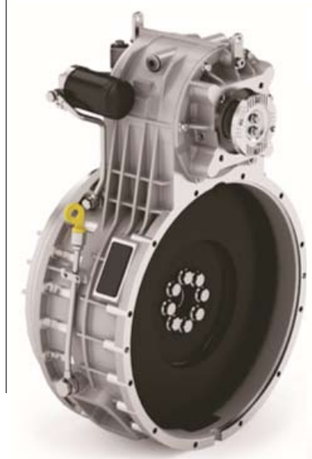
This intense first quarter of the exhibition season will end with the Offshore Mediterranean Conference in Ravenna, 29 - 31 March. DIESEL and DIESEL International also will attend this conference, which totaled 18,923 visitors, 1,285 operators and 688 exhibitors in 2015. Strongly penalized by the collapse of Brent, Oil&Gas could take advantage of oil price increase even as regards engine market, mainly marine engines for PSV, tugs and other work ships, UPS and emergency genset, fire-fighting pumps. The Stars of boating are Fincantieri and Rosetti Marino shipyard. The edition 2015 protagonists were Caterpillar, MTU and Wärtsilä, while this year such brands as **Cummins** and **Yanmar** will make their debut. The Americans launched at Bauma the Stage V Platform, which is a candidate as global scale solution, without recirculation, in order to modulate the responses to workload, sulfur content and regulations without after- treatment unit. Also regarding power generation Cummins is able to provide solutions up to 2,750 kWe (diesel) and 1 MW (gas) equipped with Stamford alternators. Yanmar focuses on marine propulsion and several power generation applications participating at Ravenna Omc and Mee in Dubai.

INTERPUMP HYDRAULICS

Three for trucks

Interpump Hydraulics completes its range adding to Efp2 two other calibrations, the EFP-1 for engines up to 720 HP (529.4 kW), the EFP-3 for engines up to 220 HP (161.7 kW). Each model is available in three versions with different torque and ratio

Interpump Hydraulics renovated its range of hydraulic PTOs for trucks and commercial vehicles. This dynamic company based in Bologna, at the very heart of Emilia Romagna Motor Valley, in Italy, introduced the new EFP-2 (Sae 2) designed for vehicles up to 397 kW (540 HP). A few months after its older and younger brother have been officially introduced: the EFP-1 (Sae 1) for engines up to 529.4 kW (720 HP) and the EFP-3 (Sae 3) for engines up to 161.7 kW (220 HP). While the EFP-1 is implemented since January 2017 as original equipment in some of the main truck manufacturers, the actual debut EFP-3 has been slightly delayed to perfect adaptation to different flanging geometries as its typical for this market. The three **different models, marked with** different power tags, are available in three versions each based on speed ratio (1: 1.02 - 1: 1.27 - 1: 1.56) and torque output. At the top of the range the EFP-1 delivers a maximum output of 392 kW at 1: 1.02 ratio and 2,500 Nm maximum torque (2,000 Nm at 1: 1.27 and 1,600 at 1.56). The same logic, with torque inversely proportional to the same speed ratio, applies to Efp-2 and Efp-3 models, delivering 127 kW and 63 kW maximum power. Focusing on Efp-1, designed for heavy trucks, its 'fast' 1: 1.56 ratio (PTO at 1,560 rpm, engine at 1,000 rpm) is a solution specifically intended for applications such as water pumps feeding on fire trucks. On the contrary, the 'slow' ratio is typically intended for applications such as mixing trucks or trucks for waste collection. In all three new models the internal pump uses for clutch engagement the lubrication oil, without engaging the compressed air system of the vehicle. Efp-1, Efp-2 and Efp-3 don't use the recently patented "silent Iph" technology: noise reduction is guaranteed by low-play gears and a damper capable to reduce rotational vibrations between engine flywheel and PTO. **The three new units made by** Interpump Hydraulics further provide an output brake to eliminate the remaining clutch torque. Such solution is implemented as standard on fast ratio versions, generally used in low inertia circuits.



THERE'S ROOM FOR EVERYONE

The global demand for energy is expected to strongly increase in the next 25 years, particularly driven by the electricity sector (from 21,600 TWh/year to 36,500 TWh/year in 2040). Renewable sources are in the spotlight, but natural gas and coal will remain absolute protagonists. Along with ambitious nuclear development programs

Neither English bookmaker would accept an alternative score, as it would be for a rugby match between All Blacks and Italy. We're talking about the future of global energy demand. The only certainty is the increase in consumption. The different scenarios developed by the most influential international agencies may (in part) diverge on the extent of this growth, the factors that will drive, accelerate or slow down it, the sources that will be required to meet it, but certainly not on the overall trend. This applies in particular for electricity generation.
Of all the energy markets – as stated by the US Energy Information Administration (US EIA) - the electricity market remains the most dynamic. The electricity is confirmed as the most important commodity in terms of end uses, as it has been in recent decades.

Residential and commercial

The main driver of the demand for electricity - says the 2017 edition of Exxon-Mobil Outlook for Energy - will be especially the residential and commercial sectors, with an expected growth of 70 percent compared to 50 percent of industry. The increase of demand due to e-mobility will be huge in terms of percentage. But in absolute terms, even in 2040, the demand generated by electric mobility will remain marginal.
So the scenario that lies ahead for the next 25 years is a great increase in today's generation capacity available, which will be added a (partial) replacement of obsolete plants in operation. The order of magnitude is hundreds of GW/year. It is worth to point out that, to date, 1.2 billion people still lack access to electricity, not counting 2.7 billion who still use traditional technologies of biomass burning for cooking and heating.
In June of 2016 there were 3,200 power plant under construction worldwide, with a total investment estimated at 980 billion dollars. The figures for the projects announced or under consideration, but still not started, were even more huge, around 100,000 with a, overall value of over 13 trillion dollars.

2,000 GW in a decade

Also in 2016 the growth estimates of the world's power generation potential for the next ten years stood at just under 2,000 GW through the creation of more than 2,700 GW of new capacity and the decommissioning of obsolete capacity for about 770 GW.
Another no less significant fact specifically concerns the new renewable sources (solar

and wind) is underlined by the International Energy Agency (IEA). Over the next four years 60 (large) wind turbines and 720,000 solar panels will be installed worldwide every day (everyday), mainly thanks to China (which will take over the 37 per cent of global growth), USA (13 percent), Europe (12 percent) and India (9 percent).
The figures of the sector development potential highlighted in the Outlook of the IEA and US EIA - the two already mentioned sources are the most influential and 'official' worldwide - that forecast the trend of the sector until 2040 are perhaps even more impressive .
According to the US EIA, generation capacity will increase from the current 21,600 TWh/year to 25,800 in 2020 and 36,500 in 2040. Over the next 25 years we'll have a growth rate close to 70 percent! In OCSE countries the average growth rate will reach just over one per cent/year, while in emerging nations the trend should be about 2.5 percent / year.

US EIA forecast

As the evolution of the different sources, US EIA forecast states: "The main role is rightfully played by new renewable sources (solar and wind), but natural gas and nuclear energy are going to play an important complementary role."
IEA team leaves out nuclear power: "Renewable and natural gas are the big winner in the race to feed the growing energy demand for the next quarter century and will replace the winner of the last 25 years, coal."
For 2012-2040 period renewable sources are worth an average annual rate of growth of 2.9 percent, a figure that rises to 5 percent excluding hydropower. The market share of non-hydropower renewable should thus grow, according to projections by the US EIA, from 5 percent in 2012 to 14 per cent in 2040.
By then, power generation from renewable sources will have a 5,900 TWh overall increase. 1,900 TWh will be provided by new hydroelectric power plants (33 percent of the total) and further 1,900 TWh by new wind farms. Solar energy will provide 860 TWh (14 percent) while other renewables (mostly biomass and waste treatment) a further output a little above 850 TWh.
This robust growth isn't still to come but indeed is already expressing its full potential since 3 or 4 years at least, as highlighted in the IEA medium term report.
The 2016 edition revises upwards (compared to projections of the previous year) the growth rate expected in 2015 – 2021 period, mainly thanks to new support policies started by USA, China, India and Mexico and a further price reduction of renewable technologies (-25 percent for PV over the next four years and -15 percent for onshore wind power). Always considering the 2015-2021 period, it is expected that 6 GW from renewable sources for every 4 GW of conventional power will be installed.

And IEA...

The same IEA still invites to be cautious, especially in the forecasts going very far in time, as the renewable energy market is still strongly influenced by supporting policies, especially related to climate change issues. In addition, the increase of generation from non-programmable renewable sources (solar and wind) is posing new problems to the distribution network (created to manage the very different load profiles of power plants fired by fossil fuels) in most advanced economies. This will require major investment ... and resources may not be enough for everyone.
In the world of energy the "coal" word is pronounced in a low voice, or is not pronounced at all, as the Dark Lord of J. R. R. Tolkien saga. Yet it remains an absolute star of present and future power generation, despite its obvious flaws in environmental terms. A total of 2,061 projects related to the construction of new power plants for the 2016-2017 biennium are under development, with an investment forecast at 1.1 trillion dollars.
Even in the long term - the next 25 years - the worldwide installed capacity will continue to grow, though at a slower pace than other sources: (0.8 percent/year).

The coal share

The share of this source, compared to the total world power generation, will decrease from 40 percent in 2012 to 29 of 2040, almost on par with natural gas. In absolute terms the annual power generation capacity will increase from 8,600 TWh (2012) to 9,700 (2020) to 10,600 in 2040. China and India, together, will generate 70 percent of this expected increase.
That is, of course, the same argument made for renewables. Political decisions against future use of this fuel may change previous forecasts significantly.
No need to remind that the demand for coal is not just about power generation but includes cement and steel production.
On the other hand, to date, official reserves - or the amount of carbon which, with reasonable certainty, it is believed can be extracted to existing market conditions at the time of evaluation - amounted to 437 billion tons of oil. It's enough for more than a century, at current consumption rates!
Globally, consumption of natural gas for power generation are forecast to increase by 2.7 percent/year over the next 25 years. In terms of power generation capacity this will bring the natural gas market share from current 22 percent to 28 percent, estimated by the US EIA to 2040. From that date, the overtaking against coal is therefore expected.
It is no coincidence that, for some time now, even the IEA

USA: SOLAR WINS... BUT THERE ARE NO LOSERS!

Ai telescopici piace l'acqua di Colonia. Non è profumo né il Reno ma In 2016 the United States connected to the grid 26 GW of new capacity relying on three main sources: solar (9.5 GW), natural gas (8 GW) and wind power (6.8 GW). Solar exploit is especially striking for three reasons. Earlier in the energy history of USA this technology had never been placed in pole position, neither was able to overcome wind and traditional sources. The value reached last year, then, surpasses all previous performances (the last record was 3.1 GW in 2015). Finally, these figures only consider large-scale plants excluding small and domestic installations (around 2 GW). The actual size of US installed PV in 2016 is therefore larger, about 11.5 GW.
No surprise for natural gas. From 2010 onwards 7.8 GW of new capacity were put into operation every year on average. Last year performance is therefore fully in line with recent trend. Wind reached its peak in 2015 with 8.1 GW, then slightly fell in 2016 (6.8 GW). The energy Poker ends with Watts Bar 2 nuclear reactor, launched last summer by the Tennessee Valley Authority and delivering a rated capacity of 1.1 GW. The United States did not open a new nuclear power plant since May 1996. And Donald Trump wasn't at the White House yet...
This is also a non-negligible signal in a market where solar certainly plays a main role; it seems there are no losers then.

TRANSPORT: TWO BILLION TANKS LOOKING FOR A FULL

In 2040 1.8 billion light vehicles - cars, SUVs, pickup – will hit the roads of the world with a total mileage estimated at 22.5 trillion kilometers. If we add to this vast fleet also heavy vehicles (trucks, vans, buses) or motorcycles it's easy to exceed 2 billion units.
Transport still represent one of the leading areas in terms of energy consumption. Even more significantly, vehicles will keep using fossil fuels for the next 25 years. 150 million electric cars in circulation in 2040 – according to IEA – seems to be a countless number, but it's still less than 10 percent of the total.
In fact, the same IEA estimates that by that time the daily oil consumption will have risen to 103.5 million barrels/day, an increase compared to today (about 96 million) and a demand increasingly driven by transport.
By that time, in the world "tank" oil products will still cover over 90 percent of total consumption. Gasoline will suffer a slight decline, while demand for diesel will grow by 30 percent, mainly driven by marine and heavy transport. The demand for jet fuel is expected to increase by 50 percent. Natural gas, biofuels and electricity have even more prospects for further development, but their share will remain marginal in absolute terms.

speaks openly (even in some of his reports) of golden age of natural gas. If in relative terms - as growth rates – gas must give up to renewables it's still the main player in absolute terms.
Coming to gas market - which not only involves power generation but also heating and, even if to a lesser extent, automotive industry - radical changes are undergoing as regards traditional supply areas and related technologies.

Liquefied natural gas

The liquefied natural gas exports are expected to strongly grow and liquefaction capacity is expected to increase by as much as 45 percent by 2021, mainly due to the commissioning of new LNG terminals in USA and Australia. By then Australia could even rival Qatar in terms of LNG export capacity (currently absorbed from Japan and Korea for about 50 percent). In short and medium term this could affect the opportunities for growth in volumes handled via pipeline, penalizing productions in Russia and the Caspian in particular.
On the other hand, the same evolution of the Japanese LNG demand will be strongly influenced by political decisions about nuclear power generation in the country of the rising sun. The nuclear travels at different speeds. This source seems to live a sharp decline in OCSE countries (which incidentally lived together with the atom for a couple of decades) while it is far more vital in emerging countries, particularly in Asia. At the aggregate level, this source is credited with an average growth rate - in terms of electricity fed into the grid - or 2.4 percent/year from 2012 to 2040. Just below the natural gas!

Rising up to 4,500 TWh

Power generation capacity should rise from 2,300 TWh in 2012 to 3,100 in 2020 to 4,500 in 2040. Environmental evaluations (zero CO2 emissions) and supply security seem therefore to outweigh the concerns over the consequences of a possible accident or a terrorist attack.
Unlike other sources, however, nuclear will have a much more geographic connotation (or, rather, concentration). China alone is planning to put into operation 139 GW by 2040 in fact monopolizing the scene (despite "China syndrome"). India is following with 36 GW along with other emerging countries (8 GW). Among OCSE countries only South Korea is working on major projects in the nuclear field.
At the end of December 2016 66 nuclear plants were under construction worldwide.
The only source with a negative balance in power generation (in terms of consumption) is oil and other liquid fuels. Economic and environmental issues will tend to more and more marginalize this technological option. Its market share - always in terms of TWh - will decrease from 5 percent in 2012 to 2 per cent of 2040, with an average annual decline of more than 2 percentage points.

2016 legacy and 2019 prospects

THE PISTON WALTZ

2016 awarded the exuberance of Perkins (Syncro Series and largest engines) and Deutz (2.2, 5 and 9 liters). The German company signed an alliance with Liebherr, which marks the activism among large engines. In 2017 and 2018 substantial news from Kubota are expected

Some look at Stage V as the diesel engine swan song, yet even the most unyielding detractors can deny the effervescence that reigns in the engine market. 2019 is the unavoidable turning point for those manufacturers who have suffered the transition from Stage IIIA/Tier 4 Interim to Stage IIIB-IV/Tier 4 Final and want to take this opportunity to kill two birds with one stone, or even three: recovering market shares and overtake competitors in Europe, take advantage of stricter standards than those of the EPA area in 2019 to settle in USA and China, and become technical-commercial partners for oems for a long period of time which will probably see the conversion of endothermic engine to generator unit within a hybrid powertrain.

We've had two protagonists in 2016, especially among the solutions for mobile applications, Perkins and Deutz.

PERKINS chose the three main events of the year to progressively unveil the Syncro platform: the 3.6-liter at Bauma; the structural pan for agricultural versions at EIMA; the 2.8 liters at Bauma China. Syncro will replace in Stage V the 854 series manufactured by FPT Industrial for stage IIIB/IV, in order to boost Perkins in the strategic compact sector. The power range led by the 3.6 ranks at the top in the current Stage IV/Tier 4 Final, 100 kW and 500 Nm, 2.8 came to 55 kW threshold, until Stage V/Tier 4 Final, with 325 Nm torque. Perkins completed its top range drawing synergies with Caterpillar. The 1706J is struggling in 9-10 liters segment: thanks to a successful calibration of the ECU the 9.3 ranks at the top of this range, as shown in the comparison on page 36. 12.5, 15.2 and 18.1 liters complete the Perkins range.

2016 was a spectacular year In Cologne. At Bauma **DEUTZ** has further strengthened its bottom range, using the 725 cc cylinder (BXS 92x110 mm) of its 4-cylinder also in three cylinders architecture. The TCD2.2 is a 2.2-liter which Deutz also offers in LPG version as its 4 cylinders, mainly for indoor applications (such as forklifts and industrial towing tractors), consolidating its primacy in off - road market: from 2.9 to 4.1 liters Deutz is highly rated both in agri and construction applications, and almost hegemonic in applications such as telescopic handlers. The 3.6-liter is announced in Stage V at 105 kW, which are worth the primacy in its segment, currently at 100 kW. Cologne knows that high power range is another relevant playfield, as demonstrated by Perkins. That's why in Munich seeing a 4 cylinders in those overall dimensions. Assembled by the joint venture Deutz Dalian, the TCD9.0 delivers 300 kW and 1,700 Nm and is a candidate for excavators and wheel loaders in the construction market. This engine opens a series that includes a 12 and a 13.5 liters in-line, which initially will be join the 6V, 90°, 12 liters currently in range resulting from a recent collaboration between **LIEBHERR** and Deutz. This agreement reconciles the leadership of Cologne in the medium -low power range and the technological and infrastructural investment of Liebherr in Bulle (Switzerland) and Colmar (France), which aims to become self-sufficient in the manufacturing of its excavators, dump trucks, cranes and aerial platforms while specializing in the free market of large sizes and as an alternative to Bosch for common rail. For the first time in the twelve-year saga of Diesel of the Year award Liebherr wins the first prize thanks to a completely new engine displacement, that of D98. After a batch of compact, with some 6 cylinders, two-liters cylinder, the time has come for a three-headed gentle giant, one featuring 12 cylinders and 62-liter, one 16 cylinders and 83 liters, and one 20 cylinders and 103 liters.

You say Liebherr and thoughts turn automatically to **MAN**, which preserves in Bulle the memory of the V6. Once retired the D28 also for stationary applications, D20, D26 and D38 will represent Man new course. The 15.2 liters will be introduced to the American audience at CONEXPO.

MAHINDRA entered the European market at EIMA in Bologna, where a 3 and a 4-cylinder, Stage IV/Tier 4 Final compliant, 2.6 and 3.5 liters were introduced. Is the undisputed leader in agricultural mechanization in India planning to enter in style even in the free market of western latitudes, thanks to competitive prices and a network of 900 engineers based in Chennai and Detroit R&D centers?

The long road of **FPT INDUSTRIAL** towards gas in mobile applications includes another milestone: the N6 Ng prototype with multipoint injection and stoichiometric combustion.

CUMMINS deployed the whole Stage V team without EGR at Bauma in Munich. Also **SCANIA** is going to be egr free by 2019.

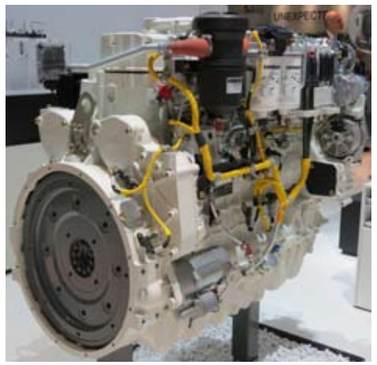
2017 and 2018 will be the years of **KUBOTA**, who after launching its offensive in a big way in the tractor sector will restructure the engine production in Stage V, covering the gap between 86 and 129 kilowatts in order to offer a comprehensive range and exploit the expertise gained in particulate filtering.

Still in the offroad market, let's keep an eye on **VOLVO PENTA** and Kohler. The first one is very active in harvesting machinery, as well as in traditional niches such as reach stackers and excavators -thanks to the synergy with Volvo CE, and would need engines below 5 liters to expand its product range. **KOHLER** is widening its product range, and the actual 100 kW limit could sooner or later become too tight.

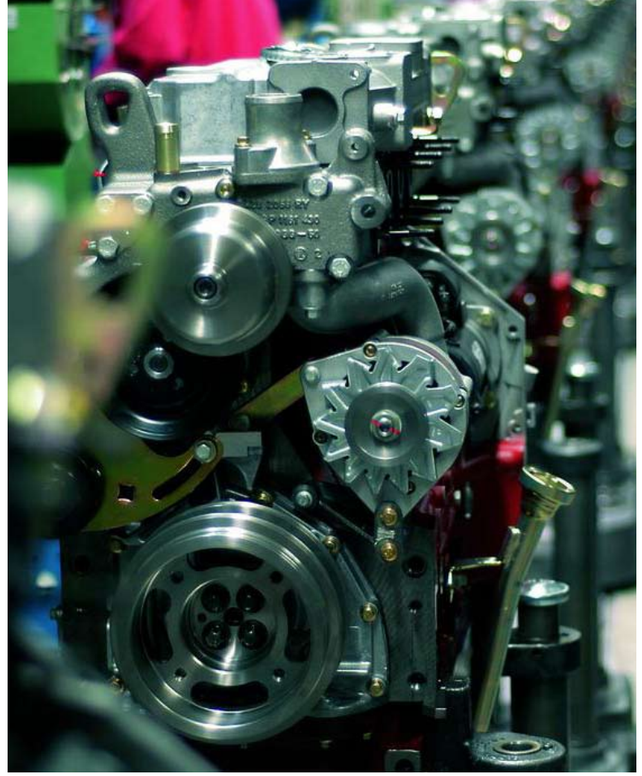
Coming to genset market, variable speed and permanent magnet alternators seem to be very lively thanks to prominent brands like Cummins and Deutz and the work of small companies such as the Italian Geminiani. Meanwhile **ISOTTA FRASCHINI** make its debut in style in Dubai, waiting for the hybrid consecration thanks to the forthcoming 'energy box'.

John Silver

Here, Deutz and Perkins. on the right side, from top to bottom, Kubota, Fpt Industrial, Mahindra, Man, Volvo Penta, Liebherr and Isotta Fraschini.



Here, Michael Wellenzohn. On the right side engines on the manufacturing plant and on show.



Deutz. Interview with Michael Wellenzohn

BOUNCING UPWARDS

Deutz leads the range under 4 liters, winning several agri applications and dominating a couple of others such as telehandlers. The partnership with Liebherr, which sprung up a 9 liters engine waiting for a 12 and a 13,5 liters, is focusing on high power market

Deutz is surfing the waves of the economic crisis, gaining new applications and market shares, independently from the identity of its shareholders. The focus is on a steady products upgrade and the ability to monitor OEMs needs. Deutz has a strong market presence under 4 liters-120 kilowatts threshold, but it's not equally rooted in higher power ratios. So, what is the solution? A mix between in house engines such as the TCD5.0 and a partnership with Liebherr in 200 – 700 kW range, a very reliable partner, such as TCD9.0. We asked Michael Wellenzohn, Deutz Executive Vice President - Chief Sales Officer, about Deutz strategies.
We haven't witnessed this level of activity from Deutz since it unveiled its Stage IIIB products at Bauma 2010. That was when Deutz first established its market leading position among OEMs in the four-litre class. The TCD2.9 L4 was voted Diesel of the year in 2010 and that was just one of the highlights.

What can we expect from Deutz in the near future?
Deutz *is gradually expanding its portfolio of engines. Now that we have added the three-cylinder TCD 2.2 variant, in both gas and diesel, to our successful TCD 2.9 four-cylinder model in the compact engine class of less than four litres cubic capacity, our focus will mainly be on broadening the selection of engines in the higher power output range. At Bauma 2016 in Munich we unveiled the TCD 5.0, which from 2019 will be bolstering our offering in the 100 to 150kW power output bracket.* Deutz *is also planning, as part of a collaboration with the Liebherr Group, to introduce a TCD 9.0, TCD 12.0 and TCD 13.5, as well as a further engine with a capacity of more than 16 litres. This will significantly strengthen our offering in the 200 to 700kW bracket.*

Can you tell us something about TCD 5.0? What will happen with the 4.1 and 6.1-litre engines because of Stage V?
The Deutz *TCD 5.0 is a new water-cooled four-cylinder in-line engine with a capacity of five litres. The engine boasts a particularly compact design as well as a turbocharger and charge air cooling and it generates 100 to 150 kW. It conforms to the downsizing principle, i.e. it produces more power from a smaller cubic capacity. It allows larger engines to be replaced or offers an increase in output from an engine of the same original size.*
The TCD 5.0 features minimum pipework, fewer components, strict separation between the hot and cold sides to avoid the need for heat protection measures, and a reduction in performance losses from the oil and water circuits. It also has an overhead camshaft, a cross-flow cylinder head including a high degree of component and functional interlinkage, maintenance-free hydraulic valve play compensation and a robust dust and impact-resistant cylinder head cover. Independently of this, we have transferred our TCD 4.1 and 6.1 engines across to EU Stage V without technical alterations, which means that our customers do not have to carry out any modifications to their equipment. Engine recertification is all that is needed. Incidentally, the installed dimensions and customer interfaces of the TCD 5.0 are virtually identical to those of the TCD 4.1, whose compact design sets a benchmark.

Am I right in saying that Deutz is looking at gas, syngas and biogas as alternative fuels to LPG for mobile applications?
Yes, that's right. We are investing a lot of time and effort in alternative fuels. Back in 2012 Deutz *teamed up with Rostock University to launch a research project for a gas engine.* Deutz*engineers and the university's Institute of Piston Machines and Internal Combustion Engines turned the TCD 3.6 diesel engine into a gas-powered four-stroke engine and then installed it into a tractor. This generated the same output as the diesel engine but with lower levels of pollutant and CO2 emissions. We see the power-to-gas (PtG) route as having the most long-term potential when it comes to meeting global targets for greenhouse gas reduction. This will enable the benefits of an efficient, high-output gas engine to be combined with renewable power generation. Biogas that is treated and fed into the gas network could also make a further positive contribution to the carbon footprint of engines.*

From IIIB models to Stage V Deutz is continuing along the path of complete exhaust aftertreatment (DOC-DPF and SCR). For what reasons? How important to you is the flexibility of the modules and the compactness in the canning process? And what is happening with the EGR?
The management of DPF systems, in particular, is a huge challenge that we have already dealt with in EU Stage IIIB. Even if our engines might have seemed somewhat overdeveloped at the time, we were able to gather lots of valuable experience in the use of DPFs. Using application-specific heat modes we can control the gas temperature and other parameters in such a way that the DPF will always work at the optimum level and with virtually no standstill regeneration.
The flexibility of our engine systems is hugely important as customer-specific configurations are one of our USPs in the market. Our modular DVERT® (Deutz *Variable Emission Reduction Technology) system offers various configuration options instead of just one prescribed solution. This gives our customers maximum flexibility. Just as important is the compactness. We are making sure that our customers who are transitioning to Stage V do not have to set aside any additional space in their equipment. This also applies to engines that do not currently have a DPF fitted as standard. Our Stage V ready strategy was extremely successful in this regard, as the relevant engines require only certification rather than modification. A further important element is exhaust gas recirculation or EGR. We ran systems both with and without EGR on our test rigs so that we could directly compare the two emissions strategies. For each engine size we decided on the optimum solution based on various factors, such as overall consumption of fuel and urea, installation restrictions, urea tank size, engine dynamics and robustness. For engines used in smaller and medium-sized machines, we see clear benefits for engines with EGR. For larger equipment, the scales tip in favour of engines without EGR.*

With regard to increasing power output, the five-litre engine in Munich was followed by the nine-litre engine in Shanghai, which fills a gap in your product range. What can you tell us about this engine? What applications is it designed for?
The TCD 9.0, which we are looking to distribute under our own brand as part of a collaboration with the Liebherr Group, has a power rating of 300kW and produces 1,700Nm of torque. It also has a highly compact design that makes it easy to install in a wide range of applications. The engine is as compact as our TCD 6.1, but generates an additional 100kW and will open up whole new possibilities for our customers. The plan is for Deutz*'s Chinese joint venture, DDE, to manufacture the TCD under licence so that it can more easily serve the local market.*

The new in-line engines resulting from the Liebherr collaboration will complement our existing products and not replace them.

We've mentioned Liebherr. Could you tell us something about the agreement with Liebherr? How can the product offerings of the two companies be integrated?
Deutz *AG and Liebherr Machines Bulle S.A. have agreed on the key aspects of a strategic alliance between the two companies. Under this arrangement, Liebherr intends to grant* Deutz *worldwide sales and service rights for 200 to 700kW diesel engines for a variety of applications. These engines are being developed for the EU Stage V, US Tier 4, China IV and EU Stage IIIA emissions standards. The engines manufactured by Liebherr will be available to* Deutz *for series delivery from 2019.*
These engines are an ideal fit with Deutz*'s product portfolio, and we intend to sell them under own our brand to customers, including via our network of dealers. The plan is also to increase the number of* Deutz *engines used in Liebherr equipment in the category up to 150kW.*

Does Deutz Dalian only produce for the Chinese market?
No. Our Chinese joint venture Deutz *(Dalian) Engine (DDE) produces both for the Chinese market and for applications in export products for Europe, the USA and Japan, among others.*

Will Volvo remain the biggest shareholder in DEUTZ?
Volvo is currently the biggest shareholder in Deutz *AG. No significant changes to the shareholder structure are expected at this point in time.*

What's your opinion on stationary machines with variable speeds? Does Deutz have any interesting ideas for TLC applications?
Our engines are already optimised for variable-speed applications. We work closely with the OEMs to tailor our engines to the specifications of the machines in which they are installed. This collaborative approach helps us achieve the best results, and this is regularly confirmed by independent institutes. I refer here to the product comparison tests conducted by the German Agricultural Society, in which Fendt tractors fitted with our engines consistently emerge victorious. In a further step, we are introducing a 'best point optimisation system', whereby the engine is calibrated to the hydraulics (and also to the generator), and during operation dynamically sets the point at which the lowest amount of fuel will be consumed. Here, too, the use of variable speeds in stationary applications opens up a lot of new potential that can be harnessed with our engines. Because of the standardisation of the emission limits for mobile gensets in EU Stage V, variable speeds are becoming very interesting for this area as well. For telecommunications applications (TLC) we have come up with an optimised solution in the shape of the BFM2011.

Just recently, we've heard about a semi-stationary diesel/electric application as well as the hybrid drive unveiled at bauma 2007. Are you developing any other hybrid solutions at the moment? If I'm not mistaken, you're currently working with Same Deutz-Fahr on agricultural applications.
Deutz *has successfully developed a diesel-electric hybrid drive for an excavator, which consists of a* Deutz *TCD 7.8 and an electric motor/generator. It has also developed a hybrid drive with a hydraulic pressure reservoir for a wheel loader. Both concepts have achieved impressive values with regard to efficiency and fuel consumption. But they are still only prototypes that we are currently assessing with regard to their market potential.*

Looking ahead to 2017, what cards will DEUTZ be putting on the table at Middle East Electricity in Dubai, Conexpo in Las Vegas and Agritechnica in Hannover?
At the trade shows in 2017 we will be showcasing our wide range of engines from 25 to 700kW to an audience of international industry professionals under the banner 'FUTURE DRIVEN: engine technology of tomorrow'. Depending on the show, we will be focusing on very different market segments and applications: at MEE 2017 it will be stationary equipment and gensets/generators, at Conexpo it will be construction equipment, forklifts and lifting platforms, and at Agritechnica in the autumn it will be agricultural machinery. At Conexpo, which will be the most important trade show for us in 2017, we will be presenting the TCD 5.0 and the new TCD 9.0 to the American public for the very first time. Our new engine solutions in the range below 56kW will also be wowing the trade crowds. In Las Vegas, we will be unveiling the brand-new 2.2 litre diesel engine as well as its G 2.2 and G 2.9 gas variants. And the new emissions legislation means that we will be presenting our customers with new solutions for exhaust aftertreatment. Our answer to the problem of balancing future emissions directives against the needs of our customers is DVERT®. DVERT® is a system of emission technology modules that can be configured in a variety of different ways for our engines. At the trade fairs, we will be showcasing our full DVERT® range, including some new products. We will also be presenting our aftersales portfolio at the trade shows. We offer a comprehensive range of products and services that cover the entire lifetime of our engines and equipment, including spare parts, maintenance parts and reconditioned exchange parts, as well as consultancy and engineering services. **FB**

Carlo Cavallero. President of Yanmar Italy

SINGLES IN THE WORLD

For over twenty years Yanmar manufactures single-cylinder engines for the whole world in Lombardy. Since 2013 its president is Italian and his name is Carlo Cavallero. We discussed with him about the present and the future of the single-cylinder engines

From Osaka, in Japan, to Lombardy, in Northern Italy, near the Switzerland border. This is the trail of Yanmar single-cylinder, which are distributed since Yanmar–Cagiva times in 1996 all over the world from Northern Italy. Since June 3 2013 the single-cylinder branch is led by the first non-Japanese president, the Italian Carlo Cavallero.

Mr. Cavallero, what has changed since the day you took office?
I came to Yanmar in 2011. The former president introduced some changes that made our structure leaner and more flexible than the typical one in large Japanese companies. In general, the organization has remained in line with the one designed in 2012. We rely on the concept of duality of functions of the top management, which also plays an operational role. As for the industrial part, we're manufacturing here single-cylinder L-series for the whole world market and set up dedicated configurations of TNV engines for European customers (local dressing). Having a superior flexibility than that of our parent company in Japan we're able to meet the market demand in lower lead times.

Is the L-series in good health?
Both L series and TNV engines in local dressing sales are increased in the European market. The global market is showing a slowdown of the Asian market, which however marked encouraging signs of recovery, as well as North American market.
We have changed our L series to meet global regulations. The Ln Series, also Europe - compliant (which does not regulate Stage IV engines below 19 kW - editor's note); the Lv Series for Japanese and Singapore markets; the EPA Tier 4 Final compliant Lw Series. With the upcoming Stage V, engines below 19 kW will also require cuts to current NOx emissions.

DOC made its debut on your single-cylinder engines. Why is Yanmar the only manufacturer to adopt this solution?
We are the only manufacturer who have received the final, not temporary approval in January 2015, without using the loophole of "deficiency" as part of our competitors did. The engine can then be used without limit until the next legislative stage. Yanmar requires every engine to meet regulatory limits in all operating conditions, even the most critical or remote. To uncompromisingly meet this requirement DOC was an obvious choice. We believe that there is no other solution than this to meet EPA Tier 4 regulations, unless of course depowering the engine.

Compared to this approach, what is going to change in the European scenario?
The European homologation does not require high altitude tests, EPA remains the strictest legislation requiring testing up to 1,700 meters.

How is the gasoline engines market scenario changed?
We've seen a partial comeback to gasoline engines to meet regulations, even sacrificing torque and transportability. Chinese manufacturers still lead the hobby market.

What is your annual production?
About fifty thousand single-cylinder engines on average, mainly used for power generators, light towers and stationary applications in general, as well as some agricultural application (sprayer, motor pumps, cultivators, tillers). The area of high pressure washers, previously monopolized by electric power and gasoline engines, is opening up to diesel for professional use. Aerial platforms market is also growing. Sales are distributed to approximately 40 percent in Europe, 40 percent in Asia and the remaining 20 percent in America.

How do you manage the issue of noise pollution?
Yanmar uses counter-rotating balance crankshafts which reduce vibrations and consequently noise to a variable extent depending on the application. The three single-cylinder series feature the same noise level. We have no intention to manufacture soundproof versions that we feel could penalize applications at the moment.

How the future of electronics is going to be? How should we imagine the single-cylinder in 2020?
The prospects drawn from the fundamental driver of environmental regulations lead us forward in time. USA will face this issue in 2025, Europe after 2020. We will meet emission limits worldwide thanks to our LW and LV Series. Stricter regulations would call into question the very same diesel engine. The use of advanced electronics on such a 'basic' engine would turn upside down layout and mechanics of applications. One of the goals of the new Chinese regulations was to ban mechanical engines and focus on common rail, but at that point we believe the liquid cooled engine is the most logical, cost-wise solution.

What about single-cylinder as generators in hybrid powertrains?
The trend in the generation area is oriented towards lower power, thus opening market spaces for smaller engines. A L48 engine is able to power a LED light tower, which is unthinkable with halogen lights. We should not only look at engines but also at the overall efficiency of applications. Even the permanent magnet alternators market is moving, still expensive but featuring clear benefits and long-term perspectives: the engine works with significantly lower noise and fuel consumption than fixed speed models. This is an important advantage, for example in the case of generators for telecommunications. The evolution of the market is so rapid and dynamic that traditional markets can quickly fall and new interesting opportunities may emerge.

Fabio Butturi

Focus on Isotta Fraschini with CEO Claudio Andrea Gemme

MAGIC BOX? ENERGY BOX

Isotta Fraschini today and tomorrow. We met in Milan, during the American Election day, Claudio Andrea Gemme, CEO of Isotta Fraschini and CEO and Chairman of Fincantieri SI. We asked him where Isotta Fraschini is going. The answer is Energy Box

The times of self-sufficient endothermic engine and lone pistons are gone. Isotta Fraschini get back to professional marine and power generation scenario that never really left. Today, however, just in a supporting role. The formula is shown above: there's no meaning in overturn the piston flow between TDC and BDC and tweak the thermodynamic parameters of the diesel engine. What engine really needs is power electronics, using a power regulator to reach optimum working conditions. This is what emerged during our meeting at Fonderie Napoleoniche in Milan with Claudio Andrea Gemme, CEO of Isotta Fraschini and Chairman of Fincantieri SI.

Our guess is: hybridization is the way. With a hybrid package lower calibrations may be used, lowering workload and thermal stress. There may be different solutions, for example working in PTO/PTI mode in a chain composed of diesel engine, clutch, electric machine, with inverter or full electric. Prospects and dynamics of hybrid systems are well known. The keywords are two idioms: 'Energy storage', suitable for marine applications such as tugs, and 'smart grid' for power generation. No one better than Claudio Andrea Gemme, then, to explain the present and the future of the company based in Bari, Southern Italy.

Welcome back, Isotta. It's a pleasure to find once again Isotta Fraschini brand associated with the industrial side of the engine world. What are your goals, also considering the strategies of your parent company Fincantieri?
First of all, Isotta Fraschini is an historical brand (One name for All? The Torpedo) that boasts a series of big hits. The goal of Fincantieri is to further enhance those values. In order to achieve this goal we intend to follow two main strategies. First of all, entering a captive market that shows important figures, also considering the prestige and the orders of Fincantieri. Secondly, today we find ourselves working in the American market, where Isotta Fraschini provides marine diesel engines for the Littoral Combat Ship class of US Navy. This is just an example of our roots in the United States. We'd also like to establish steady relationships in supplying diesel engines for land sector, and locomotives are a paradigmatic example of that strategy. Another example are the engines for emergency generators, both for marine and land applications.

Gemme summarizes the meaning and the mission of corporate strategies as follows:

Isotta Fraschini is not a "big figures" company and still works in a niche market. We are looking for an evolution towards systems with integrated electronics. In my dual role of Isotta Fraschini CEO and President and CEO of Fincantieri SI, I'm doing my best to "dress up" engines and find niches with interesting potential, exploiting the prestige of a fantastic brand".

What are the main captive applications?
Surely the cruise ships, for the whole Emergency diesel section, large ships such as Carnival and Costa. In the Military market we usually provide our engines for patrol ships and frigates. In the Land market we provide integrated packages, also including if possible other components made available by other Fincantieri Group brands.

And in the United States?
As I said above, our "bridgehead" is the Military sector, in which Fincantieri operates since 2008 through the acquisition of several local facilities. We equipped a couple of products such as LCS (the aforementioned 'Littoral Combat Ship') with Isotta Fraschini units.

What about power generation outside of Atlantic duopoly?
Frankly speaking, currently our product range shows a limit. We cannot compete on the ground of MegaWatts. We're rooted in a market area that is closer to our potential in terms of volumes and product range. What we can do is dressing up our product with electronics and explore new horizons, such as diesel combined to storage. A textbook example is an island that cannot make use of an usual electric grid and have to rely on diesel engines. Relying on a back up with storage is an interesting opportunity. We're looking at those markets that may provide us this opportunity.

Also in industrial application?
Our main market is marine captive, but we rely on an interesting architecture and a technological heritage in various diesel applications such as service locomotives and other locomotives. We delivered to Trenitalia (the former Italian railway monopolist) more than 650 engines and today there are evolutions both for service, an interesting network in terms of figures and penetration, and some new opportunities.

What should we expect from power generation?
We are strongly investing on the Italian market. Isotta Fraschini planned several investments to improve its product range, because after several years an upgrade is mandatory. We also intend to focus on some innovative applications.

What about new marine regulations such as Imo, Tier 3, EPA Tier 4, RCD2?
We are also working to meet environmental regulations.

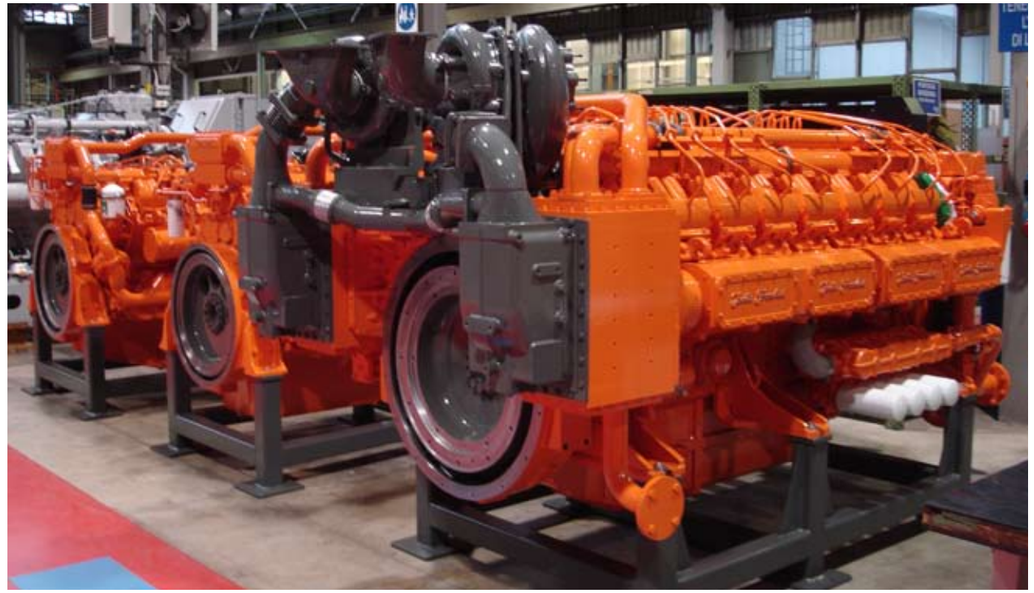
Is the SCR a nightmare?
Not for us, absolutely. This is a matter we can manage quite easily. The real goal for our company is developing market volumes. When you invests on such products this is your final haven. Our competitors have completely different volumes, so we absolutely must reach larger markets. We're ready from a technological point of view, so we're trying to bring Isotta Fraschini into markets never explored before.

Do you mean Korea, Japan, China?
We're already working in Korea.

What can you tell us about the production?
It's a synergy between Isotta Fraschini Bari and Fincantieri Marine Systems North America, with interesting values in manufacturing and even more in service.

The next step of Isotta Fraschini?
We can no longer afford stand alone diesel. We have to make "dressed up" products. Then we need to find internal synergies with Fincantieri in order to exploit this new opportunity.

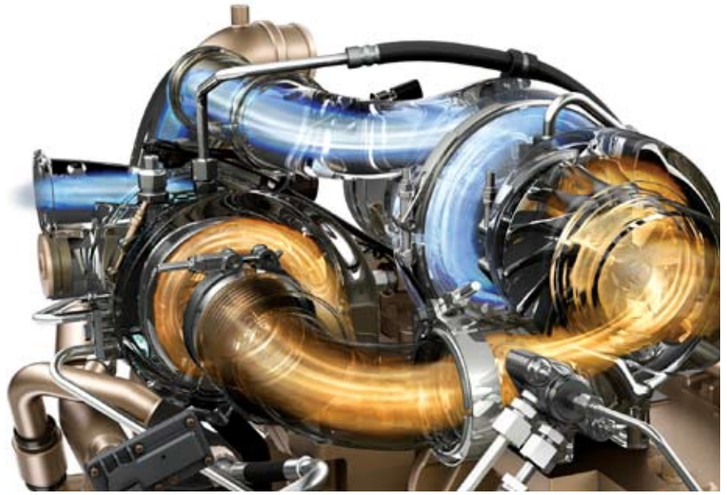
In summary, Isotta Fraschini is steadily moving towards a "Smart Energy Box". **FB**

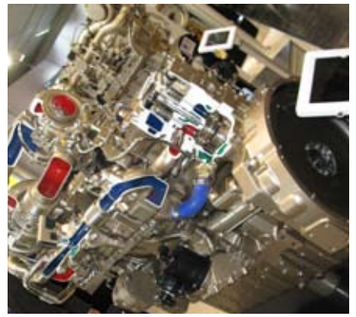


In these pictures, some Isotta Fraschini engines and an aerial photo of Isotta Fraschini factory. On the top, one of the legendary cars that made the Italian brand famous worldwide. The engine in the background and right is the 746 kW that equipped the seaplane reproduced in the scale model and a photo of Fincantieri SI and Isotta Fraschini CEO, Claudio Andrea Gemme.

OPERATION: DIVERSIFY

John Deere crossed the line of Stage V by promoting and adjusting that DPF technology which was never denied. The codes used to identify engine series intuitively identify turbo and aftertreatment. “Et voilà” the Deere acronyms: EWX, PSS, PVS, PWL





Here, the ‘Lego’ engine and some images of combustion system. The onomastics consists of cross markings to displacements, intuitively illustrating the engineering coordinates of Tier 4 Final/Stage IV certified engines.

Valves, turbocharger and aftertreatment are the guidelines that drive through the onomastics of John Deere. Heavy - duty vocation, a particular feeling for agricultural applications and power generation, segmentation from 2.9 to 13.5 liters: this is how John Deere combined ‘footprint and performance’ factors in order to have a flexible mix of costs, specific curves and displacements able to harmonize with different workloads and regulations. The onomastics of Americans consists of cross markings to displacements, intuitively illustrating the engineering coordinates of Tier 4 Final/Stage IV certified engines. For its engines over 56 kw John Deere has not given up the particulate filter, except for PWL series, and had to implement the SCR. Let’s take a look at the acronyms starting from the EWX series, the only with the initial E - a legacy of mechanical platform indicating two valves per cylinder, the W specifying the use of the waste gate valve and the X standing for doc - dpf module without urea, since delivered power stops at 55 kilowatts. The EWX adopted both on 2.9 and 4.5 liters does not use the aftercooler on four cylinders engine but only on 3 cylinders. This platform does not make use of recirculation of exhaust gases. The PWL, a 4.5-liter providing power rates from 63 to 104 kW, is notable for having ruled out regeneration. In summary, P stands for 4 valves version, W stands for waste gate valve, L indicates doc and scr. Egr is also used, seamless adopted by John Deere aside from the above mentioned EWX. Upgrading to Stage V will necessarily involve dpf, with a leap ahead to 110 kilowatts.

The most powerful solution is hidden behind PSS acronym, crossing 4.5 to 13.5 liters engines, with final S standing for in series turbo - one fixed and one variable. The second S indicates the use of doc - dpf - scr plus egr. PSS are designed to deliver torque at low rpm, low derating, ability to work at high altitudes. The 4-cylinder engine delivers 93 to 129 kW, the 6-cylinder, 6.8-liter reaches 224 kW (300 hp), the 9-liter 317 kW. As the 13.5 liters the 9 liters is manufactured in Waterloo, United States. Engines up to 6.8 liters are also manufactured in Mexico, while engines from 2.9 to 6.8 liters are made in Saran. John Deere factories located in India and Argentina manufacture engines for local market. In India, being the demand for low-power tractors very strong, the company manufactures the 2.9 liters for captive use, while Saran kept the exclusive for oems. The 104 kW engine can be made both in PWL and PSS version to meet the demand for dpf as in Switzerland. In the meantime the switch to Stage V ready has been formalized and reached through calibrations, re-modulation and the downsizing of post-treatment. The reduction peaks declared by John Deere are ranging from 39 percent of the overall dimensions to 57 percent of the weight. At present John Deere confirmed the double box for scr, and doc-dpf, without providing at the time a single case. Dpf will be mandatory in 19 to 530 kW range, needing the adaptation of the software for soot particles monitoring. JD has developed a dual type of application, supporting the customer with projects and drawings. Those who have the possibility to install the system outside the machine combining the two cases with special supports may rely on a ready-to-go application. The oem just have to plug turbo into doc intake. All components such as supports, clamps, connectors, sensors, pipes, cables, extension cords are tailored and provided by JD, in various types and sizes.

The other solution is available on some engines starting from Stage IIIB, and is to apply the Doc-dpf module directly on the engine, on the valve cover, leaving only the scr to be placed externally. Thanks to an expected reduction of fuel consumption around 3/3.5 percent scr is downsized in Stage IV compared to scr - only solutions. Some customers are testing it on their machines because of its smaller footprint compared to the double module.

GENERATORS AND DUBAI

John Deere tailored a dedicated range for Stage IV featuring a simplified after-treatment solution without dpf of almost all engines, DOC and SCR, internal EGR and 4 valves. The real compromise was the 250 kVA 6068 model, not certified and based on most of the components of Stage IIIB/IV version to raise 6.8 liters output at 250 kVA while keeping its compactness, as in the Kohler-Sdmo version. The MEE in Dubai is the stage of a series for generator sets, the Revamp, which relocates current mechanical generators in terms of downsizing, cost reduction and power.

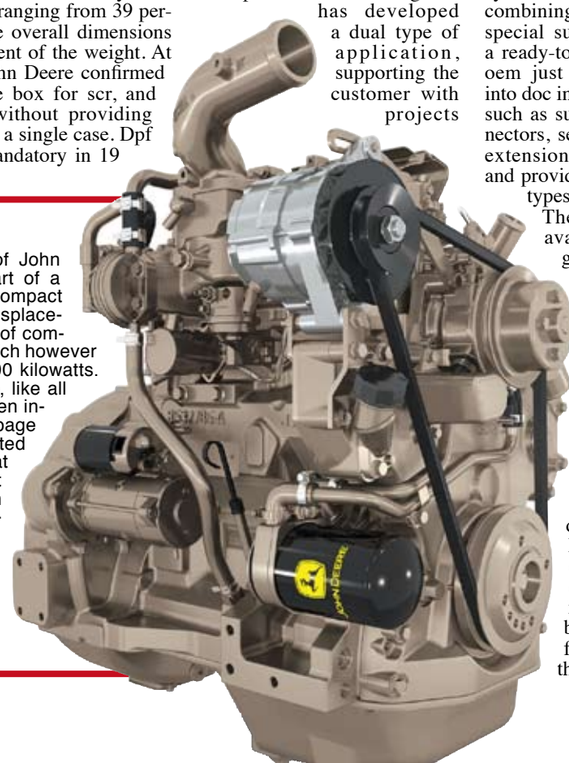
The 3-cylinder range expands from 30 to 60 kVA, which affects price rates, because it’s possible to install engines up to 60 kVA in the same canopy which once hosted smaller engines. Even the 120 kVA focuses on downsizing, switching from a 6-cylinder turbo to a 4-cylinder aftercooler. The 6.8 mechanical will raise from 80 kVA to 200 kVA, covering a gap in the product range, while the 250 Series will segment to 225 kVA previously provided by the 9 liters. The benefits for EMEA market are clear also in terms of time and cost of delivery, being this model manufactured in Saran, France, and not in Waterloo.

There are news also at the very heart of mechanical versions, where Stanadyne injection pumps will be replaced by a new generation. These engines will be progressively available on the market up to the first half of 2018.

The John Deere booth at the previous Mee edition.

EWX 2.9

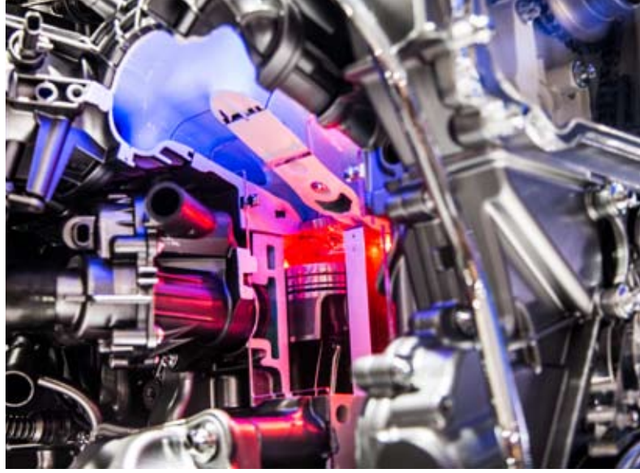
The 2.9 liter is the entry level model of John Deere Power Systems range and is part of a smooth power range focusing on super-compact engines from 2 to 3 liters, featuring a displacement that looks at the higher range, that of compact engines between 3 and 3.8 liters, which however features power rates between 74 and 100 kilowatts. Being a captive but also versatile engine, like all John Deere range, this model has not been included in the comparison published on page 42 of DIESEL International issue distributed at EIMA International in Bologna and at Bauma China, which covered 12 compact engines from 3 to 3.8 liters currently on Stage IV/Tier 4 Final market and also included VM and Isuzu 2.97 liters engines. It will surely be included in the next comparison to be published on the Agritechnica issue, which will focus on the range from 2 to 2.9 liters. The 2.9 three-cylinders (BxS 106x110 mm) provides 36 to 55 kW and 190 to 304 Nm.



Conference “Stage V and beyond...”

THE LONG SHADOW OF CO2

The seminar sponsored by DIESEL magazine at Eima in Bologna pointed out that the visions of the manufacturers are not perfectly coincident: EGR is not gone for good, and after-treatment modules will have different layouts. CO2 will be under the spot after 2019



“*2019: a space Odyssey*” and the space is that under the hood: that’s not a remake of Kubrick’s masterpiece, but the mood of technical offices of motorists and OEMs. The European Union, usually chasing EPA in the race to standardization, this time surpassed the Agency lowering PM threshold, introducing Pn (Particulate number) and widening regulations up to power ranges and applications untouched so far.

But what does this mean to manufacturers? DIESEL asked some of the protagonists, a group that does not includes all potential speakers but still provides a comprehensive and competent representation of the strategies to be in the off-road environment.

Let’s start from the beginning: “Stage V”.

The cornerstone of the discussion were the SCR system, mandatory for over 56 kW engines to meet Tier 4 Final and Stage IV standards, and the overcrowdings of after-treatment systems which are going to include DPF in 2019. And what about EGR? A dead man walking, according to the common ‘mood’.

But is that really so?

Let’s see what speakers think about it, in strictly alphabetical order.

Deutz

The speech of Roberto Brivio, Deutz Managing Director Iml Engines, shuffles the cards on the table: «*Deutz consider EGR a must that allows the reduction of fuel consumption up to 10/15 percent”. Speaking about cylinder modularity, Deutz goes against the following speakers: “Eat (Deutz aftertreatment, ed) for Deutz means flexibility, with different solutions available (only DOC, DOC + SCR, SCR + DPF) to ensure the optimization of engine volume and minimize the space required for the installation of the entire system”*.

Fpt Industrial

The second speaker is Fabio Rigon, Off Road Sales Director of FPT Industrial*: «Today, waiting for Stage V, our solution is called Hi-eSCR2, the second generation of the high efficiency after-treatment technology patented by FPT, that we will use on all Stage V engines above 4 liters. the system is equipped with DPF integrated on SCR, without dimensional increase compared to that for Stage IV, with best-in-class values in fluscr, all packed in a single container which we call ‘all-in-one’. The ‘all-in-one’ also contains the mixing pipe. The solution of Stage V Kdi3404 and its after-treatment system»*, De Giglio underlines, «*will not undergo any dimensional change, as the DPF can be perfectly integrated in the same housing*».

After drawing a wedge between Deutz on one hand and FPT Industrial and Kohler on the other regarding the allocation of the after-treatment, it’s the turn of Man, which raises the egr issue.

Man

According to Marianna Benetti, Ets Technical Manager, «*Man in general always believed in egr, making it one of its strongpoints since Euro 4 era*». Benetti stresses Man automotive synergies: «*Man D38, the Diesel of the Year 2016, is fully Stage V compliant. In the next future, while Scania - also part of VW Group will handle 13-liter platform for both manufacturers, Man will focus on 5 and 9 liters for Sodertalje also*».

Perkins

Simone Buraschi, General Sales Manager of BU Power Systems Italy, closes the first round telling us about Perkins: «*We believe that it would be a terrible mistake allowing the engine to produce more particulate and think to clean up everything through dpf. Reducing Pm to a minimum is a key part of our combustion strategy. Our Synchro, for example, will use a vertical injector in order to achieve a better atomizing model, an advanced turbo, a new design of the piston crown and four valves per cylinder*».

Also Perkins, Deutz and Man renew their confidence in recirculation of exhaust gases. «By using the EGR», Buraschi underlines «*we may lower the amount of NOx and minimize the workload on scr, with a lower urea consumption and a smaller tank*».

Beyond Stage V

This is about the near future. But DIESEL didn’t stop here and asked the speakers to imagine what lies beyond Stage V, when in the third decade of the new millennium CO2 and therefore consumption will end up under the spot.

Could this involve the very same diesel engine?

Let’s take a look at the following quick roundup.

Deutz: «*Starting from Stage V the EU will separate from the United States, and 2019 will be the year of China 4 also. We’ll need then the most unified and modular products to meet the demands of every market. Further future constraints will surely address the CO2 issue. The keypoint will then become the definition of a plausible test cycle for a huge number of different applications*».

FPT Industrial: «*The transversality of FPT Industrial have positive effects in terms of proliferation and exchange of experience and know-how. We have seven research and development centers worldwide and more than 130 cells for testing. This is where successful engines such as Cursor 9 CNG - which we launched in May 2016 are conceived. That’s an engine ‘naturally powerful’ that reaches the same performance of a diesel but it is powered by natural gas. We brought here at Eima an example of our experience in this area, the N60 Ng prototype*».

Kohler: «*Reducing CO2 is going to be the major challenge. How? In our long-term vision, the engine is going to become the key component around which the machine will be built, fully linked and able to meet the demand of more and more complex work cycles. Any regulation of CO2 will be an opportunity to carry out the downsizing of the machines*».

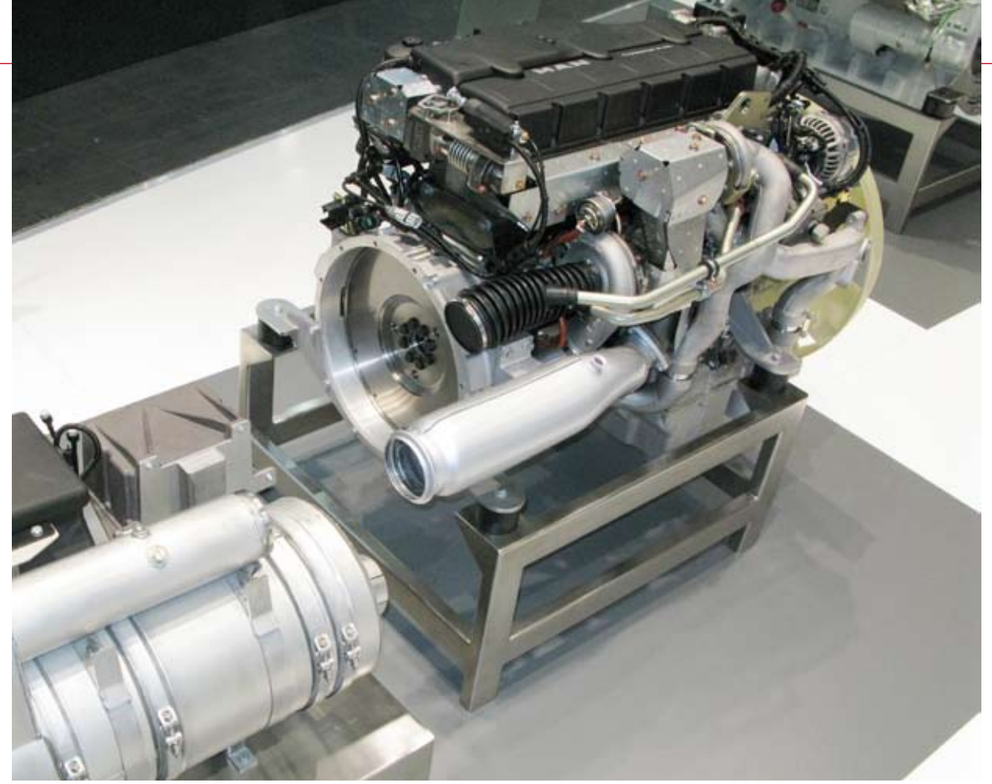
Man: «*we believe that the next step of the regulations will address topics such as increasing efficiency and reducing CO2, as requested also by Cop 21 agreements. Hybrid-electric solutions are therefore generally possible with smaller internal combustion engines and a boost of the electric side. In addition, another possible scenario is a wider use of natural gas and LNG*».

Perkins: “*One approach is looking at current industry trends and assume they will remain the same in the next future. We think that the machines will be more integrated, engines will be smaller, the attention to new product support models will increase and telemetry will be a part of those models*».

In other words, gas and hybrid are among us now and they will more and more in the near future.

AT THE CORE OF THE INDUSTRIAL

Focus on 1.1-liter cylinder, the natural heir of traditional one liter displacement. Man outperforms other competitors thanks to its D08, Cummins, FPT Industrial, John Deere and Perkins are aligned on similar power and torque rates. Agco Power, Cat e Jcb are a step backwards. FPT N Series leaves behind EGR



The one-liter cylinder is history, and its natural evolution comes from the increase of stroke and bore to snatch a few cubic centimeters in order to satisfy the hunger for HP and high pressures. The result is the 1.1 liter cylinder, resulting in 4.4 to 4.6 liters displacement on 4 cylinders engines which are the focus of this comparison.
Eight manufacturers are part of this elite, strongly oriented to the free market, some exclusively as Cummins, some mainly as Perkins, some both as free and captive as is the case of FPT Industrial and John Deere. Man is the bigger one. Which are the 'macro' of the technological matrix of these engines?

Egr? Not for Fpt Industrial

EGR hangs on in Tier 4 Final and is left definitely out only by the N series and its 'big sister', the Cursor series, in accordance with the design philosophy of FPT Industrial. Also Cummins 'banned' the EGR at the last Bauma: the CEO and President Tom Linebarger announced that recirculation will not be promoted to the Stage V. EGR valve is coupled with supercharging pressures, a choice that could favor the survival of recirculation in a light format, depending on proper aspiration of the engine, the lightening of the urea percentage supplied and, consequently, of the catalyst volume. In this case the fixed turbine together with wastegate is in fact adopted only on Nef, with Cummins and John Deere choosing the variable geometry alternative, and Man and Perkins the double stage architecture. Power curves stand between 125 and 129 kilowatts at 2,200 rpm, apart from Cummins running at 2,500. Those rules apply to every competitor except from Man D0834. Its 162 kW at 2,100 rpm and a piston speed of 8.8 meters per second show off an excellent balance between performance requirements and reduced stress. Specific curves are outstanding: 35.3 kW and 185.5 Nm, a rate overcoming by 15 per cent the following trio, except from Perkins which has halved the gap instead thanks to the double stage that stretched torque curve and pumped up power.
Among the pioneers of no-dpf strategy JCB offers the firstborn 4.4 liters, but competing against the top players requires using the oversized 1.2 liters cylinder. Agco Power was instead one of the first manufacturers to join the cause of SCR, featuring here its 4.4-liters, 110 kW engine. Caterpillar keeps the Acert formula also on the Perkins twin, the 4.4 liters, gaining with the aftercooler version a few decimals over 129 kW (0.4).

1.1 LITER. A PERFECT COMPROMISE

Brand Brand - Model	AGCO SISU POWER 44 CTIM 2V	CATERPILLAR C4.4 ACERT	CUMMINS QSB4.5	FPT N45 ENT SCR	JCB ECOMAX 93	JOHN DEERE PVX 4045 HFC93	MAN D0834	PERKINS 1204E-ETTA
I. D.								
B x S mm - S/B	108 x 120 - 1.11	105 x 127 - 1.21	107 x 124 - 1.16	104 x 132 - 1.27	103 x 132 - 1.28	106 x 127 - 1.20	108 x 125 - 1.16	105 x 127 - 1.21
N. cil. - dm3	4 - 4.39	4 - 4.39	4 - 4.46	4 - 4.48	4 - 4.39	4 - 4.48	4 - 4.58	4 - 4.39
Maximum power kW - rpm	110 - 2,200	129.4 - 2,200	129 - 2,500	125 - 2,200	93 - 2,200	129 - 2,200	**162** - 2,100	129 - 2,200
Mep at max power bar	13.9	16.4	14.2	15.5	**11.8**	16	20.6	16.3
Piston speed m/s	**8.8**	9.3	10.3	9.7	9.7	9.3	**8.8**	9.3
Maximum torque Nm - rpm	650 - 1,100	750 - 1,400	706 - 1,500	696 - 1,600	550 - 1,500	713 - 1,600	**850** - 1,400	750 - 1,400
Mep at max torque bar	19	21.9	20.3	19.9	**16**	20.4	23.8	21.9
Torque rise %	48.9	48	44.9	45.7	**49.4**	45.3	42.5	48.3
Torque at max power Nm	480	559	490	539	402	559	**735**	559
% power at max torque (kW)	68.1 (75)	85 (110)	86 (111)	93.40 (117)	93 (86)	92.70 (120)	96.20 (**156**)	85.30 (110)
Work range rpm	**1,100**	800	1,000	600	700	600	700	800
DETAILS								
Specific power kW/dm³	25	29.4	28.8	27.8	21	28.7	**35.3**	29.2
Specific torque Nm/dm³	147.8	170.4	158.3	155.1	125	159	**185.5**	170.4
Areal spec. power kW/dm²	30.05	37.40	35.83	36.76	27.93	36.54	**44.26**	37.28
RULES AND BALANCE								
Dry weight kg	530	420	360	410	540	540	490	420
L x W x H mm	1.112x654x896	845x741x867	818x713x820	810x678x901	787x701x921	867x680x1.211	937x882x926	845x741x867
Volume m³	0.65	0.54	**0.48**	0.49	0.51	0.71	0.77	0.54
Weight/power kg/kW	4.8	3.2	**2.8**	3.3	5.8	4.2	3	3.3
Weight/displacement kg/dm³	120.5	95.5	**80.7**	91.4	122.8	120.5	107	95.5
Power density kW/m³	169.2	239.6	**268.8**	255.1	182.4	181.7	210.4	238.9
Total density t/m³	0.82	0.78	0.75	0.84	1.06	0.76	0.64	0.78
Displacement/volume dm³/m³	6.76	8.15	**9.29**	9.15	8.63	6.31	5.95	8.15
INDEX								
Torque	**13.4**	10.8	12.7	8.7	9.3	8.8	6.3	10.8
Performance	5.6	6.3	6	6	5.1	6	6.8	6.3
Stress	9.3	10.4	10.2	9.9	**8.6**	9.9	10.9	10.4
Lightness	14.6	11.3	9.5	11	14.8	14.7	13.3	11.3
Density	13.5	18.8	**19.9**	19	14.5	13.5	14.7	18.8
DIESEL INDEX	6.9	7.5	**7.7**	7.1	6.2	6.9	7,6	7.5

ABOVE AND BELOW

Widening the scope of the comparison range involving the 1.1 liter cylinder enlarges to ten the number of competitors. We start from DEUTZ 4 liters and close with MTU and VOLVO PENTA 5.13 liters. The top range of this segment will probably attract the attention of several manufacturers. In addition to JCB 4.8, AGCO POWER 4.9, MTU and Volvo Penta 5.1, this range recently included the 5 liters by Deutz, which will be available in Stage V version. All engines feature common rail and SCR, the typical architecture virtually adopted for all engines above 56 kW after the Stage IIB. This lot includes the two most qualified competitors of MAN D08, MTU, featuring top performances such as 170 kW at 2,200 rpm and 950 Nm at 1,400 rpm, and Volvo Penta following right behind behind MTU, with 160 kW and 900 Nm. The R4 1000 stands close its fellow D08 also in specific curves.

9 to 10.8 liters

THEY'RE GROWING

Engine platforms are not only segmenting at their bottom, as evidenced by the vivacity of 9 - 11 liters range. Caterpillar-derived Perkins is flying high, reaching the top, Deutz unveiled in Shanghai its 4-cylinders, 9-liters Stage V with Liebherr roots

Segmenting is the key to success in engine market and an effective way to become unique partners. The main path is laid, at least looking at the efforts of some of the players in diesel scenario. Kohler has done yet the great leap to 100 kW, and there's probably more to come in the next future. Volvo Penta meets the approval of "land" oems and could finalize agreements to complete the under 5 liters range. JCB froze its Tier 2 6-cylinders and has the technology to comply with USA regulations. Doosan Infracore has a six-cylinders in its range. FPT Industrial reinforced its product range with the 2.2 liters made in Cento and the Cursor 16. Man introduced the D38 and was exhibiting the small Volkswagen before the Dieselgate.
Perkins surprized the market at Bauma with the demo of a 3.6 liters, a strategic displacement for offroad applications, along

DEUTZ AND 9 LITERS FOR STAGE V

Deutz continues the renewal strategy of its high range - which began with the launch of its Stage V 5 liters in Munich with the new 6-cylinder 9-liter introduced at Bauma China in Shanghai, which revamps Cologne in the large displacement range and is the first result of the liaison with Liebherr. Assembled by the joint venture Deutz Dalian, the TCD9.0 delivers 300 kW and 1,700 Nm and is a candidate for excavators and wheel loaders in the construction market, challenging the other competitors included in this comparison (which features a Stage IV/ Tier 4 Final line up) such as Cummins QSL 9, FPT Industrial Cursor 9 (another Chinese with European roots) and Cat C9 ACERT, and in the future probably also Perkins and John Deere at home, ie in agri applications, which is - it should be remembered, is familiar to Deutz AG also. The project carried out with Liebherr stands out for its silhouette: it is rare to see a 2.25 liters cylinder (BxS 135 x 157 mm) on a 4-cylinder, and its one - meter width and 838 mm depth draw a very compact unit. Among the distinguishing features, the common rail and electronic control unit that drives the Liebherr production system and the four pto located on the flywheel side. Regulation standards are met through Doc-dpf-scr system without egr, with several possible post-treatment configurations.

GOD SAVE THE QUEEN!

Brand Model	AGCO POWER 98 CTA SCR	CATERPILLAR C9.3 ACERT	CUMMINS QSL9	FPT INDUSTRIAL CURSOR 9	JOHN DEERE PSS9.0L	LIEBHERR D936 A7	MAN D20	MTU 6R1100	PERKINS 1706J-E93TA	SCANIA DC9	VOLVO D11 K460
I.D.											
B x S mm - S/B	111 x 145 - 1,31	115 x 149 - 1,30	114 x 145 - 1,27	117 x 135 - 1,15	118 x 136 - 1,15	122 x 150 - 1,23	120 x 155 - 1,29	125 x 145 - 1,16	115 x 149 - 1,30	130 x 140 - 1,08	123 x 152 - 1,24
N. cylinder - liter	7 - 9,82	6 - 9,28	6 - 8,88	6 - 8,70	6 - 8,92	6 - 10,52	6 - 10,51	6 - 10,67	6 - 9,28	5 - 9,29	6 - 10,83
Maximum power kW - rpm	**365** - 2.100	298 - 2.200	298 - 2.100	330 - 1.900	317 - 2.200	320 - 1.900	309 - 1.800	320 - 1.900	340 - 2.200	294 - 2.100	339 - 1.800
Mep bar	21,7	**17,9**	19,6	18	19,8	19,6	20	19,3	20,4	18,4	21,3
Piston speed m/s	10,2	10,9	10,2	**8,6**	10	9,5	9,3	9,2	10,9	9,8	9,1
Maximum torque Nm - rpm	1.900 - 1.500	1.715 - 1.400	1.627 - 1.400	1.850 - 1.400	1.685 - 1.600	1.970 - 1.000	1.900 - 1.200	2.100 - 1.000	2.081 - 1.400	1.827 - 1.500	**2.200** - 1.400
Mep at max torque bar	24,8	23,7	23,5	27,2	24,2	24	**23,2**	25,2	28,7	25,2	26
Torque rise %	42,1	47,6	42	**66,2**	42,3	51,6	51,5	55,6	51,3	52,1	54,9
Torque at max power Nm	1.656	1.294	1.352	1.215	1.372	1.607	1.637	1.607	1.470	1.333	**1.793**
% Power at max torque (kW)	81,8 (299)	84,40 (252)	80,10 (239)	11,20 (27)	89,10 (282)	64,50 (206)	77,30 (239)	68,80 (220)	89,80 (305)	91,20 (268)	95,20 (**323**)
DETAILS											
Specific power kW/dm³	**37,1**	32	33,5	27,8	35,5	30,4	29,3	29,9	36,5	31,6	31,2
Specific torque Nm/dm³	193,4	184,6	183,2	212,4	188,8	187,2	180,6	196,6	**224,1**	196,6	203
Areal specific power kW/dm²	53,91	47,83	48,69	37,67	48,32	45,65	45,51	43,48	**54,57**	44,28	47,55
RULES AND BALANCE											
Dry weight kg	850	885	708	870	1.044	1.150	975	990	865	970	994
L x W x H mm	1.200x850x1.100	1.119x827x1.066	1.128x704x1.166	1.216x883x1.007	1.271x856x1.265	1.592x918x1.151	1.516x893x1.279	1.325x955x1.230	1.125x791x1.068	1.235x980x1.100	1.309x913x1.227
Volume m³	1,12	0,99	**0,93**	1,08	1,38	1,68	1,73	1,56	0,95	1,33	1,47
Weight/power kg/kW	**2,3**	3	2,4	3,6	3,3	3,6	3,2	3,1	2,5	3,3	2,9
Weight/displacement kg/dm³	86,5	95,3	**79,7**	99,9	117	109,3	92,7	92,7	93,2	104,4	91,7
Power density kW/m³	325,9	301	320,4	225	229,7	190,5	178,6	205,1	**357,9**	221,1	230,6
Total density t/m³	0,76	0,89	0,76	0,81	0,76	0,68	0,56	0,63	0,91	0,73	0,68
Displacement/volume dm³/m³	8,77	9,38	9,55	8,06	6,47	6,26	6,08	6,84	**9,77**	6,99	7,37
SPECIFICATION											
Emission level	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv	tier 4 final/stage iv
Injection system	common rail	common rail	xpi 2.400 bar	common rail	common rail	common rail 2000	common rail	common rail	common rail	xpi 2.400 bar	common rail
Techno	wg egr scr	wg scr egr	vgt egr scr doc	wg Hi-eScr	egr scr doc dpf	waste gate scr	waste gate scr	singolo asimmetrico scr egr	waste gate scr	vgt egr scr	vgt egr scr
INDEX											
Torque	9,2	11,1	11,2	**20,2**	11	12	9	12,1	11,6	10,4	7,5
Performances	7,3	6,9	5,7	7,1	5,9	6,9	6,7	7	7,9	7,1	7,2
Stress	11,7	11,5	13,2	11,9	216	11,2	10,8	**11,5**	13,2	11,7	11,7
Lightness	11,2	12,3	1,3	12	1,2	14,1	12,2	11,9	11,7	13,4	11,8
Density	11	11,8	3,1	11,7	2,6	7,2	6,7	8	**14,8**	9,6	8,8
DIESEL INDEX	7,9	7,6	7,9	6,2	7,7	7,4	7,3	7,7	**8,2**	7,6	7,2

with a series of oversized engines blossomed from the liaison with Caterpillar. These include the 1706J-E93Ta, featuring the same cylinder of its American brother, which reflects the confidence of the group in a brand that made the history of diesel engine in agriculture. This 9.3 liters engine comes in showing an unusual vivacity for a British.

Powerful British

Rpm ramp up to 2,200 along with a relative speed of the piston of 10,9 meters per second, equalling the C9.3 ACERT and showing a stress index that confirms the exuberance of the Anglo-American duet. The brilliant performance of the 1706J reverberates on specific curves.
Speaking of power, the displacement ratio puts Perkins immediately behind the best in class, the AGCO Power with its surprising and unusual 7-cylinders configuration. Speaking of specific torque, the 6-cylinders from Britain sweeps away the other competitors with its 224 Nm per liter, digging a gap from 5 to 19 percent. Acert system is shadowed by its English brother, that wins again even for power at maximum torque.

Eleven in the field

Eleven manufacturers are competing in such an exuberant power range. Yet the are many potential mobile applications out there, starting from large harvesting machines and maxi-excavators. Just to mention a few names in agricultural market, the New Holland Cr8.90 uses the other potential protagonist of this range, the Cursor 11 by FPT Industrial. The Claas Lexion 700 starts from the Mercedes 10.7 liters up to the Perkins 12,6 liters and the 15.6 liters Om 473 La (Mercedes are equivalent to MTU 1100 and 1500 series). But there are also the plowing giants, the maxi Optimum by Case, equipped by the Cursor 8.7, which we also find on Claas Axion who, in turn, mounts the MTU on the Xerion. JCB boasts its 8.5-liter flagship, chosen by Agco Power and also used under the hoods of Massey Ferguson and Valtra. Cursor 9 and 11 rule the New Holland range. Scania is definitely among the pioneers of 9 liters engines. The Scandinavians have a peculiar predilection for odd cylinders. While Sisu has chosen the powerful and bulky 7-cylinders in line Scania goes for the 5-cylinders, which equips Doosan dump trucks and excavators.

Born to be captive

The result is a competitive set of dimensional indicators, such as volume and mass-power ratio. Second only to Perkins in terms of torque, it loses ground when switching from Nm to kW, echoing a similar profile to that of Cummins, who shares with Scania the Xpi, although the Americans declare a fraction of the weight and footprint. Both Cummins and Scania introduced at Bauma a 9-liters looking at Stage V, both without egr.
Among the hard-core captive of the lot we find Agco Power and Caterpillar, which really has not a particular inclination to agriculture and designed its unit with building, excavation, mining and power generation in mind.

Let's Cursor

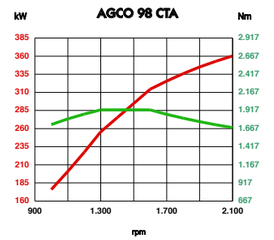
FPT proposes the Cursor 9, fully made in SFH - the joint venture with SAIC, which loses part of the undisputed value of the Cursor family in terms of power output, even if its specific torque is second in the ranking. In this range the Italian brand shows the 11-liters too, Cursor 11. Needless to say, electronics dominates in every form, from the almost ubiquitous Bosch common rail to the aforementioned X'pi for Cummins and Scania, with the exception of Volvo, still relying on its proven injector units.
The 6-cylinders, 10.8 liters from Goteborg is at the top of its class, closer to Cursor 11 than 9 in terms of direct comparison. Specific values, including available power, testify the reliability of the injectors and of the entire combustion process. Power density is also convincing; here the engines are aligned with the exception of Agco, Cat, Cummins and Perkins surpassing the 300 kW per cubic meter threshold.
The Germans, MAN and MTU, are substantially aligned on median rates, without their usual peaks (see D26 for Nuremberg and 1300 and 1500 series for MTU).
John Deere boasts its typical PSS package, which filters gases through DPF and SCR module. The textbook speed of the piston, 10 meters per second, and the specific power place this engine immediately behind the leader, Agco.

Liebherr and the 10.5

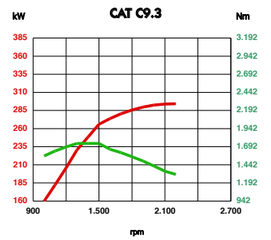
Even Liebherr ranks among the best with its 10.5, embracing the new wave of SCR-only ad showing all its impressive strength: 320 kW and 1,970 Nm. Switzerland manufactures all components in house: the control unit and common rail are homemade. The memory of its roots brings this engine, like the others of the Liebherr D series, to the construction world, but reliability is there and the versatile engines made in Bulle are surely not afraid of a structural sump. ■


The Challenger captive solution is called Agco Power. In the agricultural environment this cluster of engines powers big tractors, combine and harvesters.

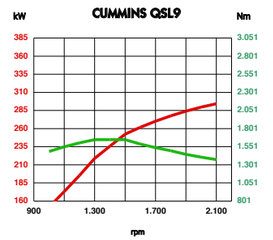
AGCO POWER



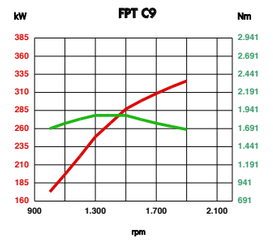
CATERPILLAR



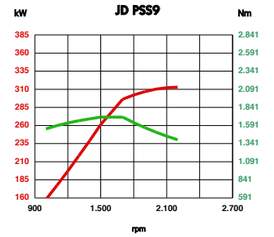
CUMMINS



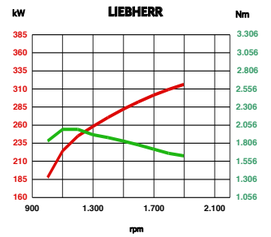
FPT INDUSTRIAL



JOHN DEERE

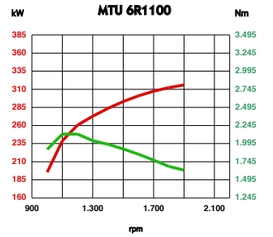


LIEBHERR

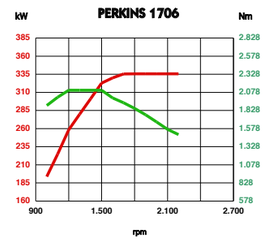


MAN

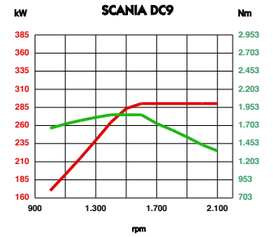
MTU



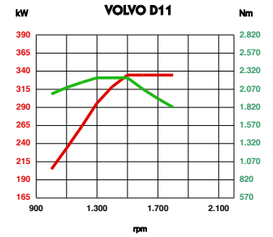
PERKINS



SCANIA



VOLVO PENTA



TURNING HALF A CENTURY

22 thousand gensets, 50 years and the strengthening of synergies with Kohler. This is the Kohler-Sdmo 2016 summary, which also brings the agreement with Liebherr on K135 and K175 series up to 103 liters

Thanks to 22 thousand gensets sold and the consecration of the brand in the business name, last year meant "Kohler" more than ever for Sdmo, which since 2005 crossed the fate of the parent company in Wisconsin with that of Brest, in Brittany, where Sdmo headquarters is based. Kohler-Sdmo brand unequivocally testifies the strategy decided overseas, aiming at genset market along with Kohler Power Systems; a brand change that occurrs exactly fifty years after the Meunier family established the company. In 1966 the strategy was focused on selling marine engines to French commercial boats: the French acronym (Société de Distribution des Moteurs de l'Ouest) means "Western Company of Engines Distribution". Only three years after the company left standalone engines to focus on design and assembly of gensets. Since then, power generation based on diesel is at the very core of the profile and the mission of the Breton company. The integration process, albeit aiming at brand complementarity and peculiarity, has been sealed a few months ago by the introduction of KD family, powered by Kohler engines, aka Lombardini, which gathers in Reggio Emilia (Northern Italy) the production of endothermic diesel engines for the whole Group.

Kdi family for KD Series

As well known to DIESEL International readers, KDI platform includes three displacements: 1.9 liters - three-cylinders, 2.5-liter – four-cylinders, both mechanical with rotary pump and common rail, and 3.4 liters, reaching 100 kW threshold in mobile applications. The union bonding the different souls of Kohler group Which provides additional sales themes without dismantle other Sdmo "weapons", which in the range under 375 kVA are called Mitsubishi, Psi, Doosan and John Deere. And it is precisely based in Saran the factory where many endothermic engines designed for Sdmo sets are manufactured. John Deere is in fact a partner for medium and low power models in the French product range. There's also a completely 'Made in France' newcomer, the J250K, which starting from the performance of 6.8 liters engine delivers 250 electric kW in a convenient compact box. The genset, in fact, is 2.4 meters long and 1.12 meters wide. The ease and low cost of transportation helped: a 12 meters container may carry up to three J250K. Sdmo uses all John Deere displacements up to 6.8 liters, including 2.9 and 4.5 liters.

Volvo Penta comes into play with its 6-cylinders, 7.1 liters, 275 kVA and 390 kVA, followed by five other power rates in the 375-750 kVA range. At the top of the range, together with Kohler, Mitsubishi and Doosan, we find MTU also providing the 16V4000G23E, the most powerful, along with Mitsubishi at 2,200 kVA. Liebherr is the last entry (see box). Mtu rules in the large sizes used for 'Contenergy' family, with the 2000 series at the top within the range between 715 and 2,500 kVA. Still in the portable segment we find the 'Rental power' series, from 650 to 700 kVA, controlled by John Deere and Volvo Penta, and 'Rental compact' from 15 to 550 kVA, powered by Mitsubishi and John Deere. The Portable series is powered by Kohler petrol engines. The above panorama is true for 50 Hz range, which is Sdmo strongpoint.

The heart beats in Europe

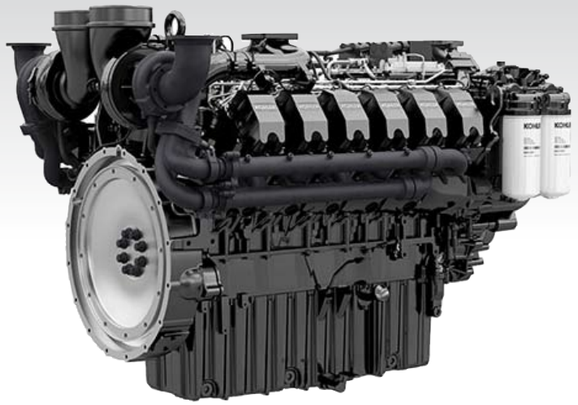
The core business of the French branch of Kohler galaxy is in Europe, in large civil applications such as hospitals, data centers and residential centers, and it spreads in Africa, Middle East and Latin America, with a sales office also in Miramar, Miami, USA. The new continent benefits from the cooptation of Maquigeral under Sdmo brand, being the third Brazilian manufacturer with its 40 to 750 kVA range. As stated above, factories are located in Brest, in Brittany, Reaumur, 3,900 sqm, and Kergaradec II, 41.500 sqm, the latter with 49 test bench for 40 to 3,800 kVA sets.

K135 AND K175 SERIES. BY LIEBHERR

The agreement between Liebherr and Kohler - SDMO is flying high. The cooperation spawned two engine series, the 135 and the 175, which consist of three units each, named from its bore size, delivering 709 to 3,608 mechanic kW in standby mode at 50 Hz and 891 to 4,250 kWm in standby mode at 60 Hz. The sizes are large: the 135 series starts from the KD27V12, a 12-cylinders, 27-liters, the KD36V16, a 16-cylinders, 36 liters, and the KD45V20, 20-cylinders, 45 liters.

The 175 series reaches dizzying peaks thanks to the D98, the winner of Diesel of the Year 2017: the KD62V12 is a 12-cylinders, 62.4 liters, the KD83V16, a 16-cylinders, 82.72 liters, and the largest of all, the KD103V20, a 20-cylinders, 103.4 liters.

Those engines include technologies developed by Liebherr in-house, starting from the 2,200 bar common rail and the electronic control unit with Koda diagnostic software. The 135 and 175 series have a curriculum of 50 thousand hours of bench test. Tom Cromwell, Kohler Group president-power, made a statement about the collaboration between Liebherr and Kohler: «*We are extremely excited to integrate our range with these engines, which combine unrivaled power density and compactness***».**



In the photos some examples of Kholer-SDMO applications.

OPERATION RESILIENCE

The Rankine cycle with organic fluid - aka Orc has two advantages, efficiency and cost effectiveness. Still, efficiency suffers. A paradox? These pages help us going into detail

Behind it all there's an acronym, ORC, Organic Rankine Cycle or, as we say, Rankine cycle with organic fluid. In other words, take the cycle used to produce most of the electric power in the world (the Rankine cycle), leave out water and put in its place an organic fluid (we'll see which one later) evaporating at much lower temperatures than water. We have two advantages here. First, it is possible to make use of heat sources otherwise unusable in a Rankine cycle. Second, everything becomes easy since the traditional cycle couples high temperature with high pressure. Managing them entails a considerable increase in system complexity and the need to use more expensive steels. ORC operates then at lower temperature and pressure, making everything cheaper. The only disadvantage is that by lowering the maximum cycle temperature efficiency decreases dramatically. We shall see that this is not a problem sometimes, because we still have the possibility to make use of an otherwise unusable heat source. Indeed, speaking of recovering heat intended to be dissipated anyway, performance does not impact on pay-back time, the latter being influenced only by the total amount of investment.

The Orc splits in two

Orc have to main scopes, depending on the temperature of the heat source and, above all, on its nature. Above 170 °C and up to 280 °C (sometimes 300 °C) we are using a primary source: these temperatures deliver a definitely interesting efficiency, above 22% and up to 30%, but on the contrary considerably increase plant complexity. There are various heat sources, ranging from high-temperature geothermal to thermodynamic solar, biomass combustion, from wood chips to droppings, from biogas to syngas. The world of heat recovery is different: here delta temperature widens, starting from 180-200 °C or more in the case of flue gas heat recovery from furnaces/gas turbines or exhaust gas of a gas engine, to 90 °C or below when recovering heat from the same engine. The combination with engines to increase performance and overall efficiency is surely among the most interesting applications, because heat is normally dispersed in this case. Such is the case of compression stations in pipelines, both in case of turbogas compressors or engines. The difference in performance is not negligible: in the first case, it's to recover 25-35% of net electric power, in the second up to 7-10%. Another example is combining Orc with motors in landfills or biogas plants. Mounted between the engine and the heat sink, Orc reduces the thermal load on the latter (less costs and consumption) allowing to increase the recovered power, burn less gas by running the engine at a lower rate or maintain the output power even when gas production, in the case of landfills, begins to decrease.

But all that glitters is not gold. Let's start by saying that when the machine is used to make use of heat produced on purpose (for example by biomass combustion), the comparison is simple and it's easy to check the process effectiveness.

Combustion in a boiler

Furthermore, in Orc systems combustion takes place in a boiler and not in the combustion chamber of an internal combustion engine, making life easier when using not very refined gas (think of some biogas or syngas) or solid fuels. The situation is different coming to co-generators. Is it worthwhile? As the word suggests, a co-generator is designed to generate both electricity and thermal energy. And this last one should have its purpose. Otherwise, there's no meaning in cogeneration.

By the way, all those evaluations don't take into account legislative and regulatory constraints. And that's be-

AQYLON

Aqylon manufactures an Orc family ranging from kWe to 5 MWe (10 MWe with double module). All machines are available in standard modules consisting of one or more containers (20 or 40 feet) to facilitate the implementation. Working temperatures are divided into two ranges: above 200 °C (efficiency up to 27%) based on renewable sources (biomass, geothermal, solar thermal) and below 200 up to 85 °C (efficiency up to 14%) for energy recovery of thermal waste. Even with these Orc, to increase the efficiency machines with two separate evaporators, one low and one high temperature, can be used. The fluids are different depending on the size of the machine and the operating conditions, ranging from silicone compounds (hexamethyldisiloxane, a silyl ether), to hydrocarbons (toluene), cyclopentane or refrigerants (R245fa); for each project, a choice of the most suitable fluid in a database of over 15,000 variants is available. The machines feature an axial turbine and up to 12 stages, with an efficiency up to 80% running below 7,000 rpm. Easily partializable, machines can quickly go from 30 to 120% of the rated output ensuring a 95% efficiency of the nominal output up to 30% of rated power.

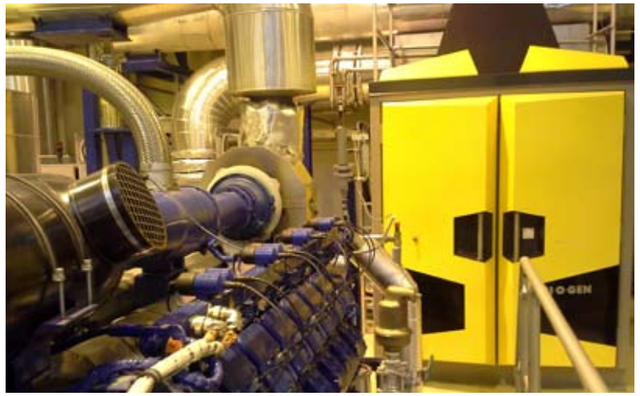
ELECTRATHERM

This excellent family of small Orc is made in Reno, Nevada, and is suitable for biomass plants, to replace torches for hydrocarbons or heat recovery from endothermic engines. There are three sizes available, 4200, from 12 to 35 kW (170,000 dollars for the single machine and 250,000 dollars with dissipation unit), 4400, from 35 to 65 kW (209,000 and 292,000 dollars) and 6500, from 80 to 110 kW (290,000 and 410.000 dollars). All machines may be equipped with a twin screw expander running at 1,800 to 4,900 rpm also suitable for steam/liquid (being the fluid Pentafluoropropane, aka R245fa), gearless and without oil pump. Load can be partialized, as confirmed by the 95% availability recorded on the first 50 machines installed.

TURBODEN

Turboden means to many the Orc par excellence, as Ferodo brake pads or Allen screws. On the other hand figures speak for itself: established in in 1980 by prof. Mario Gaia, Full Professor at Politecnico Milan, the company has now entered Ihi Mitsubishi Group together with Pratt & Whitney Power System (now Pw-Power System), boasting more than 277 operating plants delivering 374.6 MW that will become very soon at least 332 MW, plus 501.7 MWe coming from active contracts. The range goes from 200 kW to 20 MW, with further segments depending on applications. For example, for geothermal wells with steam temperature above 100 °C a 40 MW machine is available. In this power range Orc Turboden modules are standardized for applications at medium and high temperature (> 250 °C), but it's possible to go up to 100 °C for special projects. All solutions provide great reliability (maintenance standard does not exceed 2-3 man-days per year), great starting speed (less than 20 minutes) and high reliability and availability (> 98%), possibility of remote control for remote management without the need for stokers supervision. The machines can also work with strong partialization (up to 10% of rated power). The limited rpm of the turbine, allowing direct connection to the electric generator without gearbox, guarantees high durability (over 20 years). Performances mainly depend on the temperature of heat and cold sources, ranging from 19 to 25 percent (in some cases up to 30 percent), always within 90% of the nominal value up to 50% of the thermal load. The fluid used has a molecular mass lower than water, leading to lower turbine speed, lower work pressure and less wear of metal parts.

cause those machines need to be sustainable in any case, even if their use must of course comply with specific regulations. Let's get back to the original question: is converting further thermal energy into electric energy worthwhile? It may seem absurd, but the answer is "maybe". In fact, in a cogeneration plant each energy source (heat or electric) has its unit sale price. If we think that in this case we speak of a 10% (sometimes, at best) of ORC efficiency, this means that electricity sale price should be ten times higher than that of the thermal energy. Indeed, at least ten times, because we must not forget that there is an investment to be repaid. So in cogeneration plants it is better to assess what should be done case by case.



Limitations to Orc use

Some limitations to Orc use comes from the boundary conditions: the temperature of the heat sink and the cold sink plays a decisive role, so crucial that just a slight change could make it unprofitable.

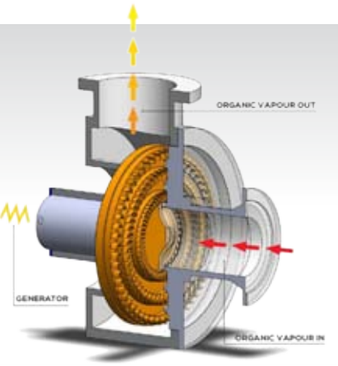
TRIOGEN

He comes from Holland and immediately stands out: he allows direct fumes exchange. Without fluids, exchangers, pumps, valves. Indeed, everything (turbine, generator and main pump) is coupled to the same shaft. Less scrap metal, then, and great attention to layout, especially for retrofit (installations in existing plants) because the fume line may have dimensions difficult to manage. Efficiency is improved (less temperature variations, less entropy, etc.). Just one size, 170 kWe, with 940 kWt input at 350-530 °C and 680 kWt output with outflow at 80 °C and inflow at 55 °C. A radial single stage turbine, running at 18 to 28,000 rpm, toluene fluid. Featuring 40 installations in over 11 countries, over 500,000 operating hours, approved by leading manufacturers of alternative engines.

That's because, due to its low efficiency, this machine is a "heat eater". It has a low-enthalpy, it is true, but we still talk of heat, and all the heat not converted into energy have to be disperded at low temperature (in a cold sink). Carrying all that heat requires a large carrier fluid flow, then big pipes, pumps, heat exchangers, etc.
For example, produce an electric MWh with a 20% efficiency requires the recovering of 5 thermal MWh and the dissipation of 4 thermal MWh. If using rivers or lakes as cold sink it's not possible, a water-air cooler must be used draining a lot of energy (and efficiency). On the other hand, if we install an Orc in series before a heat sink, the electric power generated by the Orc means less heat to be dissipated through a radiator. Several fluids can be used. But we have constraints even here.
What fluids? The choice is made primarily as a function of the temperature of the hot source, that have to be well above the boiling temperature of the chosen fluid. This condition brings sometimes to work with fluids that deserve some care because of their high flammability and noxiousness such as hydrocarbons (toluene) or cyclopentane. No danger when silicone compounds (hexamethyldisiloxane, a silyl-ether) or refrigerant gas (R245fa) may be used.
We already spoke about the non-always-exciting efficiency, let's take a look at another issue, size and weight. A few tons for a 50 kW installation is normal, while 2-3 MW machines are bigger than a truck. That's not impossible to manage, of course, but special attention to spaces and dimensioning of the foundations is mandatory. On the cost side, it's not easy defining a price, even if indicative. Very few manufacturers provide a price list (being one of them ElectraTherm Americans). But it is well known that any price is just a starting base.

EXERGY

At the heart of Exergy Orc (Maccaferri Group) there's a special radial output (Rot, Radial outflow turbines) turbine which central intake and the capability to realize the expansion on the turbine disk up to 7 expansion stages. Featuring a patent unique in the Orc market, the range starts at 100 kW for smaller standard machines up to 50 MW for special machines. The outstanding Rot efficiency allows working with temperatures up to 90 °C with efficiency rates up to 6% better than axial turbines. The crankshaft is very short for lower vibrations, along with a low rotation speed.



ZUCCATO

Zuccato is focused on small power applications (such as biomass plants and recycling facilities) with 16 models (but the range is constantly evolving) covering power rates from 30 to 300 kW (hot water models) and from 75 to 561 kW (overheated water models). Efficiency rate is very different, under 10% for the first range, 7/10% higher for pressurized water range. The machines use an eco-friendly, non-flammable, non-toxic, 100% biodegradable hydrofluorocarbons suitable for a temperature range of 60 to 165 °C. The turbine rotates on ceramic bearings providing greater durability and reliability. In addition to Orc, Zuccato manufactures all inclusive installations. For example, thanks to an agreement with a boiler manufacturer the company offers a key in hand plant for droppings treatment.

Sartorial inspiration

The reason for such secrecy is simple: even if we talk of very tested machines made in (small) series, each installation looks more like a tailor-made suit than a "pret-a-porter" dress, exclusive but still made in dozens. On the other hand, Orc often forces to take into account every single Celsius degree in every circuit, making plant optimization an operation that requires the highest level of specific design thus making price list meaningless. At the end of the day, Pay Back Time rules: you won't mess around with it, believe me.

In this photo, Panasonic, and, on the right side, a Toyota K-Type.

Panasonic gas conditioners

ENDOTHERMIC THAT MAKES AIR

Four cylinders, two liters. A super-classic engine, if it were not for the application. Nissan, along with its 2.5-liter older brother, is replacing electric machines in air conditioning systems. It is available in three versions, one integrating the electric load, for a total of nine models

Solid, efficient, reliable, now they're everywhere. We are talking of split air conditioners, those little boxes - mostly white installed on facades and balconies that made air conditioning a commodity for all, then, thanks to smart tax deductions, made everyone familiar with heat pumps.
They're easy to install, efficient, reliable and robust: just a little electric power, and that's it.
But even if we're used to have electric power everywhere (just flip the switch, and the light turns on or the machine starts) it is not always so simple, and not only in central Africa or in the desert. Just move to an island, in the mountains or in rural areas, and you could find yourself with no electricity available. There may be grid limits; maybe you don't want (or cannot) increase load capacity. Even solar and wind power are of little help, being too subject to weather conditions.

Here, then, a brilliant solution that solves any problem: operating the compressor through a directly coupled engine, with a further advantage: thanks to the heat normally wasted by the internal combustion engine, heat pumps may operate also in once prohibitive weather conditions.

A simple idea

A simple idea, needing however a solid implementation, because an electric motor (a typical "install and forget" application) and an internal combustion engine are two really different devices. Endothermic engine is maybe just as reliable, but you can't entirely forget it.
The first manufacturer which introduced such a solution in Italy was Sanyo, which has now passed the baton to **Panasonic**. At the core of the system there's a **Nissan** gas engine, the D25, although Panasonic carefully conceals this information. On the other hand, who cares about fans or electric motors manufacturers of an air conditioner?
Like its younger brother D21 (which is also used in some markets and models of heat pump), those engines are now a classic. They're used, for example, in Nissan forklift trucks (marketed with Unicarriers American logo, which focused its activities on the area of the Japanese brand since 2015) but also on those of several more or less known Chinese manufacturers. The renowned Nissan reliability, in other words, does not excludes an interesting price/quality ratio.
Both featuring four cylinders and overhead camshaft, the smallest has a 89x83 mm bore and stroke and 2,065 cc displacement. The D25 is more interesting to us: same bore, but an extra long stroke (100 mm) and a displacement almost reaching 2.5 liters (2,488 cc) that allowed to adopt a Miller cycle by working on timing of the valves.
That difference emerges looking at calibrations. The industrial version for trucklift delivers 42 kW at 2,700 rpm and 160 Nm at 2,000 rpm, while the D21 and the D25 stop at 44 kW at 2,400 rpm and 181.4 Nm at 1,600 rpm. Kilowatt further decrease in heat pumps, ranging from 10 kW of the smaller one up to 18.8 of the largest.
Those calibrations allow on the one hand to easily reach 10,000 hours before inspection and 30,000 before replacement, and on the other to easily work at variable speeds in a range from 600-700 rpm to just under 3,000 with minimum noise and vibrations.

Able to follow the load rate

That's because one of the advantages of the internal combustion engine presence is the ability to steadily follow the load rate, providing the very same operation of the most advanced electric motor/inverter machines. Of course both natural gas LPG may be used.
The product range of the Japanese manufacturer includes three basic models for external drives, available in three sizes each, making a total of 9 machines.
The basic ECO G two ways version (therefore capable of cooling or heating, but not simultaneously) delivers 45 kW (referred to as 16 HP), 56 kW (the 20 HP) or 71 kW (the 25 HP) in cooling mode, and respectively 56, 63 or 80 kW in heating mode. There's also a 30 HP version, delivering respectively 85 and 95 kW in cooling or heating mode.
And if those rates are not enough, the machines can be combined in 10 different configurations, achieving a capacity ranging from 90 kW in cooling mode and 100 kW in heating mode (32 HP) up to 142 and 160 kW (50 HP). Just enough for a duplex (16 HP) or a small building (HP50).
Since they're double machines, indoor units (normally 24) are also doubled, becoming 48 and boasting a external power unit/total internal power ratio ranging from 50 to 130 percent (200 percent for double units).

In case of renovation...

No problem, then, in case of renovation work: instead of using direct expansion indoor units, a hydronic module may be used to transfer cooling or heating capacity to the water in the circuit and you're done. In addition to increased available power, using two machines allows the optimization of work cycles; it is also possible to stop a machine for inspection and maintenance while leaving the other one in operation.
So far, so good. Almost just like any ordinary heat pump. Because gas fuel definitely makes the life of electricians easier: an ordinary single-phase 100 W line and 30 A start-up current are enough. But advantages do not stop there.

- For starters, in cooling mode there's 13 to 30 thermal kW available for domestic hot water or post-heating in more advanced systems. Actually, they're also available in heating mode, but only as long the temperature does not drop below 7 °C.

At low temperatures

But the benefits of a gas machine are greater especially at low outdoor temperatures. First of all, the fans already stop at 4 °C. Thanks to the endothermic engine, reusing heat usually dispersed through a high-efficiency heat exchanger allows an almost immediate operation, much faster than a classic heat pump, and a guaranteed full output up to an outdoor temperature of - 20 °C, where classic machines can't go below -10/-15 °C and power losses up to 60 - 70 percent.
The special water-refrigerant

ALL THAT GLITTERS IS NOT GOLD...

The idea is very good and definitely pushes the utilization range of heat pumps where they normally start to fail, ie at low and very low temperatures. And without excessive downturns both in terms of productivity and efficiency, because power stays steady but efficiency is affected by the decrease in the evaporation temperature. It's difficult to ask for more, running at full power at - 15 or even - 20 °C constitutes a real alternative to traditional boilers, while keeping intact the enormous advantage of using ambience heat.
Even the disavantages compared to water-water heat pumps (which draw heat from groundwater or soil) are reduced or disappear, especially when not only peak performance (extreme conditions that only occur a few days per year and often, even in those days, for a few hours), but also average season efficiency is measured. In this condition the air-water pump often even the score or performs better, also providing a much simpler installation.
That's why the classic heat pumps Cop (Coefficient of Performance: the output/input energy ratio) and EER (Energy efficiency ratio, a similar parameter for refrigeration units), which express maximum efficiency under extreme conditions, were sided in Europe by real-life parameters such as Sper (Seasonal primary energy ratio), Scop (Seasonal cop) and Seer (Seasonal eer). Moreover, here we compare a calorific value of a source of energy (gas) or the energy of an energy carrier (electricity: 100 percent pure energy) with low enthalpy energy; ratios are consistent in terms of size (as Joule taught us) but not functionality.
Different manufacturers also often measure these values in different conditions. That is sometimes necessary: the operating condition of an air conditioning system in Brisbane is very different (for both inside and outside conditions) from that of Dubai or Milan. Moreover, construction and design traditions also are changing. That's why a plain comparison between two machines designed for two different markets (assuming that it is precisely the same machine) is likely to be not so significant, needing instead a careful design and a comparison in real operating conditions.
Maintenance is a different playfield: all manufacturers provide warranties and maintenance packages, but a combustion engine and an electric motor are very different in terms of construction and maintenance. 10,000 hours maintenance interval for a heat pump that works 4/5.000 hours per year are not a long period of time.It is also true that an advanced application of an electric heat pump includes the combination with a boiler (which involves further complications and costs), but an internal combustion engine remains a reliable machine (especially in these calibrations) still potentially challenging.
Noise is a less critical issue: compressors and fans make a little noise anyway, and exhaust noise is attenuated by all the air in motion; that's why the two machines are substantially equivalent.
The choice of a gas heat pump must then be driven mainly by exceptional boundary conditions (typically, the absence of an adequate power supply) and must be weighed carefully.
Storing LPG or better yet natural gas in liquid form is a clear advantage, but also a splendid use for exceeding heat.
From an economic point of view the issue is even more complex: besides different cost of investment (but it's better to compare full installations, not only machines) we need to confront with a taxation system that often impairs market rules; once again, an accurate evaluation is a must.
Let then to others CO2 balance comparison, a topic that would take us too far with sometimes surprising results. All catalogs emphasize the advantages of gas heat pumps although many are the same of electric pumps (for example, the Cop or the use of ambience heat), leaving aside a not-so-little detail such as exhaust gases and emissions.

GIVE ME AN ENDOTHERMIC ENGINE AND...

The temptation must have been strong and too good to be true for Yanmar and Aisin. Here then two micro CHP families: remove the compressor, put an alternator in and you're done, plenty of electricity and heat too. Even if that's still a very niche application, here we have then Aisin CP range.
Two sizes, 4.6 and 6 kW electrical power which correspond to almost 12 thermal kW at 65 ° C.
Two operating modes (Electrical Priority mode and Thermal Priority mode) and the electronics needed to work in parallel and protect downstream users and the inverter.
In addition, a house load operation mode is also available (only with Electrical Priority mode).
The main engine is the well know, indestructible three cylinders Toyota 1KS.

With its just under a liter displacement it ensures 10,000 smooth working hours, needing an inspection at 30,000 hours.
Yanmar is no less and offers for residential use (other ranges are for industrial purposes) four machines ranging from 5 to 25 electric kW, equal to a thermal power ranging from about 10 to almost 40 kW. As a trademark of engineers it is possible to feed CHP with biogas.
Another new product is the neoTower® M +, a new combined heat/power system developed in close collaboration with Rmb/Energie relying on the well known 3.3 liter Yanmar 4Gp98-S gas. neoTower® M + is designed for large apartment buildings, office buildings and hotels. The goal is a 96 percent total efficiency. Mission accomplished.

A Yanmar CHP machine, GHP Series.

battery makes defrosting cycles unnecessary, ensuring a steady output at full power thanks to hot water in contact with cooling fluid preventing ice formation.

Talking at thermal energy

In fact, at low temperature operation, we're talking of thermal energy instead of thermal power, since lower performances are due not only to lower thermal power output available (because the condensation temperature drops below the optimum threshold) but also because in traditional machines the external battery (cold) freezes, not delivering thermal output during the defrost cycle (i.e. when the machine temporarily switches to the refrigerating cycle to heat up the external battery thus melting the ice); therefore, even thermal energy further decreases . But surprises do not end here. Panasonic confirms an old Sanyo workhorse offering a version named ECO G High Capacity (available in three basic sizes only) where heat pump becomes a micro CHP, delivering 2 kW available in all operating conditions such as integration to electric consumption.

Three way version

Another really interesting product from the energy and functional point of view is the three ways version, only available for the three basic sizes, which is capable to simultaneously work in refrigeration and heating.
For example, think of an office building in spring and autumn that may have on a clear day heating demand for the facade facing north and cooling demand for the one facing south. A nice functional - but also energetic advantage, because heat is transferred from one side of the building to another, not simply dispersed.

THEY'RE NOT ALONE

Some start from the internal combustion engine (then leaning on air conditioning specialists), some is an air conditioning specialist instead looking for the right engineer. And some wants to manufacture everything in house.
In any case, several Far East manufacturers offer their products even with gas supply because of a different air conditioning culture (direct expansion systems, commonly referred to as split, have spread especially in the Middle and Far East). Yanmar, for example, offers four direct expansion cooling GHP series machines, featuring 45 to 85 kW cooling capacity and 50 to 95 Kw heating capacity, plus another one for water systems featuring respectively 71 and 80 kW. In this case, the heat percentage coming from the endothermic engine is evident. No doubt about the engines (the 3Gph88 for the two smaller models and the 4Gph88 for the larger ones), while Yanmar chose a specialist such as Daikin for internal drives.
Aisin is a league apart. Part of the Toyota Group, this brand is less known than other outside domestic market (many of its products are specifically addressed to it).
Its range is divided into two families: the first is based on a three-cylinder, one liter Toyota 1KS driving a variable capacity scroll compressor and providing 22.4 to 35.5 kW in cooling mode and 25 to 40 kW in heating mode.
The second one features a double compressor and a four-cylinder, two liters engine from 3Y range, providing 45 to 71 kW in cooling mode and 53 to 84 kW in heating mode.
Hydronic kits are available for both families, allowing the use of terminals with water as heat transfer fluid; it is possibile to combine two external drives to expand the range of utilization with Combination Multi for direct expansion Vrf and Aws Twin for water plants.
Maintenance to 10,000 hours and revision to 30,000 are confirmed, as the possibility to drain hot water for sanitary use or of air-conditioning post-heating.
Daikin also has its product range, but it's not distributed in Italy and its small models definitely look like Aisin, while the biggest one looks like a Yanmar: it's hard to tell where refrigeration specialist and engineer stand in a machine that combines two worlds usually very far from each other, once again demonstrating the extraordinary vitality of the internal combustion engine.

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