Explanation of equations and Parameters of Bioenergy-effect-policy System Dynamics model that make the biomass power generation project economically feasible.

1.distance from temporary storage station to biomass power plant=18 （unit：km）

2. SO2 emission factor of diesel heavy-duty vehicles=3e-007 （unit：ton/km）

3. SO2 emission factor of diesel light-duty vehicles= 1e-007 （unit：ton/km）

4. SO2 emission factor of traditional power= 0.0151579 （unit：ton/MWh）

5. CO emission factor of biomass power generation= 0.0080332 (ton/MWh)

6. NOx emission factor of biomass power generation= 0.0008626 (ton/MWh)

7. SO2 emission factor of biomass power generation= 0.0000228 (ton/ MWh)

8. NOx emission factor of traditional power=0.0038332 （unit：ton/MWh）

9. emission reduction of CO= equivalent traditional power*(CO emission factor of traditional power-CO emission factor of biomass power generation) （unit：ton）

10. CO emission factor of traditional power= 0.0001937（unit：ton/MWh）

11. difference between fiscal subsidy and positive externalities=positive externalities-fiscal subsidy（unit：thousand US dollars）

12. accumulated difference between fiscal subsidy and positive externalities= INTEG(difference between fiscal subsidy and positive externalities,0) （unit: thousand US dollars）

13. CO2 emission factor of diesel light-duty vehicles=0.000356 （unit：ton/km）

14. distance from household to temporary storage station=13 （unit：km）

15. CO2 emission factor of diesel heavy-duty vehicles=0.000932 （unit：ton/km）

16. CO2 emission of transportation= total volume of biomass transportation/average load of light-duty vehicles per trip*distance from household to temporary storage station*tortuous factor of rural road*CO2 emission factor of diesel light-duty vehicles + total volume of biomass transportation/average load of heavy-duty vehicles per trip*distance from temporary storage station to biomass power plant*CO2 emission factor of diesel heavy-duty vehicles （unit：ton）

17. CO2 emission factor of traditional power= 1.09417 （unit：ton/MWh）

18. emission reduction of CO2=equivalent traditional power*CO2 emission factor of traditional power-CO2 emission of transportation-equivalent traditional power*life cycle GHG emission intensity of biomass power （unit：ton）

19. average load of heavy duty vehicles per trip=12 （unit：ton）

20. tortuous factor of rural road=1.414

21. average load of light-duty vehicles per trip=3.5 （ton）

22. life cycle GHG emission intensity of biomass power=0.045 （unit：ton/MWh）

23. benefit of CDM=emission reduction of CO2*price of CO2 （unit：thousand US dollars）

24. SO2 emission of transportation= total volume of biomass transportation/average load of light-duty vehicles per trip*distance from household to temporary storage station*tortuous factor of rural road*SO2 emission factor of diesel light-duty vehicles+total volume of biomass transportation/average load of heavy-duty vehicles per trip*distance from temporary storage station to biomass power plant*SO2 emission factor of diesel heavy-duty vehicles （unit：ton）

25. total volume of biomass transportation=consumption of apple branches+consumption of other biomass

26. price of CO= 0.34572 （unit: thousand US dollars/ton）

27. price of SO2= 2.2126 （unit: thousand US dollars/ton）

28. price of NOx= 2.76574 （unit: thousand US dollars/ton）
29. price of CO2= 0.01521 （unit: thousand US dollars/ton）
30. social benefits = benefits of employment increase + increased income from biomass sales （unit: thousand US dollars）
31. positive externalities = positive environmental externalities + social benefits （unit: thousand US dollars）
32. positive environmental externalities = benefit of CDM + environmental value of CO emission reduction+ environmental value of NOx emission reduction + environmental value of SO2 emission reduction （unit: thousand US dollars）
33. retrieve of circulating fund = IF THEN ELSE(Time=2039, 4231, 0 ) （unit: thousand US dollars）
34. environmental value of CO emission reduction=emission reduction of CO*price of CO （unit: thousand US dollars）
35. environmental value of NOx emission reduction =emission reduction of NOx*price of NOx （unit: thousand US dollars）
36. environmental value of SO2 emission reduction=emission reduction of SO2*price of SO2 （unit: thousand US dollars）
37. emission reduction of SO2 = equivalent traditional power*(SO2 emission factor of traditional power-SO2 emission factor of biomass power generation) （unit: ton）
38. emission reduction of NOx = equivalent traditional power*(NOx emission factor of tradional power-NOx emission factor of biomass power generation) （unit: ton）
39. equivalent traditional power = biomass power generation （unit: MWh）
40. available sales rate of apple branches = INTEG(increment of sales rate,0.5)
41. increment of sales rate = IF THEN ELSE(available sales rate of apple branches<=0.7,0.02 , 0)
42. production rate of other biomass ash = 0.0514 （unit: ton/ton）
43. production rate of apple branches ash = 0.0247 （unit: ton/ton）
44. production of ash = consumption of apple branches*production rate of apple branches ash + consumption of other biomass*production rate of other biomass ash （unit: ton）
45. consumption of apple branches = IF THEN ELSE(available sales rate of apple branches*total output of apple branches>=demand of apple branches ,demand of apple branches, available sales rate of apple branches*total output of apple branches ) （unit: ton）
46. benefit of biomass ash = price of ash*production of ash （unit: thousand US dollars）
47. price of ash = 39.29（unit: US dollars/ton）
48. demand of apple branches = biomass power generation*3.6*10000/lower heat value of apple branches/generating efficiency/1000 （unit: ton）
49. total output of apple branches = yield of apple branches per unit area*apple cultivated area*10000 （unit: ton）
50. yield of apple branches per unit area = (([(2018,300)-(2040,700)],(2018,375),(2020,450),(2025,480),(2030,525),(2035,600),(2040,660) )) （unit: ton/$km^2$）
51. apple cultivated area = 707 （unit: $km^2$）
52. agricultural population = IF THEN ELSE(Time=2018,387802 ,-2.41667e+007*EXP(-0.0184247*(Time-2010))-(-2.41667e+007*EXP(-0.0184247*(DELAY1(Time, 1)-2010)))) （unit: person）
53. total population = IF THEN ELSE(Time=2018,487821,-3.65806e+009*EXP(-0.000133*(Time-2010))+3.65854e+009-(-3.65806e+009*EXP(-0.000133*(DELAY1(Time,1)-2010))+3.65854e+009)) （unit: person）

54. urbanization rate = (total population-agricultural population)/total population
55. increment of rural per capita net income = fuel cost*1000/agricultural population（unit: US dollars/person）
56. fuel cost = price of apple branches*consumption of apple branches/1000+consumption of other biomass*price of other biomass/1000 （unit: thousand US dollars）
57. consumption of other biomass = IF THEN ELSE(consumption of apple branches<demand of apple branches, (demand of apple branches-consumption of apple branches ) *lower heat value of apple branches/lower heat value of other biomass, 0 ) （unit: ton）
58. demand of apple branches = biomass power generation*3.6*1000/lower heat value of apple branches/generating efficiency/1000（unit: ton）
59. lower heat value of apple branches = 16.34 （unit: MJ/kg）
60. generating efficiency = 0.175
61. biomass power generation = IF THEN ELSE(Time=2018, 0 , 210000 )（unit: MWh）
62. price of apple branches =45 （unit: US dollars/ton）
63. lower heat value of other biomass = 15.33 （unit: MJ/kg）
64. price of other biomass = 45 （unit: US dollars/ton）
65. increased income from biomass sales = fuel cost-electricity expense/1000（unit: thousand US dollars）
66. rural energy consumption from biomass = (consumption of apple branches*1000*lower heat value of apple branches+consumption of other biomass*1000*lower heat value of other biomass)*combustion efficiency/3.6 （unit: kWh）
67. combustion efficiency = 0.1
68. electricity expense = rural energy consumption from biomass*rural electricity price （unit: US dollars）
69. rural electricity price = 0.0771 （unit: US dollars/KWh）
70. value-added tax payable = INTEG(output tax-input tax,0) （unit: thousand US dollars）
71. urban construction tax = (output tax-input tax)*tax rate of urban construction （unit: thousand US dollars）
72. tax rate of urban construction = 0.05
73. business tax and surcharges = education surcharges+urban construction tax （unit: thousand US dollars）
74. input tax = (fuel cost+material expenses+purchased water)*VAT Rate （unit: thousand US dollars）
75. output tax = business income*VAT Rate （unit: thousand US dollars）
76. VAT Rate = 0.17
77. value-added tax exempted = output tax-input tax （unit: thousand US dollars）
78. education surcharges = (output tax-input tax)*tax rate of education surcharges （unit: thousand US dollars）
79. business income = earnings from electricity sales+heating income+ benefit of biomass ash （unit: thousand US dollars）
80. tax rate of education surcharges = 0.03
81. purchased water = consumption of water*price of water （unit: thousand US dollars）
82. price of water = 0.5289 （unit: US dollars/ton）
83. consumption of water = IF THEN ELSE(Time=2018, 0, 1279.2 ) （unit: thousand ton）

84. price of heating = 3.92904 （unit: US dollars/GJ）
85. heating income = Heat output*price of heating （unit: thousand US dollars）
86. Heat output = IF THEN ELSE(biomass power generation=0, 0, 483 ) （unit: thousand GJ）
87. earnings from electricity sales = price of biomass power*biomass power generation*ratio of electricity sales （unit: thousand US dollars）
88. price of biomass power = price of traditional power + subsidy intensity of biomass power price （unit: US dollars/kWh）
89. price of traditional power= 0.0453 （unit: US dollars/kWh）
90. subsidy intensity of biomass power price= 0.0619 （unit: US dollars/kWh）
91. ratio of electricity sales = 0.9
92. total investment = INTEG(current year investment,0) （unit: thousand US dollars）
93. current year investment = circulating fund investment + Fixed assets investment （unit: thousand US dollars）
94. Fixed assets investment = IF THEN ELSE(Time=2018,self-owned construction fund + long-term loan, 0 ) （unit: thousand US dollars）
95. long-term loan = 31844 （unit: thousand US dollars）
96. self-owned construction fund = IF THEN ELSE(Time=2018,13649, 0 ) （unit: thousand US dollars）
97. self-owned circulating fund = IF THEN ELSE(Time=2018, 1269, 0) （unit: thousand US dollars）
98. circulating fund investment = IF THEN ELSE(Time=2018, "self-owned circulating fund"+ "short-term loan" , 0 ) （unit: thousand US dollars）
99. short-term loan = 2962 （unit: thousand US dollars）
100. total cost = Depreciation of fixed assets + financial expenses + fuel cost + maintenance cost of fixed assets + material expenses + purchased water + wages and benefits （unit: thousand US dollars）
101. Depreciation of fixed assets = IF THEN ELSE(Time=2018, 0 , 1911)（unit: thousand US dollars）
102. maintenance cost of fixed assets = IF THEN ELSE(Time=2018, 0 , 796.196 ) （unit: thousand US dollars）
103. financial expenses = "long-term loan"*"Long-term loan interest rate"+"short-term loan"*"Shor-term loan interest rate" （unit: thousand US dollars）
104. material expenses = IF THEN ELSE(Time=2018, 0 , 36.26)
105. Long-term loan interest rate = 0.0594
106. Short-term loan interest rate = 0.0556
107. average wage = IF THEN ELSE(Time=2018, 7.56, 7.56*(1+0.05)^(Time-2018)) （unit: thousand US dollars）
108. benefits of employment increase = IF THEN ELSE(Time=2018, 0, wages and benefits-number of employees*(rural average income*(1-urbanization rate)+urban average income* urbanization rate)/1000) （unit: thousand US dollars）
109. rural average income = IF THEN ELSE(Time=2018, 1160, 1160*(1+0.05)^(Time-2018) )（unit: US dollars）
110. urban average income = IF THEN ELSE(Time=2018, 3840, 3840*(1+0.05)^(Time-2018) ) （unit: US dollars）
111. number of employees = 74 （unit: person）
112. wages and benefits = IF THEN ELSE(Time=2018, 0 , average wage*number of employees )

（unit: thousand US dollars）

113. current year profit = business income-business tax and surcharges-total cost （unit: thousand US dollars）
114. subsidy of biomass power price = 0.0619（unit: US dollars）
115. subsidy from exempted tax = income tax exempted+"value-added tax exempted" （unit: thousand US dollars）
116. fiscal subsidy = price subsidy + subsidy from exempted tax（unit: thousand US dollars）
117. price subsidy= biomass power generation*subsidy intensity of biomass power price （unit: thousand US dollars）
118. accumulated net profit = INTEG(net profit,0) （unit: thousand US dollars）
119. net profit = current year profit-Income tax （unit: thousand US dollars）

(net profit = current year profit-Income tax -subsidy from exempted tax; in Scenario Ⅴ and Ⅵ)

120. Income tax = IF THEN ELSE(Time<=2021, 0 , IF THEN ELSE(Time<=2024, current year profit*0.9*income tax rate*0.5 , current year profit*0.9*income tax rate ) ) （unit: thousand US dollars）
121. income tax exempted = IF THEN ELSE(Time<=2021, IF THEN ELSE( current year profit<=0, 0 , current year profit*income tax rate), IF THEN ELSE(Time<=2024, current year profit*income tax rate-current year profit*0.9*income tax rate*0.5 , current year profit*0.1*income tax rate) ) （unit: thousand US dollars）
122. income tax rate = 0.25
123. coefficient of present value = 1/(1+discount rate)^(Time-2018)
124. discount rate = 0.14
125. accumulated after-tax present value = INTEG(after-tax present value,0) （unit: thousand US dollars）
126. after-tax present value = after-tax net cash flow*coefficient of present value （unit: thousand US dollars）
127. accumulated net cash flow = INTEG(net cash flow,0) （unit: thousand US dollars）
128. net cash flow = cash inflow-cash outflow （unit: thousand US dollars）
129. cash outflow = business tax and surcharges + operating cost + circulating fund investment + Fixed assets investment+subsidy from exempted tax （unit: thousand US dollars）
130. operating cost = total cost-Depreciation of fixed assets-financial expenses （unit: thousand US dollars）
131. cash inflow = business income+retrieve of circulating fund+residue value of the fixed assets （unit: thousand US dollars）
132. residue value of the fixed assets = IF THEN ELSE(Time=2039, 2275, 0 ) （unit: thousand US dollars）