



ENGIE

Ensuring and validating process stability for qualification of large industrial selective laser melting machines

A Challenge !

ETN Additive Manufacturing Meeting – 28 March 2019
3dprinting.laborelec@engie.com

ENGIE, a global energy and services group

Focus on three core activities

ENGIE TODAY



LOW CO₂ POWER
GENERATION

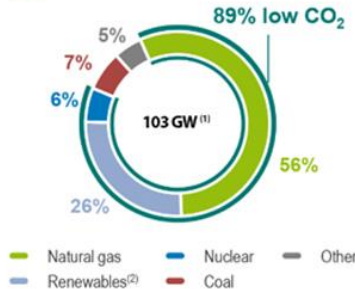
World leader in IPP

103 GW⁽¹⁾ installed

~90% low CO₂

23% renewables⁽²⁾

Capacity breakdown



(1) At 31/12/2017, at 100%
(2) excl. pumped storage for hydro (3%)



GLOBAL
NETWORKS

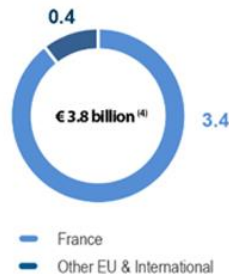
European leader in gas infrastructures

12 bcm storage capacity

Objective green gas in France:
100% by 2050

Expertise in power
transmission & distribution (T&D)

EBITDA gas infrastructures



(3) Incl. Storage in France, regulated as from 01/01/2018
(4) 2017 EBITDA



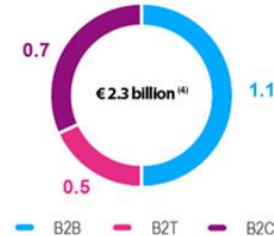
CUSTOMER
SOLUTIONS

24 million customers worldwide

Global leader in energy solutions
for cities

+ 250 District & Heating networks
worldwide

EBITDA by type of business



ENGIE Laborelec

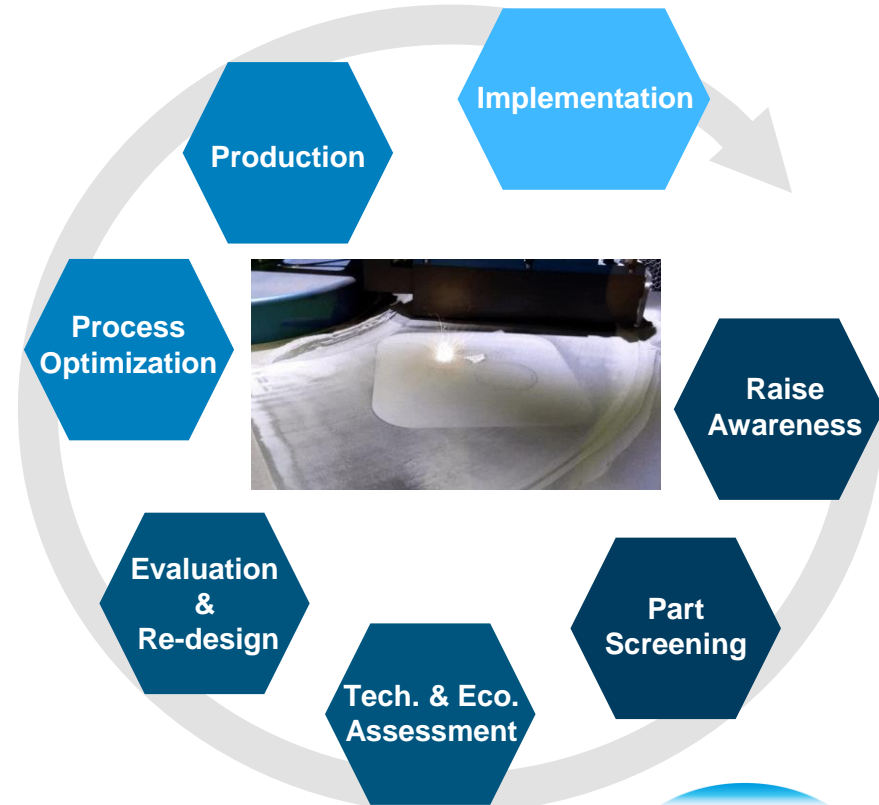
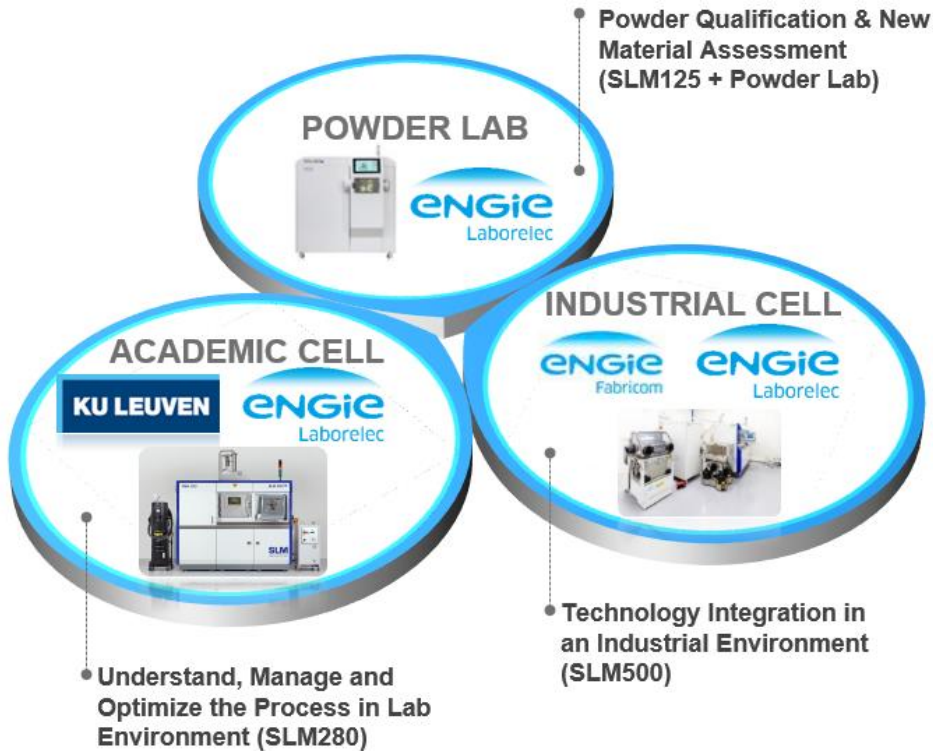
- Laborelec is a leading **expertise** and **research** center in **electrical power technology**.
- Founded in 1962, Laborelec has **over 55 years** experience in the power sector.
- Laborelec is a **cooperative company** with ENGIE and independent grid operators as shareholders.



- Our competencies cover the **entire electricity value chain**: generation, transmission & distribution, RES, storage, for the industry and other end-users.
- We put a strong focus on the **energy transition** and the 3D's : **decentralization**, **decarbonisation** and **digitalisation**.
- We offer specialised **services**, **R&D** and **products** in each of these domains, to companies in **all parts of the world**.

Additive Manufacturing as key enabler for operational excellence

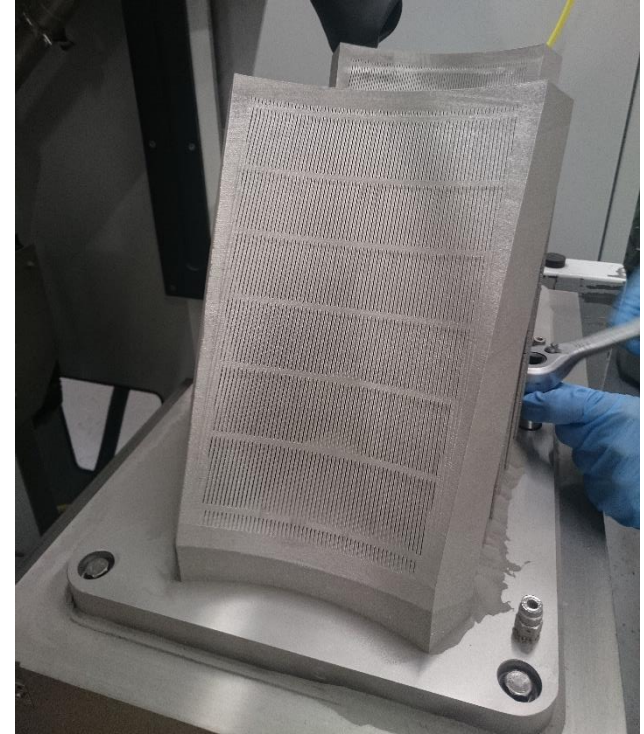
Launch of ENGIE AM Expertise Centre in late 2015



Additive Manufacturing as key enabler for operational excellence



Additive Manufacturing Product Quality



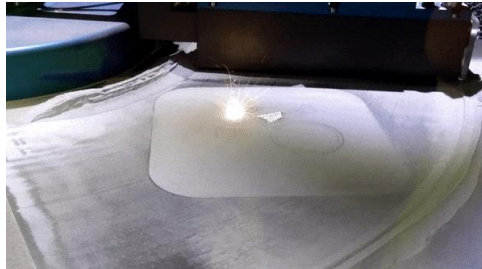


Simple facts

Production of 10mm-cube in IN718 by selective laser melting requires:

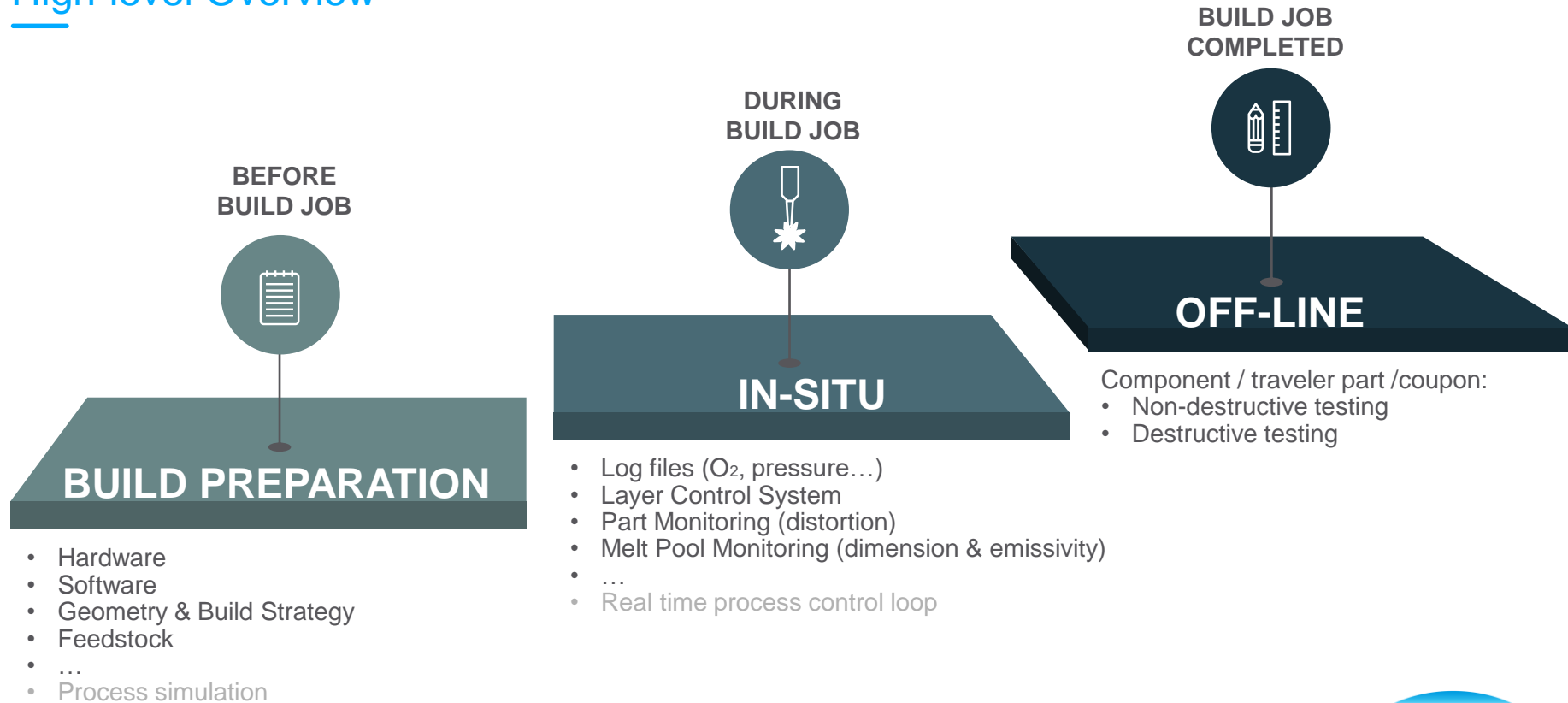
- 200 meters of scanned lines at a layer thickness of $50\mu\text{m}$!
- 333 meters of scanned lines at a layer thickness of $30\mu\text{m}$!

Fast and local welding process with high heating/cooling cycles



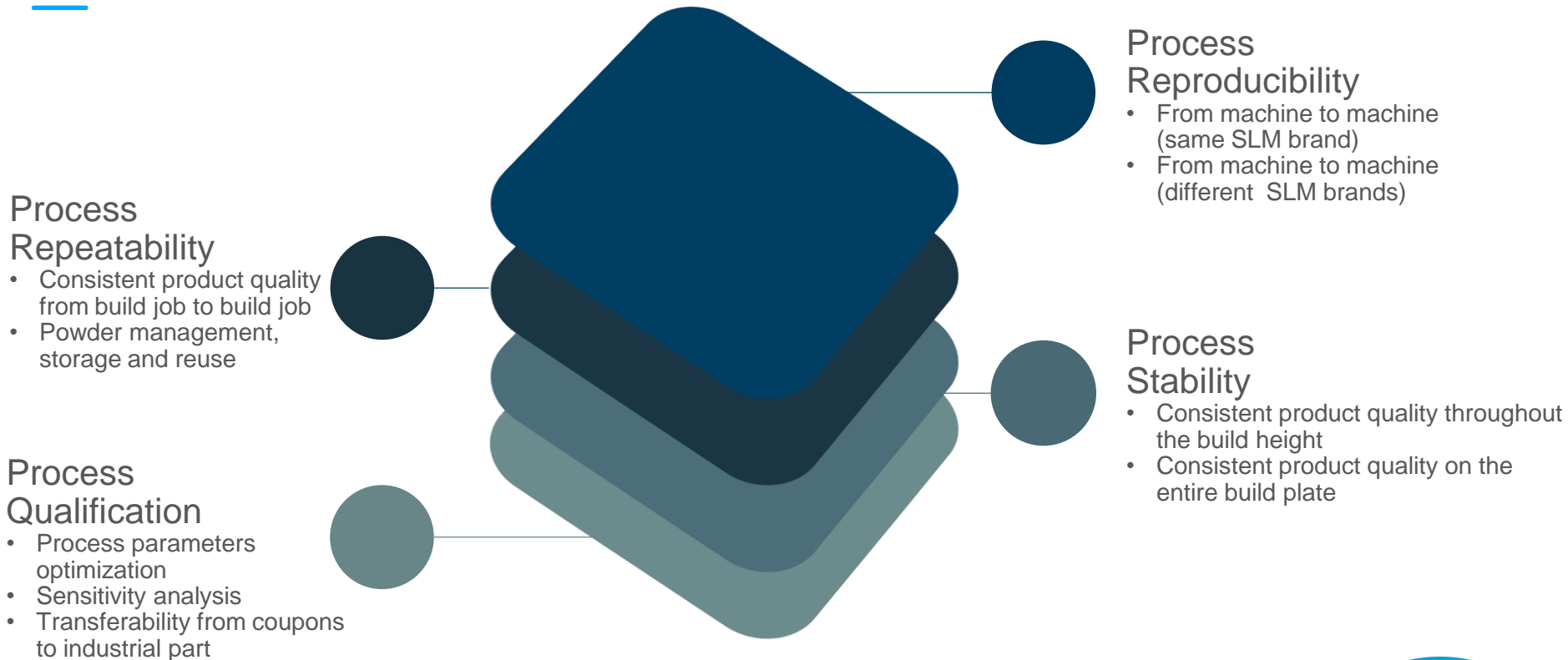
Additive Manufacturing Quality Control

High-level Overview



Additive Manufacturing Product Quality

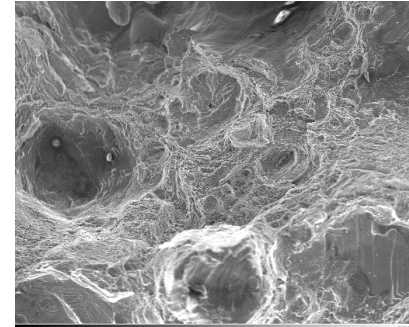
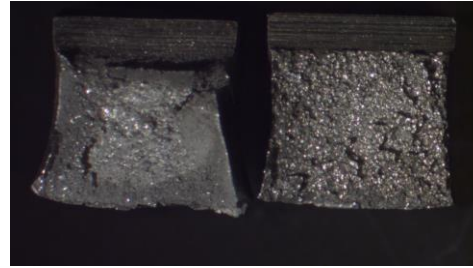
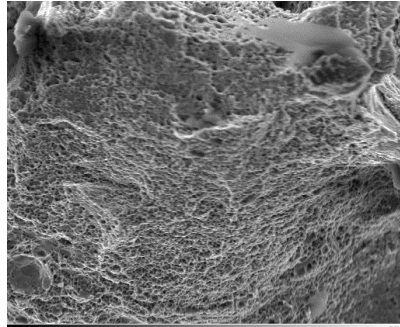
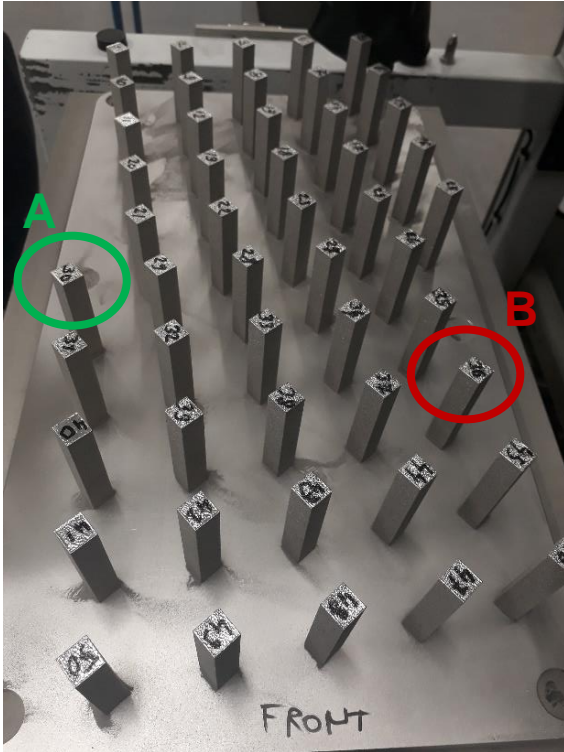
High-Level Overview



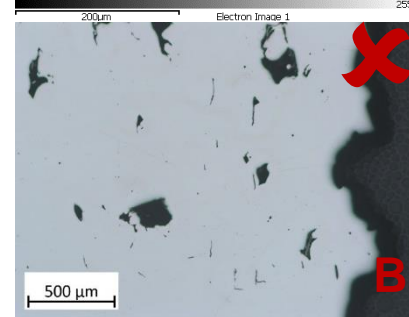
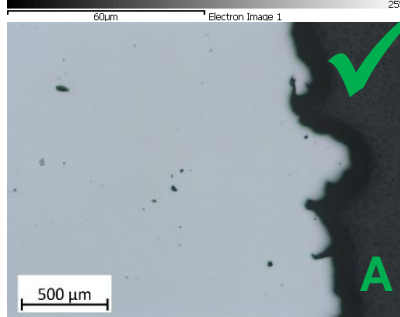
Challenges for production of high-end components

Process stability & reproducibility

Large quality discrepancy for heavy-loaded platform without careful machine fine-tuning, even with optimal laser process parameters



Impact testing
136 J vs. 16 J



Additive Manufacturing Product Quality



Process Qualification

- Material database build up through extensive test program (**creep ! Fatigue !**)



Process Stability

- Consistent product quality on the entire build plate



Process Stability

- Consistent product quality throughout the build height



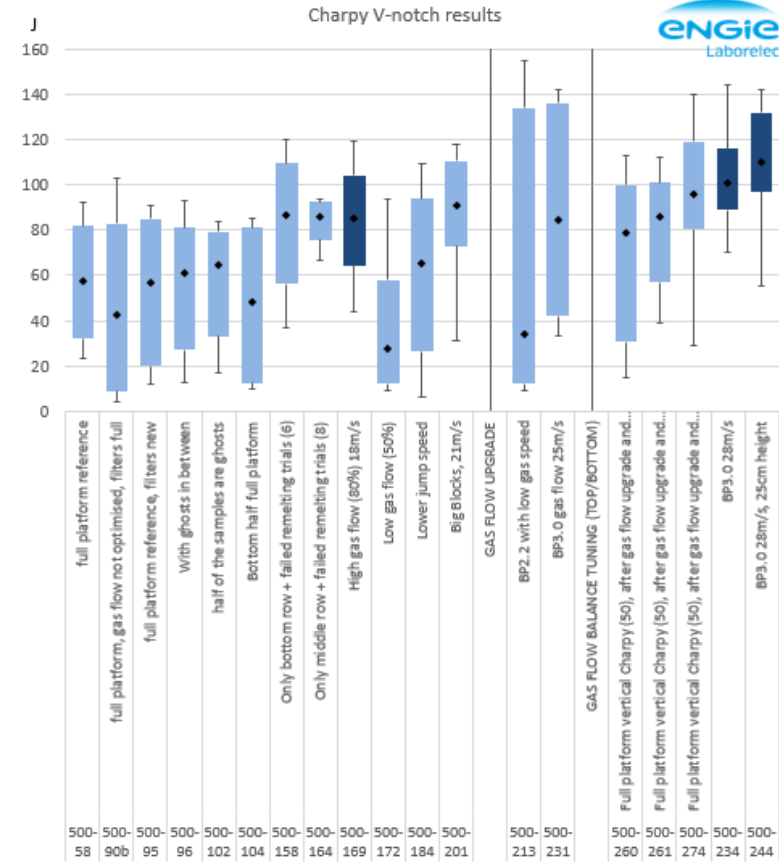
Process Qualification

- Transferability from coupons to industrial part

Our Approach

Applied research as basis for our certification project

- In total, more than 30 jobs have been achieved in this framework:
 - > 850 Charpy test specimens analysed
 - Sensitivity analysis on gas speed, filter quality, build sequence
- Testing campaign also includes tensile testing



Our Approach

Applied research as basis for our certification project

- Same build strategy & laser parameters !
- Charpy V-notch toughness values over the build platform



	87	70	61	66	32
	54	74	49	75	47
	79	76	69	54	61
	73	77	89	47	35
	73	33	52	60	45
76	71	85	78	49	
65	65	92	64	39	
61	82	56	35	42	
58	47	50	25	27	
40	49	33	23	24	

Baseline values

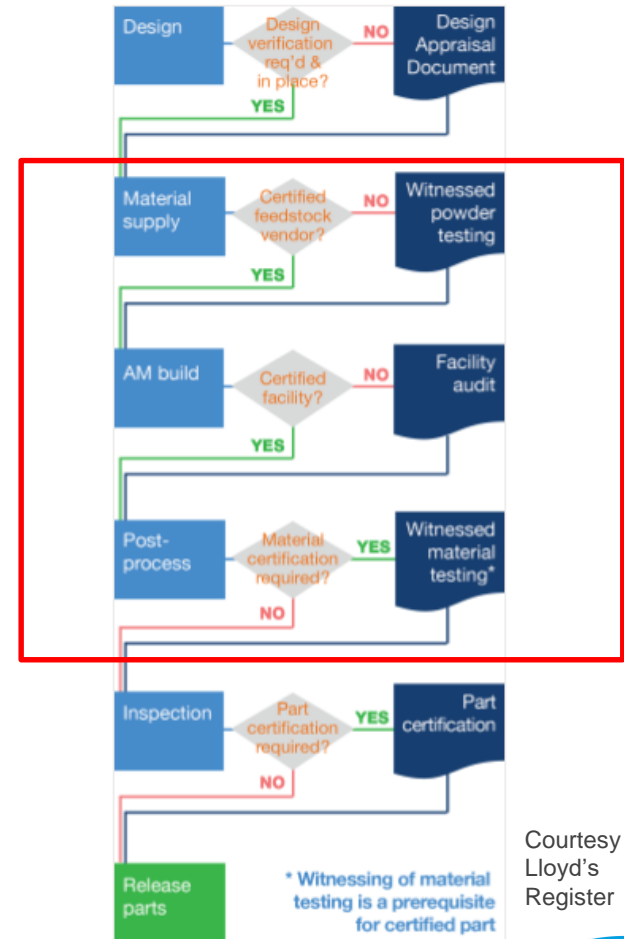
	96	96	89	89	92
	101	95	94	98	106
	98	98	98	104	116
	91	97	94	113	125
	93	97	101	75	83
100	101	99	96	144	
95	99	89	106	133	
111	92	99	102	70	
96	102	103	102	118	
104	101	102	111	112	

Achieved values

ENGIE Certification Project

Main Goal

Achieving ENGIE AM Facility Qualification
& Material Certification



Courtesy of
Lloyd's
Register

Any Questions ?

