Operating gas engines at landfill sites in new LFGTE countries

Drivers – Barriers
Commercial and Technical
Success Factors

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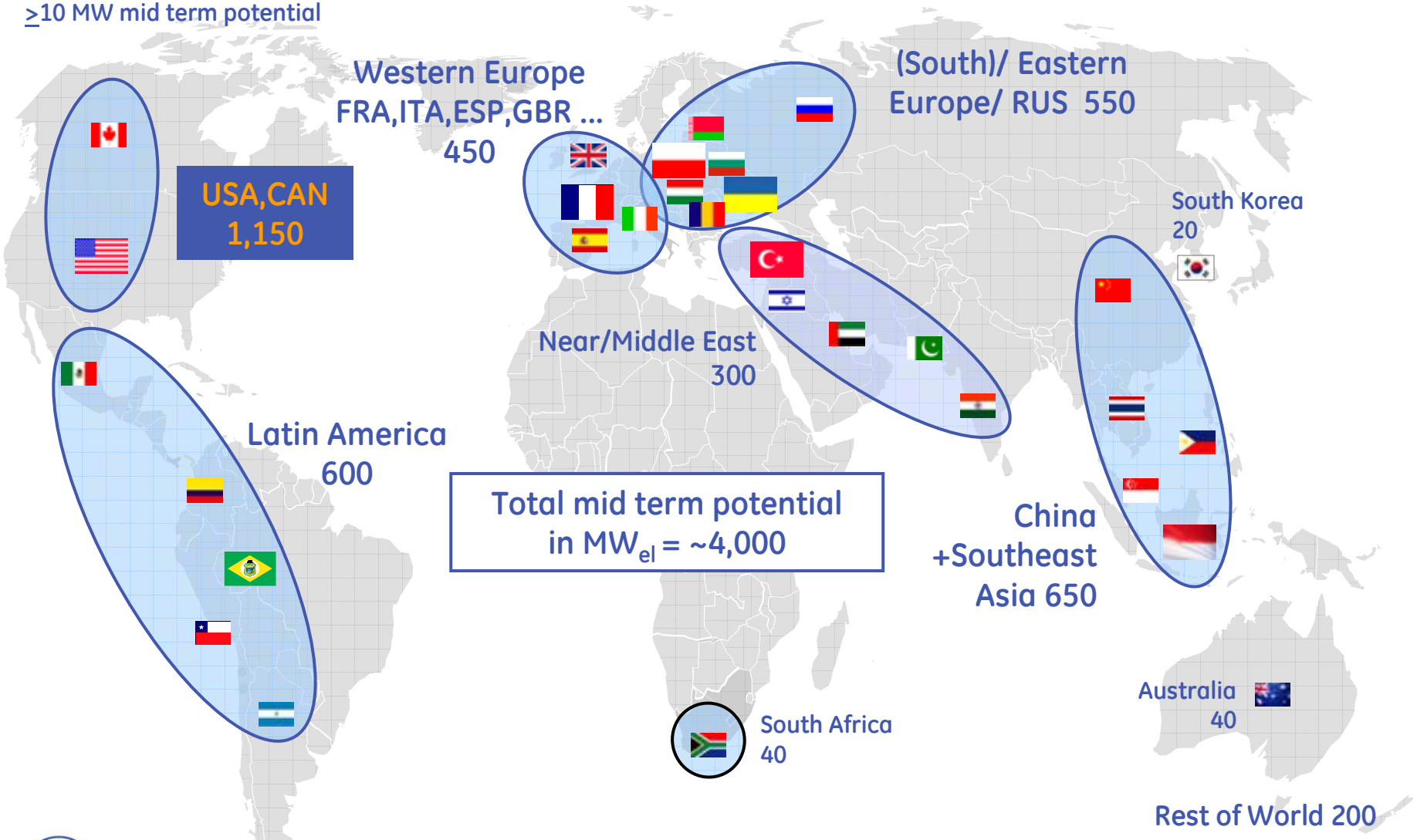
GE imagination at work

LFG to Energy - Future regions

30 countries with
≥10 MW mid term potential



Drivers & Barriers in new countries

Drivers

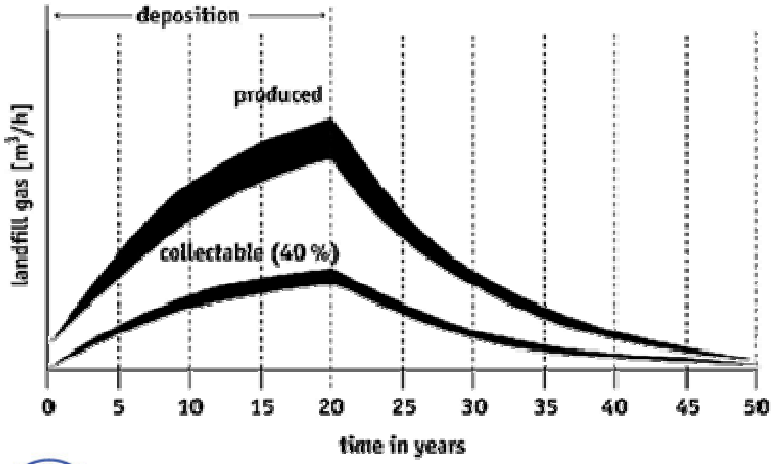
- Some well managed landfills (mostly in the capital/ bigger cities)
- First reference plants
- High share of biodegradables
- Incentives
  - Attractive/ supported feed in tariff
  - Utilities obliged to by renewable energy
- Carbon Trading (CDM, JI a.o.)
- Technology partners and financing schemes available

Barriers

- **Landfill design and management not suitable for LFGTE**
- **Low feed-in tariffs** (in case of coal-based energy supply e.g.)
- Changing political situation, municipalities own gas rights
- No regulations on environmental protection imposed
- Lengthy process of project preparation
  - Gas suction system not optimized
  - CDM, JI Bureaucracy
- Pilot projects relatively risky, practical financing at risk

The amount and composition of the produced gas depends on a variety of factors …

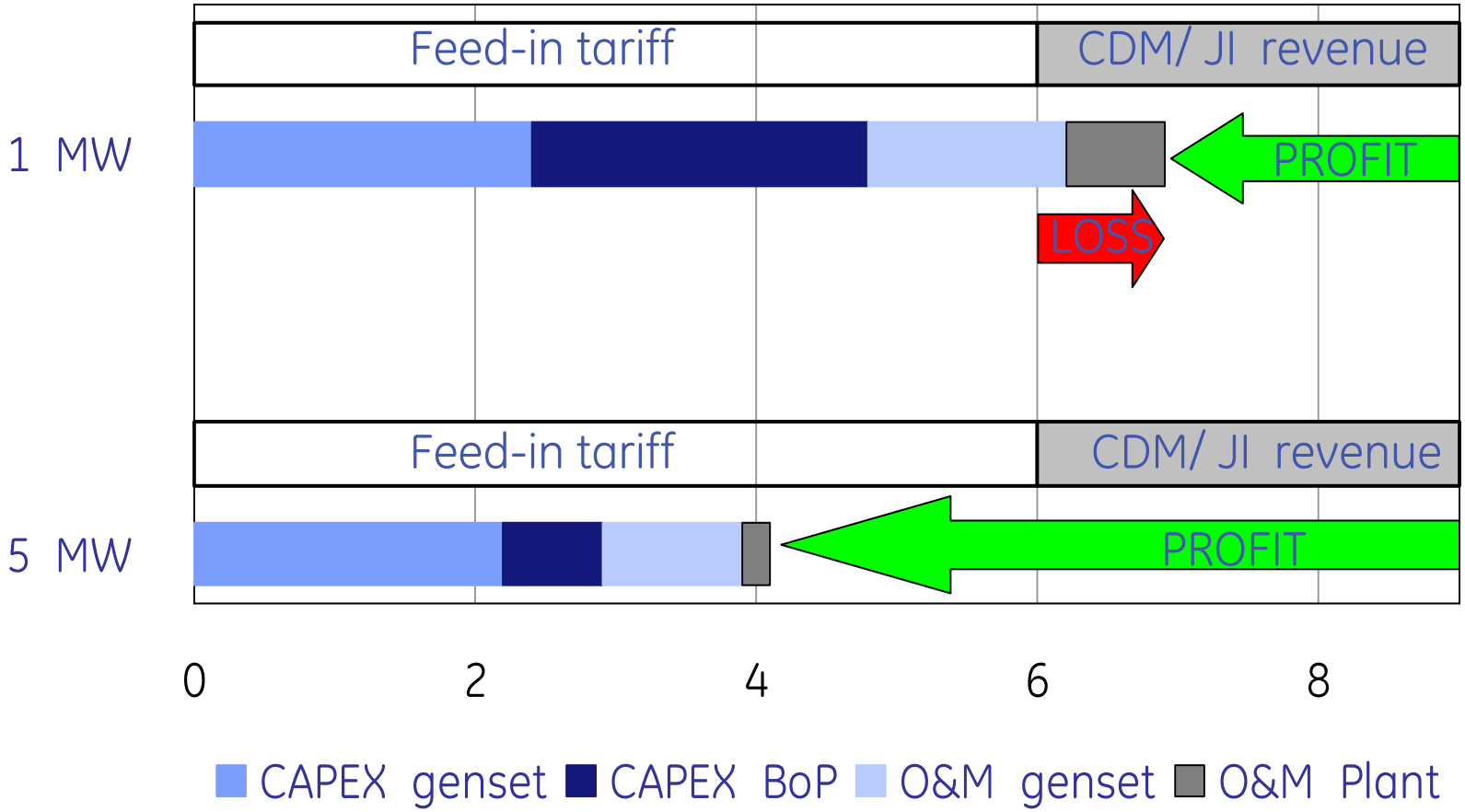
- **Landfill size**
  total size of the landfill
- **Waste composition**
  organic portion in MSW, VOSCs
- **Time**
  opening and closure of landfill



- **Water level**
  amount of leachate in the landfill body
- **Climate**
  temperature, wind, air pressure etc.
- **Emplacement**
  landfill structure, design, compression

Project margin LFGTE:

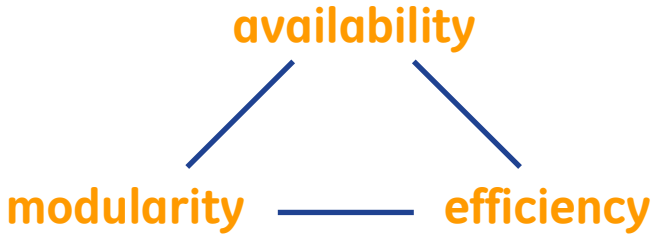
Gas collection & flaring/utilization **NOT** mandatory



*all figures stated in US$ cent per kWh_{el} and calculated for 60,000 operating hours (=7,5 years) of J320

Success factors for profitable LFGTE projects

- Try to reach project size >> 1MWel
- Thorough assessment of landfill condition and gas quality
  (gas curve, VOSCs, other impurities, leachate ...)
- Long-term planning of entire project
- Professional and flexible gas capturing system
- Strive for stable Power Purchase Agreement
- Further revenues from heating (CHP) or other



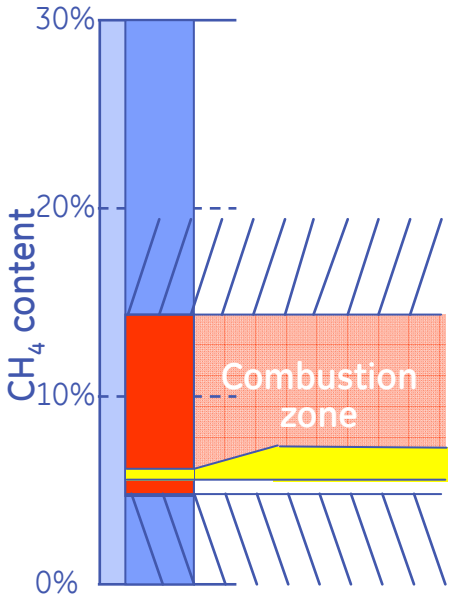
- **Broad range of robust, light-weight containerized engines with high power density**
- **Engine, which can run full load with low LHV and varying gas qualities**
- **Ensure long-term service structure and contracts**

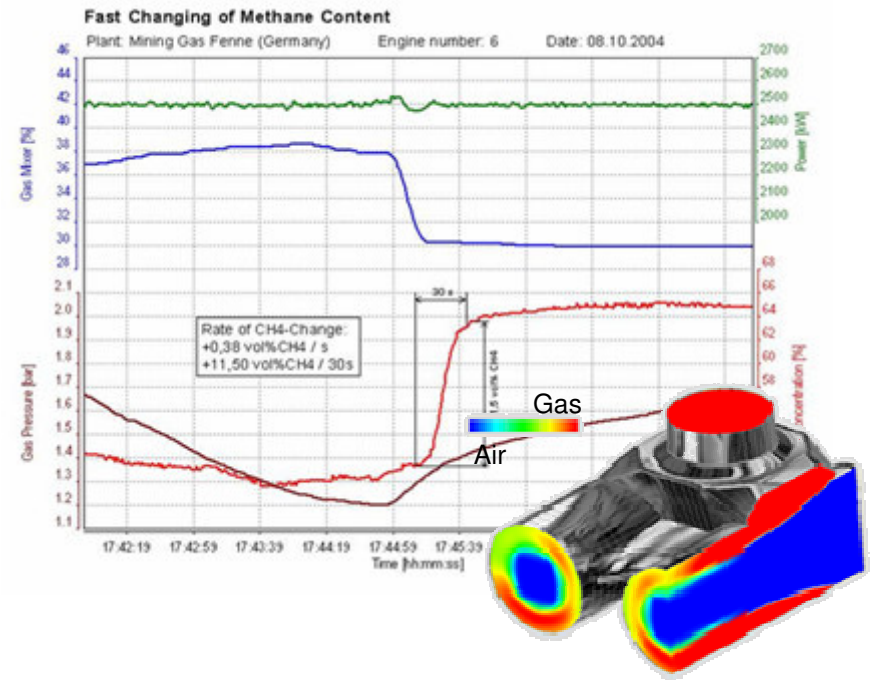
Maximum exploitation of LFG energy value

Combustion limit LHV:

CH_4:CO_2 min. 1:1 ✓

CH_4/N_2 min. 28/72 ✓





- Special ignition system ...
- Spark plugs
- Piston heads
- Combustion chamber geometry

- *LEANOX* control system
- Fast Reaction of Gas Mixer
- Turbo charger bypass system
- Pre-defined operation modes

>> Installed capacity and engines operation always in line with varying gas volume and heating value

Life-cycle management is key

- For project operator LFGTE is not core business
- Maintaining the gas collection system is already a big challenge
- Site conditions and gas quality more challenging than in NG operation

>> Engine and auxiliary equipment needs to be synchronized and managed throughout life-cycle

LFGTE development in Turkey

History

After poor start with dumpsites in Bursa/ Kemerburgaz Istanbul >> very successful reference site at Mamak LF, Ankara

From 2006 – 2010 orders for >50 units with total >70MW capacity: Istanbul LF, Gaziantep, Denizli, Adana, Sincan

planned: Bolu, Kayser, Samsun LF a.o.

Total LFGTE Capacity of Turkey ~150 MW

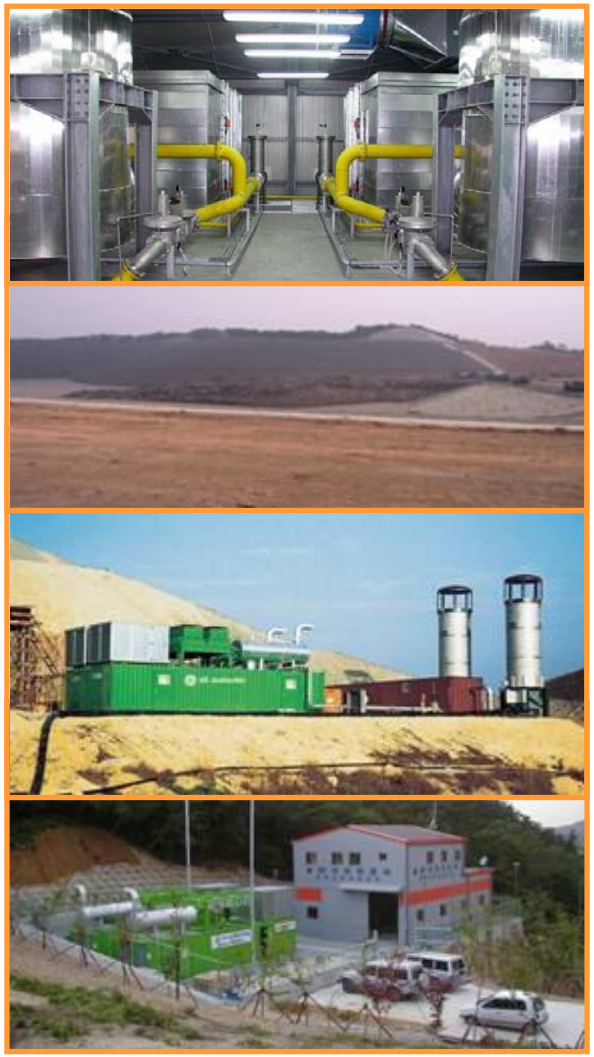
Total population of Turkey ~72.000.000

Success factors

- Some well managed landfills
- LFGTE lead by privatized companies
- Professional feasibility studies and other technical support
- Financially sound investors
- Distributor well trained in LFGTE
- Well connected distributor (municipality general contractor, consultants, financiers)
- Standardized engine type
- Flexible, well LFG proofed engines
- Applied local scope where useful
- High service capacity in Turkey
- Kyoto protocol ratification 2009 (CDM!)

TOPKAPI ENDÜSTRI MALLARI TICARET A.S.

LFGTE business in >30 countries worldwide



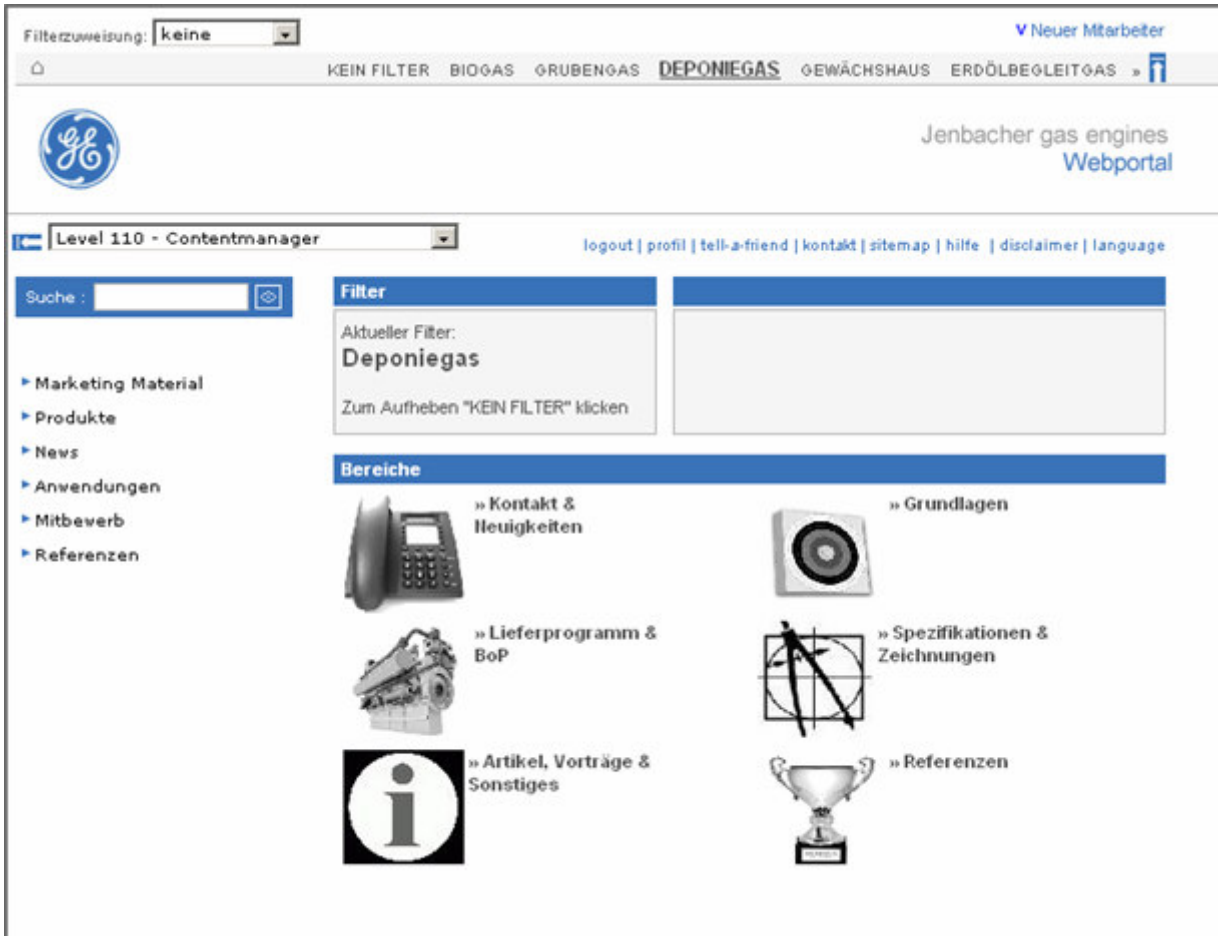
Installed base: total >1,400 units ~1,400 MWel

Project	Delivery	Land	#	Type	P el	P th
CLIBA	2009	ARG	1	JGC 208 GS-L.LN	330	0
Landfill Suhodol	2009	BGR	1	JGS 316 GS-L.L.	834	0
TDF Deponie Trostinets	2010	BLR	1	JGC 320 GS-L.L.	1063	613
SVE Salvador Landfill	2008	BRA	19	JGS 320 GS-L.L-	20.121	0
changsha heimeifeng	2009	CHN	2	JGS 320 GS-L.L-	2.126	0
JEB 0902 LFG 1/2	2009	CHN	1	JGS 320 GS-L.L-	1.063	0
JEB 0902 LFG 2/2	2009	CHN	1	JGS 320 GS-L.L-	1.063	0
JEB LFG 0802	2009	CHN	3	JGS 320 GS-L.L-	3.189	0
JEB LFG 0803	2009	CHN	3	JGS 320 GS-L.L-	3.189	0
Micropower	2009	CHN	1	JMS 320 GS-L.L-	1.063	572
SZ xiaping 400V-1	2009	CHN	1	JGS 320 GS-L.L-	1.063	0
Tallinn Landfill	2009	EST	1	JGS 616 GS-L.L-	1.940	0
Bali Waste	2007	IDN	1	JGS 320 GS-L.L	1.063	0
Talia Landfill	2008	ISR	1	JGC 320 GS-L.L	1.063	617
Getlini 6	2009	LVA	1	JGS 320 GS-L.L-	1.063	613
OUJDA	2009	MAR	1	JGS 320 GS-L.L-	850	0
Benlesa III Unit 1-4	2009	MEX	4	JGC 320 GS-L.LL	4.244	2.472
Chiang Mai Landfill	2009	THA	1	JGS 320 GS-L.L-	1.063	0
SCC-Landfill-BKK-BGP	2009	THA	4	JGS 320 GS-L.L-	4.252	0
SCC-Landfill-BKK-Zenith	2009	THA	5	JGS 320 GS-L.L-	5.315	0
CSD Tunis	2009	TUN	1	JGC 208 GS-L.L-	330	0
CEV - Gaziantep Landfill 1	2009	TUR	1	JGC 416 GS-L.L-	1.131	0
Mamak Landfill 15&16	2009	TUR	2	JGC 420 GS-L.LN	2.830	0
Bisasar Road Landfill 2	2009	ZAF	2	JGC 320 GS-L.L.	2.128	0
Bisasar Road Landfill	2007	ZAF	4	JGC 320 GS-L.L	4.256	0

Recent project Highlights in young LFGTE countries
(not including 2010 orders from UKR, CHI, PHI ...)

Where do you find information?

>> GE Jenbacher intranet - Webportal



https://information.jenbacher.com