

Electronic Supplementary Material

Appendix A The carbon management score of the Hubei Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------------------------|---|------|------|------|------|------|------|------|------|------|------|
| Carbon Management System (CMS) | Carbon Management Effectiveness and Continuous Improvement | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| Administration (A) | Leadership and Resource Support | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | Policy Alignment and Communication | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | Team Structure and Authority | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 |
| | Risk Mitigation and Opportunity Identification | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Planning and Indicator Management | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| Strategies (S) | Carbon Accounting | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| | Carbon Performance Monitoring and Evaluation | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | Supply-Side Management Mechanisms | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| | Demand-Side Management Mechanisms | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 |
| | Power Transmission and Distribution Management Mechanisms and Updates | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| Implementation (I) | Resources and Capabilities | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Training and Communication | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | Sustainable Energy Procurement Practices | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 |
| | Carbon-Efficient Power Dispatching Practices | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Transmission Line Loss Management | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 |
| | Application and Innovation of Efficient Transmission Technologies | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 |
| | Application and Innovation of Efficient Transmission Equipment | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

| | | | | | | | | | | | |
|------------------|---------------------------------|---|---|---|---|---|---|---|---|---|---|
| | Monitoring System | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| Compliance (C) | Evaluation System | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 |
| | Internal Audit System | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Review System | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| Optimization (O) | Issue Management and Prevention | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |

Appendix B The carbon management score of the Hunan Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------------------------|---|------|------|------|------|------|------|------|------|------|------|
| Carbon Management System (CMS) | Carbon Management Effectiveness and Continuous Improvement | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | Leadership and Resource Support | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 5 |
| Administration (A) | Policy Alignment and Communication | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Team Structure and Authority | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| | Risk Mitigation and Opportunity Identification | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Planning and Indicator Management | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| Strategies (S) | Carbon Accounting | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Carbon Performance Monitoring and Evaluation | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | Supply-Side Management Mechanisms | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Demand-Side Management Mechanisms | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 |
| | Power Transmission and Distribution Management Mechanisms and Updates | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 5 |
| Implementation (I) | Resources and Capabilities | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | Training and Communication | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | |
|------------------|---|---|---|---|---|---|---|---|---|---|---|
| | Sustainable Energy Procurement Practices | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Carbon-Efficient Power Dispatching Practices | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | Transmission Line Loss Management | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 |
| | Application and Innovation of Efficient Transmission Technologies | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 |
| | Application and Innovation of Efficient Transmission Equipment | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| Compliance (C) | Monitoring System | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| | Evaluation System | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | Internal Audit System | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | Review System | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Optimization (O) | Issue Management and Prevention | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |

Appendix C The carbon management score of the Henan Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------------------------|--|------|------|------|------|------|------|------|------|------|------|
| Carbon Management System (CMS) | Carbon Management Effectiveness and Continuous Improvement | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | Leadership and Resource Support | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 4 | 4 |
| Administration (A) | Policy Alignment and Communication | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | Team Structure and Authority | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | Risk Mitigation and Opportunity Identification | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| Strategies (S) | Planning and Indicator Management | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | Carbon Accounting | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 |
| | Carbon Performance Monitoring and Evaluation | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | |
|--------------------|---|---|---|---|---|---|---|---|---|---|---|
| | Supply-Side Management Mechanisms | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | Demand-Side Management Mechanisms | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | Power Transmission and Distribution Management Mechanisms and Updates | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | Resources and Capabilities | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | Training and Communication | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Sustainable Energy Procurement Practices | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 |
| Implementation (I) | Carbon-Efficient Power Dispatching Practices | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Transmission Line Loss Management | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Application and Innovation of Efficient Transmission Technologies | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 |
| | Application and Innovation of Efficient Transmission Equipment | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Monitoring System | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 |
| Compliance (C) | Evaluation System | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | Internal Audit System | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| | Review System | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| Optimization (O) | Issue Management and Prevention | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |

Appendix D The carbon management score of the Jiangxi Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------------------------|--|------|------|------|------|------|------|------|------|------|------|
| Carbon Management System (CMS) | Carbon Management Effectiveness and Continuous Improvement | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| Administration (A) | Leadership and Resource Support | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Policy Alignment and Communication | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |

| | | | | | | | | | | | |
|--------------------|---|---|---|---|---|---|---|---|---|---|---|
| | Team Structure and Authority | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Risk Mitigation and Opportunity Identification | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 |
| | Planning and Indicator Management | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Carbon Accounting | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |
| Strategies (S) | Carbon Performance Monitoring and Evaluation | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Supply-Side Management Mechanisms | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Demand-Side Management Mechanisms | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Power Transmission and Distribution Management Mechanisms and Updates | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Resources and Capabilities | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Training and Communication | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | Sustainable Energy Procurement Practices | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 |
| Implementation (I) | Carbon-Efficient Power Dispatching Practices | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| | Transmission Line Loss Management | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 |
| | Application and Innovation of Efficient Transmission Technologies | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Application and Innovation of Efficient Transmission Equipment | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| | Monitoring System | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | Evaluation System | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| Compliance (C) | Internal Audit System | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Review System | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| Optimization (O) | Issue Management and Prevention | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 |

Appendix E CRE data for the Hubei Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------|---|-------|-------|--------|--------|-------|--------|-------|-------|--------|-------|
| | Renewable Energy Integration (%) | 61.19 | 52.47 | 58.05 | 55.92 | 73.82 | 58.89 | 55.12 | 49.53 | 58.52 | 55.19 |
| Input (IP) | Electricity Supply Growth (%) | 5.86 | 8.25 | 1.85 | 0.98 | 7.66 | 6.10 | 11.24 | 7.73 | -3.24 | 15.57 |
| | Regional Net Inflow Power Ratio (%) | -8.67 | -9.52 | -10.48 | -10.69 | -8.40 | -10.18 | -8.34 | -8.96 | -8.57 | -6.30 |
| Flow (F) | Comprehensive Line Loss (%) | 7.08 | 6.68 | 6.42 | 6.58 | 6.82 | 6.78 | 6.75 | 6.63 | 5.34 | 4.70 |
| | SF6 Recycling Efficiency (%) | 95.20 | 95.50 | 95.70 | 95.70 | 95.80 | 95.80 | 96.00 | 96.10 | 96.10 | 96.30 |
| Output (OP) | Carbon Emission Growth (%) | 4.25 | -2.20 | 4.46 | -3.99 | 7.19 | 0.84 | 7.24 | -0.45 | 0.44 | 11.57 |
| | Carbon Emission Intensity (kgCO ₂ e/kwh) | 0.34 | 0.34 | 0.33 | 0.32 | 0.32 | 0.31 | 0.30 | 0.29 | 0.29 | 0.28 |
| | Infrastructure Investment Growth (%) | 6.45 | 63.95 | -31.12 | 54.34 | 39.12 | -13.49 | 19.88 | -3.81 | -22.89 | 0.35 |
| Economic (E) | Revenue Growth (%) | 5.16 | 5.32 | 2.14 | 0.81 | 7.39 | 8.37 | 14.43 | 7.86 | -3.10 | 16.35 |
| | Waste Management Cost Efficiency (%) | 16.02 | -2.89 | -2.21 | 3.57 | 11.59 | 9.07 | 15.76 | 5.81 | -22.07 | 1.72 |

Appendix F CRE data for the Hunan Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------|---|--------|-------|-------|-------|-------|--------|-------|-------|-------|-------|
| Input (IP) | Renewable Energy Integration (%) | 34.92 | 28.97 | 35.11 | 37.75 | 39.96 | 36.72 | 31.69 | 36.85 | 40.91 | 41.47 |
| | Electricity Supply Growth (%) | 2.89 | 6.79 | -0.17 | 2.06 | 8.24 | 11.15 | 13.15 | 7.80 | 3.94 | 12.90 |
| | Regional Net Inflow Power Ratio (%) | 15.20 | 14.71 | 11.83 | 13.06 | 9.92 | 12.04 | 7.74 | 5.28 | 8.38 | 6.95 |
| Flow (F) | Comprehensive Line Loss (%) | 7.44 | 9.42 | 8.95 | 8.32 | 8.53 | 8.29 | 7.98 | 7.96 | 7.76 | 7.71 |
| | SF6 Recycling Efficiency (%) | 95.20 | 95.50 | 95.70 | 95.70 | 95.80 | 95.80 | 96.00 | 96.10 | 96.10 | 96.30 |
| Output (OP) | Carbon Emission Growth (%) | -2.26 | 7.57 | -9.28 | -4.09 | 0.20 | 3.48 | 2.87 | 3.55 | 3.20 | 20.48 |
| | Carbon Emission Intensity (kgCO ₂ e/kwh) | 0.50 | 0.48 | 0.46 | 0.44 | 0.43 | 0.43 | 0.43 | 0.43 | 0.42 | 0.42 |
| | Infrastructure Investment Growth (%) | -18.88 | 7.20 | -9.40 | 33.15 | 74.63 | -13.58 | 2.33 | 28.33 | 20.69 | -1.79 |
| Economic (E) | Revenue Growth (%) | 8.60 | 11.76 | 0.08 | 3.49 | 7.37 | 3.48 | 11.61 | 5.85 | -0.13 | 17.70 |
| | Waste Management Cost Efficiency (%) | 11.01 | 37.98 | -6.03 | -8.62 | 6.87 | 2.27 | 11.30 | 8.98 | -4.61 | 17.99 |

Appendix G CRE data for the Henan Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------|---|-------|-------|-------|-------|-------|--------|--------|--------|-------|-------|
| Input (IP) | Renewable Energy Integration (%) | 4.94 | 4.16 | 3.84 | 4.59 | 4.45 | 6.14 | 8.57 | 10.60 | 12.38 | 19.80 |
| | Electricity Supply Growth (%) | 2.31 | 5.63 | 3.46 | -3.83 | 1.85 | 7.52 | 8.16 | 4.56 | 0.26 | 9.58 |
| | Regional Net Inflow Power Ratio (%) | 3.63 | 3.17 | 4.74 | 7.00 | 7.91 | 7.96 | 9.04 | 14.86 | 14.21 | 16.69 |
| Flow (F) | Comprehensive Line Loss (%) | 5.15 | 5.15 | 6.06 | 7.87 | 7.97 | 7.93 | 7.84 | 7.55 | 7.45 | 7.05 |
| | SF6 Recycling Efficiency (%) | 95.20 | 95.50 | 95.70 | 95.70 | 95.80 | 95.80 | 96.00 | 96.10 | 96.10 | 96.30 |
| Output (OP) | Carbon Emission Growth (%) | 0.63 | 7.69 | -3.40 | -2.31 | 2.32 | 3.93 | 10.22 | -0.31 | -2.62 | 9.34 |
| | Carbon Emission Intensity (kgCO ₂ e/kwh) | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.80 | 0.80 | 0.79 |
| | Infrastructure Investment Growth (%) | -0.22 | -5.23 | 29.20 | 32.62 | 39.66 | -15.37 | -10.41 | -20.42 | 9.85 | -4.17 |
| Economic (E) | Revenue Growth (%) | 2.34 | 5.63 | -4.69 | -5.56 | -2.77 | 7.56 | 6.39 | 10.11 | -6.82 | 10.05 |
| | Waste Management Cost Efficiency (%) | 1.71 | 5.55 | 12.42 | 25.14 | -4.35 | 6.98 | 3.78 | 9.29 | -1.07 | 3.70 |

Appendix H CRE data for the Jiangxi Power Grid from 2012 to 2021

| Dimension | Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------|---|-------|--------|-------|-------|-------|--------|-------|-------|--------|--------|
| Input (IP) | Renewable Energy Integration (%) | 11.54 | 8.47 | 9.62 | 11.75 | 15.04 | 13.52 | 12.04 | 14.31 | 14.51 | 19.65 |
| | Electricity Supply Growth (%) | 3.33 | 8.66 | 4.87 | 3.89 | 10.15 | 9.88 | 11.33 | 7.87 | 4.16 | 14.50 |
| | Regional Net Inflow Power Ratio (%) | 13.66 | 6.55 | 10.80 | 8.95 | 6.23 | 7.91 | 7.90 | 10.50 | 9.11 | 0.60 |
| Flow (F) | Comprehensive Line Loss (%) | 7.06 | 7.36 | 7.22 | 6.99 | 6.95 | 6.92 | 6.91 | 6.37 | 4.20 | 4.15 |
| | SF6 Recycling Efficiency (%) | 95.20 | 95.50 | 95.70 | 95.70 | 95.80 | 95.80 | 96.00 | 96.10 | 96.10 | 96.30 |
| Output (OP) | Carbon Emission Growth (%) | -6.80 | -8.87 | -3.73 | -1.23 | 4.77 | 11.63 | 10.89 | 8.76 | 2.60 | 4.70 |
| | Carbon Emission Intensity (kgCO ₂ e/kwh) | 0.58 | 0.52 | 0.46 | 0.44 | 0.43 | 0.43 | 0.43 | 0.42 | 0.42 | 0.42 |
| Economic (E) | Infrastructure Investment Growth (%) | 2.51 | -11.74 | 40.58 | 13.79 | 6.06 | -15.92 | -9.61 | 36.52 | 54.68 | -15.11 |
| | Revenue Growth (%) | 6.24 | 11.78 | 3.96 | 1.22 | 4.98 | 7.34 | 10.58 | 6.15 | 2.62 | 19.62 |
| | Waste Management Cost Efficiency (%) | 2.60 | 14.51 | -0.33 | -4.02 | 0.20 | 14.62 | 12.77 | -2.44 | -31.70 | 18.45 |