Supplementary information

Table S1. Measured average temperatures at different measurement points operating with sand, C28 and ilmenite with methane as fuel.

	Sand					Ilmenite					C28				
MP	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**
8	576	694	584	584	584	591	689	747	789	835	584	584	752	794	839
7	589	719	596	596	596	599	705	745	803	850	596	596	771	809	853
6	599	741	605	605	605	604	722	758	813	856	605	605	781	815	856
5	608	759	611	611	611	608	747	786	835	869	611	611	793	833	870
4	608	756	605	605	605	607	754	802	857	911	605	605	805	857	905
3	608	753	605	605	605	607	758	807	862	906	605	605	803	854	902
2	604	750	604	604	604	603	753	802	857	905	604	604	802	853	901
1	604	750	600	600	600	600	748	797	854	898	600	600	797	849	897
0	473	448	488	488	488	461	569	631	704	515	488	488	495	502	529

Table S2. Measured average concentrations of CH_4 (%, dry) at different measurement points operating with sand, C28 and ilmenite with methane as fuel.

	Sand					Ilmenite					C28				
MP	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**
8	9.14%	0.03%	0.03%	0.03%	0.03%	9.12%	0.03%	0.05%	0.02%	0.03%	9.16%	0.03%	0.03%	0.03%	0.03%
7	9.20%	0.05%	0.04%		0.03%	9.14%	0.06%	0.11%	0.03%	0.03%	9.20%	0.04%	0.03%	0.03%	0.03%
6	9.24%	0.32%	0.08%	0.04%	0.03%	9.16%	0.63%	0.59%	0.05%	0.03%	9.22%	0.04%	0.04%	0.03%	0.04%
5	9.15%	2.69%	0.91%	0.15%	0.04%	9.11%	2.89%	2.07%	0.42%	0.03%	9.16%	0.98%	0.50%	0.09%	0.03%
4	9.11%	6.56%	4.24%	2.44%	0.99%	9.08%	4.68%	2.03%	0.47%	0.06%	9.16%	5.90%	3.76%	1.19%	0.14%
3	9.10%	6.86%	4.71%	3.12%	1.20%	8.92%	3.86%	1.40%	0.36%	0.05%	9.13%	6.35%	3.67%	1.08%	0.14%
2	9.13%	7.36%	5.63%	3.88%	1.42%	9.01%	3.85%	1.08%	0.15%	0.03%	9.15%	7.08%	4.43%	1.04%	0.07%
1	9.21%	8.28%	7.38%	6.07%	0.03%	9.12%	6.78%	0.85%	0.30%	0.05%	9.22%	8.39%	6.84%	3.43%	0.03%
0	9.14%	0.03%	0.03%	0.03%	0.03%	9.12%	0.03%	0.05%	0.02%	0.03%	9.16%	0.03%	0.03%	0.03%	0.03%

The concentration measurement with sand as bed material at MP7 at a bed temperature of 850°C is missing.

Table S3. Measured average concentrations of CO (%, dry) at different measurement points operating with sand, C28 and ilmenite with methane as fuel.

	Sand					Ilmenite					C28				
MP	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**	**600°C**	**750°C**	**800°C**	**850°C**	**900°C**
8	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%	0.08%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
7	0.00%	0.04%	0.02%		0.01%	0.00%	0.09%	0.09%	0.02%	0.01%	0.00%	0.01%	0.01%	0.01%	0.01%
6	0.00%	0.16%	0.04%	0.01%	0.01%	0.00%	0.27%	0.22%	0.05%	0.01%	0.00%	0.03%	0.03%	0.01%	0.01%
5	0.00%	0.23%	0.17%	0.06%	0.01%	0.00%	0.24%	0.34%	0.21%	0.02%	0.00%	0.26%	0.22%	0.07%	0.01%
4	0.00%	0.06%	0.17%	0.27%	0.31%	0.00%	0.19%	0.28%	0.22%	0.14%	0.00%	0.42%	0.93%	1.14%	0.54%
3	0.00%	0.04%	0.15%	0.27%	0.35%	0.00%	0.17%	0.20%	0.16%	0.06%	0.00%	0.45%	1.03%	1.06%	0.44%
2	0.00%	0.04%	0.13%	0.30%	0.44%	0.00%	0.17%	0.17%	0.08%	0.03%	0.00%	0.41%	1.11%	1.25%	0.31%
1	0.00%	0.03%	0.10%	0.28%	0.01%	0.00%	0.15%	0.64%	0.35%	0.21%	0.00%	0.22%	0.77%	1.91%	0.02%

Table S4. Measured gas concentrations of CO (%, dry) at different measurement points for all three bed materials using PSA off-gas as fuel.

	Sand				Ilmenite				C28		
MP	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**
8	0.2%	0.8%	0.5%	0.1%	0.2%	0.3%	0.4%	0.1%	0.5%	0.4%	0.5%
7	0.4%	0.9%	0.6%	0.1%	0.2%	0.4%	0.4%	0.1%	0.5%	0.4%	0.4%
6	1.1%	0.9%	0.5%	0.2%	0.5%	0.4%	0.5%	0.2%	1.2%	0.4%	0.4%
5	2.1%	1.1%	0.6%	0.3%	1.7%	1.1%	0.4%	0.2%	2.2%	0.5%	0.5%
4	2.4%	1.4%	0.7%	0.6%	2.5%	1.9%	1.6%	1.4%	2.6%	1.7%	1.1%
3	2.3%	1.3%	0.7%	0.5%	2.4%	1.9%	1.6%	1.3%	2.3%	1.5%	1.0%
2	2.3%	1.4%	0.7%	0.4%	2.7%	2.2%	1.9%	1.4%	2.1%	1.3%	0.8%
1	3.1%	2.4%	0.1%	0.1%	3.6%	3.3%	3.0%	2.5%	3.3%	2.5%	1.8%

Table S5. Measured gas concentrations of CH_4 (%, dry) at different measurement points for all three bed materials using PSA off-gas as fuel.

	Sand				Ilmenite				C28		
MP	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**
8	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.6%	0.1%	0.1%
7	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%	0.2%	0.2%
6	1.1%	0.2%	0.1%	0.1%	0.5%	0.2%	0.2%	0.1%	1.3%	0.3%	0.2%
5	2.4%	0.5%	0.3%	0.1%	2.0%	0.5%	0.2%	0.1%	2.6%	0.4%	0.2%
4	4.1%	3.4%	2.4%	1.4%	4.1%	3.5%	2.7%	1.4%	4.0%	3.2%	2.4%
3	4.3%	4.0%	3.1%	1.7%	4.4%	4.2%	3.6%	1.6%	4.2%	3.7%	2.8%
2	4.4%	4.6%	4.0%	2.2%	4.5%	4.6%	4.3%	2.0%	4.4%	4.3%	3.5%
1	4.4%	4.6%	0.1%	0.1%	4.4%	4.5%	4.4%	2.9%	4.4%	4.4%	4.1%

Table S6. Measured gas concentrations of CO_2 (%, dry) at different measurement points for all three bed materials using PSA off-gas as fuel.

	Sand				Ilmenite				C28		
MP	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**
8	26.6%	27.4%	26.5%	26.7%	26.8%	26.5%	26.8%	27.0%	24.6%	26.4%	26.7%
7	26.4%	27.5%	26.6%	27.2%	27.1%	26.8%	26.7%	26.9%	25.9%	26.4%	27.0%
6	23.9%	27.2%	26.6%	27.3%	26.0%	26.6%	26.6%	27.1%	23.5%	26.7%	27.0%
5	19.6%	26.1%	25.9%	26.6%	21.1%	26.1%	26.2%	26.7%	19.3%	25.7%	26.3%
4	16.4%	20.3%	22.0%	24.2%	16.6%	18.8%	20.6%	23.3%	16.2%	19.2%	21.9%
3	16.1%	19.1%	20.6%	23.8%	16.1%	17.4%	19.2%	23.1%	16.2%	18.6%	21.3%
2	15.8%	18.0%	19.1%	22.9%	15.4%	16.3%	17.5%	22.4%	16.2%	17.9%	20.3%
1	14.8%	16.5%	27.3%	27.3%	14.1%	14.7%	15.5%	19.0%	14.4%	15.8%	17.4%

Table S7. NO concentration (ppm, dry) at different measurement points with different bed materials and measurement points.

	Sand				**Ilmenite**				C28		
MP	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**	**750°C**	**600°C**	**650°C**	**700°C**
8	34	12	5	6	34	12	6	6	63	9	3
7	33	10	4	6	41	15	8	4	49	10	6
6	30	11	3	3	35	16	10	6	38	11	6
5	18	9	3	4	29	17	11	6	17	11	6
4	2	1	2	5	4	5	5	6	0	2	3
3	0	1	1	6	4	2	5	1	1	1	3
2	0	1	1	1	4	2	2	0	2	2	1
1	1	0	4	7	4	3	2	2	1	0	3