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Potential evaluation of Carnot battery integrating waste heat recovery in industry Olivier Thomé*, Olivier Dumont, Vincent Lemort [Proceedings of ECOS 2023]

or

Techno-economic assessment tool for the pre-study of Carnot battery integrating waste heat recovery in industry Olivier Thomé*, Olivier Dumont, Vincent Lemort [/!\ **Preprint** - Elsevier Journal of Energy Storage, 2024]

Appendix A : Additional mappings

Author: THOMÉ Olivier 💿

For an older version of this document or mappings with other values, don't hesitate to contact the author.

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Ambient temperature: 20°C 1

1.1 Waste heat temparature: 40°C



and (C) with CB based on Carnot cycles



and (D^{*}) with CB based on Carnot cycles



and (D) with CB based on Carnot cycles



Figure 1: Maximum gain for electricity pricing (A) Figure 2: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 3: Maximum gain for electricity pricing (C*) Figure 4: Maximum gain for electricity pricing (C*) and (D^{*}) with CB based on Lorenz cycles



Figure 5: Maximum gain for electricity pricing (B) Figure 6: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

Waste heat temparature: 60°C 1.2



and (C) with CB based on Carnot cycles



and (D^*) with CB based on Carnot cycles



and (D) with CB based on Carnot cycles



Figure 7: Maximum gain for electricity pricing (A) Figure 8: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 9: Maximum gain for electricity pricing (C*) Figure 10: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Lorenz cycles



Figure 11: Maximum gain for electricity pricing (B) Figure 12: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

1.3Waste heat temparature: 80°C



and (C) with CB based on Carnot cycles



Figure 13: Maximum gain for electricity pricing (A) Figure 14: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 15: Maximum gain for electricity pricing Figure 16: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 17: Maximum gain for electricity pricing (B) Figure 18: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

Waste heat temparature: 100°C 1.4



and (C) with CB based on Carnot cycles





Figure 19: Maximum gain for electricity pricing (A) Figure 20: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 21: Maximum gain for electricity pricing Figure 22: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 23: Maximum gain for electricity pricing (B) Figure 24: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

1.5Waste heat temparature: 120°C



and (C) with CB based on Carnot cycles





Figure 25: Maximum gain for electricity pricing (A) Figure 26: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 27: Maximum gain for electricity pricing Figure 28: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 29: Maximum gain for electricity pricing (B) Figure 30: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

1.6Waste heat temparature: 150°C



and (C) with CB based on Carnot cycles





Figure 31: Maximum gain for electricity pricing (A) Figure 32: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 33: Maximum gain for electricity pricing Figure 34: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles

, u=100% , g=50%) Reduct [%] (Twaste =150°C 0 -5 ∑ -10 Cmin/Cmax -15 -20

Figure 35: Maximum gain for electricity pricing (B) Figure 36: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

 E_{gas}/E_{el} [%]

10²

103

101

-25 + 10⁰

1.7Waste heat temparature: 200°C



and (C) with CB based on Carnot cycles





Figure 37: Maximum gain for electricity pricing (A) Figure 38: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 39: Maximum gain for electricity pricing Figure 40: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 41: Maximum gain for electricity pricing (B) Figure 42: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

1.8Waste heat temparature: 250°C



and (C) with CB based on Carnot cycles





Figure 43: Maximum gain for electricity pricing (A) Figure 44: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 45: Maximum gain for electricity pricing Figure 46: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 47: Maximum gain for electricity pricing (B) Figure 48: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

1.9 Waste heat temparature: 300°C



and (C) with CB based on Carnot cycles





Figure 49: Maximum gain for electricity pricing (A) Figure 50: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 51: Maximum gain for electricity pricing Figure 52: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 53: Maximum gain for electricity pricing (B) Figure 54: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.10Waste heat temparature: 350°C

Figure 55: Maximum gain for electricity pricing (A) Figure 56: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





and (C) with CB based on Lorenz cycles



Figure 57: Maximum gain for electricity pricing Figure 58: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 59: Maximum gain for electricity pricing (B) Figure 60: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.11Waste heat temparature: 400°C

Figure 61: Maximum gain for electricity pricing (A) Figure 62: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





and (C) with CB based on Lorenz cycles



Figure 63: Maximum gain for electricity pricing Figure 64: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 65: Maximum gain for electricity pricing (B) Figure 66: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.12Waste heat temparature: 500°C

and (C) with CB based on Carnot cycles





Figure 67: Maximum gain for electricity pricing (A) Figure 68: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 69: Maximum gain for electricity pricing Figure 70: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 71: Maximum gain for electricity pricing (B) Figure 72: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.13Waste heat temparature: 600°C

and (C) with CB based on Carnot cycles





Figure 73: Maximum gain for electricity pricing (A) Figure 74: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 75: Maximum gain for electricity pricing Figure 76: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 77: Maximum gain for electricity pricing (B) Figure 78: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.14Waste heat temparature: 700°C

and (C) with CB based on Carnot cycles





Figure 79: Maximum gain for electricity pricing (A) Figure 80: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 81: Maximum gain for electricity pricing Figure 82: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles

Reduct [%] (T_{waste}=700°C , u=100% , g=50%) 0 -5



Figure 83: Maximum gain for electricity pricing (B) Figure 84: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.15Waste heat temparature: 800°C

and (C) with CB based on Carnot cycles





Figure 85: Maximum gain for electricity pricing (A) Figure 86: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 87: Maximum gain for electricity pricing Figure 88: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles



Figure 89: Maximum gain for electricity pricing (B) Figure 90: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles



1.16Waste heat temparature: 900°C

and (C) with CB based on Carnot cycles





Figure 91: Maximum gain for electricity pricing (A) Figure 92: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 93: Maximum gain for electricity pricing Figure 94: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



and (D) with CB based on Carnot cycles

Reduct [%] (T_{waste} =900°C , u=100% , g=50%) 0 -5 ∑ -10 Cmin/Cmax -15 -20 -25 -10° 101 10² 103

Figure 95: Maximum gain for electricity pricing (B) Figure 96: Maximum gain for electricity pricing (B) and (D) with CB based on Lorenz cycles

 E_{gas}/E_{el} [%]

Ambient temperature: -5°C $\mathbf{2}$

2.1Waste heat temparature: 40°C



Reduct [%] (T_{waste} =40°C , u=100% , g=50%) 100 90 80 //C_{max} [%] 70 60 50 40 30 101 102 100 103 E_{gas}/E_{el} [%]

and (C) with CB based on Carnot cycles

Figure 97: Maximum gain for electricity pricing (A) Figure 98: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 99: Maximum gain for electricity pricing Figure 100: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles





Figure 101: Maximum gain for electricity pricing Figure 102: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



 (C^*) and (D^*) with CB based on Lorenz cycles



2.2Waste heat temparature: 60°C

Figure 103: Maximum gain for electricity pricing Figure 104: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 105: Maximum gain for electricity pricing Figure 106: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 107: Maximum gain for electricity pricing Figure 108: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{2.3}$ Waste heat temparature: 80°C

(A) and (C) with CB based on Carnot cycles



Figure 109: Maximum gain for electricity pricing Figure 110: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 111: Maximum gain for electricity pricing Figure 112: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 113: Maximum gain for electricity pricing Figure 114: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{2.4}$ Waste heat temparature: 100°C

(A) and (C) with CB based on Carnot cycles



Figure 115: Maximum gain for electricity pricing Figure 116: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 117: Maximum gain for electricity pricing Figure 118: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 119: Maximum gain for electricity pricing Figure 120: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

$\mathbf{2.5}$ Waste heat temparature: 120°C



(A) and (C) with CB based on Carnot cycles



Figure 121: Maximum gain for electricity pricing Figure 122: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 123: Maximum gain for electricity pricing Figure 124: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 125: Maximum gain for electricity pricing Figure 126: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{2.6}$ Waste heat temparature: 150°C





(A) and (C) with CB based on Lorenz cycles



Figure 129: Maximum gain for electricity pricing Figure 130: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 131: Maximum gain for electricity pricing Figure 132: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.7Waste heat temparature: 200°C





(A) and (C) with CB based on Lorenz cycles



Figure 135: Maximum gain for electricity pricing Figure 136: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 137: Maximum gain for electricity pricing Figure 138: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{2.8}$ Waste heat temparature: 250°C





(A) and (C) with CB based on Lorenz cycles



Figure 141: Maximum gain for electricity pricing Figure 142: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 143: Maximum gain for electricity pricing Figure 144: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{2.9}$ Waste heat temparature: 300°C





(A) and (C) with CB based on Lorenz cycles



Figure 147: Maximum gain for electricity pricing Figure 148: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 149: Maximum gain for electricity pricing Figure 150: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.10Waste heat temparature: 350°C

(A) and (C) with CB based on Carnot cycles





Figure 151: Maximum gain for electricity pricing Figure 152: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 153: Maximum gain for electricity pricing Figure 154: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 155: Maximum gain for electricity pricing Figure 156: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

Reduct [%] (T_{waste}=350°C , u=100% , g=50%)

102

 E_{gas}/E_{el} [%]

10

101



2.11Waste heat temparature: 400°C

Figure 157: Maximum gain for electricity pricing Figure 158: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles

Cmin/Cmax [%]



(A) and (C) with CB based on Lorenz cycles



Figure 159: Maximum gain for electricity pricing Figure 160: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 161: Maximum gain for electricity pricing Figure 162: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.12Waste heat temparature: 500°C

(A) and (C) with CB based on Carnot cycles





Figure 163: Maximum gain for electricity pricing Figure 164: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



103

Figure 165: Maximum gain for electricity pricing Figure 166: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 167: Maximum gain for electricity pricing Figure 168: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.13Waste heat temparature: 600°C

(A) and (C) with CB based on Carnot cycles





Figure 169: Maximum gain for electricity pricing Figure 170: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 171: Maximum gain for electricity pricing Figure 172: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 173: Maximum gain for electricity pricing Figure 174: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.14Waste heat temparature: 700°C

(A) and (C) with CB based on Carnot cycles





Figure 175: Maximum gain for electricity pricing Figure 176: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 177: Maximum gain for electricity pricing Figure 178: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste} =700°C , u=100% , g=50%) 101 102 103 E_{gas}/E_{el} [%]

Figure 179: Maximum gain for electricity pricing Figure 180: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



2.15Waste heat temparature: 800°C

(A) and (C) with CB based on Carnot cycles





Figure 181: Maximum gain for electricity pricing Figure 182: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 183: Maximum gain for electricity pricing Figure 184: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 185: Maximum gain for electricity pricing Figure 186: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

10²

103



2.16Waste heat temparature: 900°C

(A) and (C) with CB based on Carnot cycles





Figure 187: Maximum gain for electricity pricing Figure 188: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 189: Maximum gain for electricity pricing Figure 190: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 191: Maximum gain for electricity pricing Figure 192: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

Ambient temperature: 15°C 3

3.1Waste heat temparature: 40°C



(A) and (C) with CB based on Carnot cycles



10



Figure 195: Maximum gain for electricity pricing Figure 196: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste}=40°C , u=100% , g=50%) 0 -5 ∑ -10 Cmin/Cmax -15 -20 -25 101 102 100 103 Egas/Eel [%]

Figure 197: Maximum gain for electricity pricing Figure 198: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles

(B) and (D) with CB based on Lorenz cycles



3.2Waste heat temparature: 60°C

Figure 199: Maximum gain for electricity pricing Figure 200: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 201: Maximum gain for electricity pricing Figure 202: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 203: Maximum gain for electricity pricing Figure 204: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.3Waste heat temparature: 80°C

Figure 205: Maximum gain for electricity pricing Figure 206: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 207: Maximum gain for electricity pricing Figure 208: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 209: Maximum gain for electricity pricing Figure 210: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{3.4}$ Waste heat temparature: 100°C





Figure 211: Maximum gain for electricity pricing Figure 212: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 213: Maximum gain for electricity pricing Figure 214: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 215: Maximum gain for electricity pricing Figure 216: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.5Waste heat temparature: 120°C

Figure 217: Maximum gain for electricity pricing Figure 218: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 219: Maximum gain for electricity pricing Figure 220: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 221: Maximum gain for electricity pricing Figure 222: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.6 Waste heat temparature: 150°C





(A) and (C) with CB based on Lorenz cycles



Figure 225: Maximum gain for electricity pricing Figure 226: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 227: Maximum gain for electricity pricing Figure 228: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.7Waste heat temparature: 200°C

Figure 229: Maximum gain for electricity pricing Figure 230: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 231: Maximum gain for electricity pricing Figure 232: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 233: Maximum gain for electricity pricing Figure 234: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



$\mathbf{3.8}$ Waste heat temparature: 250°C







Figure 235: Maximum gain for electricity pricing Figure 236: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 237: Maximum gain for electricity pricing Figure 238: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 239: Maximum gain for electricity pricing Figure 240: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.9 Waste heat temparature: 300°C







(A) and (C) with CB based on Lorenz cycles



10²

10

Figure 243: Maximum gain for electricity pricing Figure 244: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



 E_{gas}/E_{el} [%] Figure 245: Maximum gain for electricity pricing Figure 246: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.10Waste heat temparature: 350°C

Figure 247: Maximum gain for electricity pricing Figure 248: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





(A) and (C) with CB based on Lorenz cycles



Figure 249: Maximum gain for electricity pricing Figure 250: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 251: Maximum gain for electricity pricing Figure 252: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.11Waste heat temparature: 400°C

Figure 253: Maximum gain for electricity pricing Figure 254: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





(A) and (C) with CB based on Lorenz cycles



Figure 255: Maximum gain for electricity pricing Figure 256: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste}=400°C , u=100% , g=50%) 101 10² 10 E_{gas}/E_{el} [%]

Figure 257: Maximum gain for electricity pricing Figure 258: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.12Waste heat temparature: 500°C

Figure 259: Maximum gain for electricity pricing Figure 260: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





(A) and (C) with CB based on Lorenz cycles



Figure 261: Maximum gain for electricity pricing Figure 262: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



101 102 103 E_{gas}/E_{el} [%]

Figure 263: Maximum gain for electricity pricing Figure 264: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.13Waste heat temparature: 600°C

(A) and (C) with CB based on Carnot cycles





Figure 265: Maximum gain for electricity pricing Figure 266: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 267: Maximum gain for electricity pricing Figure 268: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste}=600°C , u=100% , g=50%) 0 -5 ∑ -10 -15 -20 -25 -10⁰ 101 102 103 E_{gas}/E_{el} [%]

Figure 269: Maximum gain for electricity pricing Figure 270: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.14Waste heat temparature: 700°C

(A) and (C) with CB based on Carnot cycles





Figure 271: Maximum gain for electricity pricing Figure 272: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 273: Maximum gain for electricity pricing Figure 274: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste}=700°C , u=100% , g=50%) 0 -5 ∑ -10 -15 -20 -25 -10⁰ 101 102 103 E_{gas}/E_{el} [%]

Figure 275: Maximum gain for electricity pricing Figure 276: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



3.15Waste heat temparature: 800°C

(A) and (C) with CB based on Carnot cycles





Figure 277: Maximum gain for electricity pricing Figure 278: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 279: Maximum gain for electricity pricing Figure 280: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 281: Maximum gain for electricity pricing Figure 282: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles





3.16Waste heat temparature: 900°C

(A) and (C) with CB based on Carnot cycles





Figure 283: Maximum gain for electricity pricing Figure 284: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



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Figure 285: Maximum gain for electricity pricing Figure 286: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 287: Maximum gain for electricity pricing Figure 288: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

Ambient temperature: 35°C 4

4.1Waste heat temparature: 40°C





Figure 289: Maximum gain for electricity pricing Figure 290: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



 (C^*) and (D^*) with CB based on Carnot cycles



Reduct [%] (T_{waste} =40°C , u=100% , g=50%) 100

(A) and (C) with CB based on Lorenz cycles



Figure 291: Maximum gain for electricity pricing Figure 292: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Lorenz cycles



Figure 293: Maximum gain for electricity pricing Figure 294: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles

(B) and (D) with CB based on Lorenz cycles

4.2Waste heat temparature: 60°C



Figure 295: Maximum gain for electricity pricing Figure 296: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 297: Maximum gain for electricity pricing Figure 298: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 299: Maximum gain for electricity pricing Figure 300: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.3 Waste heat temparature: 80°C

Figure 301: Maximum gain for electricity pricing Figure 302: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 303: Maximum gain for electricity pricing Figure 304: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 305: Maximum gain for electricity pricing Figure 306: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



Waste heat temparature: 100°C 4.4

Figure 307: Maximum gain for electricity pricing Figure 308: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 309: Maximum gain for electricity pricing Figure 310: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 311: Maximum gain for electricity pricing Figure 312: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

4.5Waste heat temparature: 120°C



Figure 313: Maximum gain for electricity pricing Figure 314: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 315: Maximum gain for electricity pricing Figure 316: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 317: Maximum gain for electricity pricing Figure 318: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.6 Waste heat temparature: 150°C





(A) and (C) with CB based on Lorenz cycles



Figure 321: Maximum gain for electricity pricing Figure 322: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 323: Maximum gain for electricity pricing Figure 324: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.7Waste heat temparature: 200°C





(A) and (C) with CB based on Lorenz cycles



Figure 327: Maximum gain for electricity pricing Figure 328: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 329: Maximum gain for electricity pricing Figure 330: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



Waste heat temparature: 250°C **4.8**





(A) and (C) with CB based on Lorenz cycles



Figure 333: Maximum gain for electricity pricing Figure 334: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 335: Maximum gain for electricity pricing Figure 336: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.9 Waste heat temparature: 300°C





Figure 337: Maximum gain for electricity pricing Figure 338: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 339: Maximum gain for electricity pricing Figure 340: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 341: Maximum gain for electricity pricing Figure 342: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.10Waste heat temparature: 350°C

Figure 343: Maximum gain for electricity pricing Figure 344: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 345: Maximum gain for electricity pricing Figure 346: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 347: Maximum gain for electricity pricing Figure 348: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.11Waste heat temparature: 400°C

Figure 349: Maximum gain for electricity pricing Figure 350: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles



(A) and (C) with CB based on Lorenz cycles



Figure 351: Maximum gain for electricity pricing Figure 352: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 353: Maximum gain for electricity pricing Figure 354: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.12Waste heat temparature: 500°C



Cmin/Cmax [%]



(A) and (C) with CB based on Lorenz cycles



Figure 357: Maximum gain for electricity pricing Figure 358: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 359: Maximum gain for electricity pricing Figure 360: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles

10

10



4.13Waste heat temparature: 600°C

Figure 361: Maximum gain for electricity pricing Figure 362: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





(A) and (C) with CB based on Lorenz cycles



Figure 363: Maximum gain for electricity pricing Figure 364: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 365: Maximum gain for electricity pricing Figure 366: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles





4.14Waste heat temparature: 700°C

Figure 367: Maximum gain for electricity pricing Figure 368: Maximum gain for electricity pricing (A) and (C) with CB based on Carnot cycles





(A) and (C) with CB based on Lorenz cycles



Figure 369: Maximum gain for electricity pricing Figure 370: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 371: Maximum gain for electricity pricing Figure 372: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.15Waste heat temparature: 800°C

(A) and (C) with CB based on Carnot cycles





Figure 373: Maximum gain for electricity pricing Figure 374: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



Figure 375: Maximum gain for electricity pricing Figure 376: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Reduct [%] (T_{waste} =800°C , u=100% , g=50%) 101 103 10 E_{gas}/E_{el} [%]

Figure 377: Maximum gain for electricity pricing Figure 378: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles



4.16Waste heat temparature: 900°C

(A) and (C) with CB based on Carnot cycles





Figure 379: Maximum gain for electricity pricing Figure 380: Maximum gain for electricity pricing (A) and (C) with CB based on Lorenz cycles



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Figure 381: Maximum gain for electricity pricing Figure 382: Maximum gain for electricity pricing (C^*) and (D^*) with CB based on Carnot cycles (C^*) and (D^*) with CB based on Lorenz cycles



Figure 383: Maximum gain for electricity pricing Figure 384: Maximum gain for electricity pricing (B) and (D) with CB based on Carnot cycles (B) and (D) with CB based on Lorenz cycles