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Solar-hydrogen supply chain network design

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Abstract:

In this study a supply chain network for the solar-hydrogen energy generation is designed. The objective of the network design is accelerating the use of hydrogen as energy source by achieving a wider coverage of the supply chain to cover distant areas and versatile applications. A mixed integer nonlinear programming model is formulated with the objective of maximization of energy flow through the supply chain reaching the demand points of several applications. The model is formulated under production, storage, and transportation constraints, and is solved using optimization software. The solved problems provide validation of the model to effectively represent the solar-hydrogen supply chain. The resultant designed networks of different scenarios are efficient in fulfilling the objective of maximizing power delivered to demand points, including ones in distance areas. Distance demand points simulate rural areas that are usually deprived of energy provision due to complications of power supply. The study emphasizes the importance of robust supply chain network designs to increase the dependability and reliability of renewables and hydrogen storage to provide required power and energy by different communities.

Keywords: *Green hydrogen storage, Green hydrogen transportation, Renewable energy network optimization, Solar-hydrogen supply chain, Supply chain network design*

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1. INTRODUCTION

The changes in the environmental conditions have an essential influence on human lives. Recent world pandemic highlighted the effect of environmental problems on all aspects of life especially the economic impact. This necessitates the use of alternative solutions that are kinder to the environment as well as developing new technologies that mitigate the effect of environmental changes.

Renewable energy is becoming a mandatory alternative to fossil fuel, but in order to fully rely on it, storage technologies must be developed. Hydrogen is a good energy storage with high energy density, and claimed by the US Department of Energy to store triple the energy when compared to same weight of other traditional fuels.

Additionally, hydrogen can be stored for long periods and transported for long distances [1]. There are several benefits for hydrogen as a fuel such as; no carbon emissions, possibility of transportation for long distances, production of clean power and industrial feedstock, and versatile range of applications [2].

There are different types of the hydrogen fuel depending on the origin and technologies used; Grey hydrogen, blue hydrogen, and green hydrogen. In terms of cost, grey hydrogen is the least expensive to produce followed by blue then green hydrogen. Although Green hydrogen generated from renewable energy source has a fairly high cost compared to other alternatives, the acceleration of advancing production and transportation technologies will lead to more availability and reliability, and accordingly drive costs down. Additionally, there is rapid advancement in the electrolysis process that transforms solar energy as a renewable source to hydrogen for storage purposes. Consequently, cost of green hydrogen is decreasing and the urgency to mitigate greenhouse gas effects is increasing [3]. Moreover, the electrolysers have evolved from megawatt capacities to gigawatt, promising of wider coverage of the solar-hydrogen supply chain. The network is then able to contain the abundance of solar energy by electrolysis into hydrogen to be transported to points of demand. According to [3] the challenges are that some industrial production of hydrogen is still from natural gas and coal, therefore CO2 emissions need to be mitigated. Cost of green hydrogen is still high, though it is decreasing rapidly. Hydrogen needs to be involved in wider sectors other than the common oil refining and ammonia production. The infrastructure for hydrogen transportation, whether pipelines or shipping solutions, needs to be developed. The governmental regulations should be improved and developed to encourage hydrogen investment. This is highlighted in [4] as need and importance of hydrogen policies released by nations to meet international agreements obligations. Levels of the policies application seek increasing reliability on green hydrogen as fuel for hard-to-decarbonize sectors.

The abundance of solar energy is a drive to develop a storage system to exploit it at all times of the day or year, even when and where the resource is limited. Thus, solar-hydrogen supply chain can address this issue. Although [10] claim that efficiency of converting solar energy into hydrogen using photovoltaic cells combined with water electrolysis is 16%, the research in [11] proves the feasibility of green hydrogen economy. The study investigates the use of several renewables for hydrogen production, and concludes that solar PV is second to best in terms of production feasibility. Efforts to investigate hydrogen viability continue in [12] by presenting a model for integration of electricity, hydrogen, and methane to increase the flexibility of the system. The proposed system is able to contain the increased renewable electricity by balancing the levels of hydrogen and methane. In [13], a cost study to evaluate the technical and economic feasibility of establishing 2.5 MW solar photovoltaic power plant is presented. The study concludes the most feasible configuration to fulfill the required demand of power. Focus of the work of [14] is to propose solution to an energy crisis of lack of electricity in some areas. The solution is based on increasing the dependability on renewable resources of energy.

Hence well-designed solar-hydrogen supply chain networks are needed to facilitate transfer of energy to areas that are not covered by the electricity grid or where the grid ability to contain the generated power is limited. Energy supply chains have been the locus of many studies in the literature. The study in [5] defines energy supply chain as the physical routes between the sources and producers of energy and the consumers of demand of this energy. In a regular fossil fuel supply chain, coal, crude oil, and natural gas are transported for long distances between continents by ships. This supply chain involves transportation in hybrid land and sea systems, emphasizing the need to combine several transportation modes in the supply chain. Authors in [6] optimize the energy supply chain using simulation techniques. They look into several aspects regarding the trade-off between service level, cost, and energy. Work introduced in [7] considers a supply chain for hydrogen that is used beyond transportation purposes. This work plans hydrogen supply chain to fulfill fuel and electricity demand. The proposed mixed-integer linear programming model minimizes the supply chain costs under production, transportation, and storage constraints. In a recent study [8], the authors suggest that hydrogen supply chain can stabilize the supply and demand of renewables. In this supply chain, hydrogen is in three uses; as a fuel produced from electrolysis using renewables, as a storage for electricity, and as a carrier of electricity for transportation to demand points. This work focuses on technical (chemical) challenges facing the hydrogen supply chain regarding production, storage, transportation, and use at final destinations. The research presented in [9] introduces a hydrogen supply chain MILP (Mixed Integer Linear Programming) model with objective of industrial decarbonization. While the work does not include demand size optimization into the model, it refers to possibility of extending the model to account for demand optimization beside the primary objective. The investigation in [16] explores the use of green hydrogen to mitigate pollution emissions of the shipping industry. The process of fueling shipping industry through production, storage, and transportation of hydrogen is highlighted with the environmental, technical, and economic considerations.

While the work of [15] enumerates the objectives of the proposed models in literature of hydrogen supply chain, ranging from costs to investment or carbon emissions driven, there is no evidence of work that addresses the objective of widening the coverage of the supply chain to provide distant areas with scarce energy resources.

The focus of current study is to achieve a wider coverage of the solar-hydrogen supply chain by formulating a model that seeks increasing demand fulfillment. The model considers the production, storage, and transportation phases of the supply chain till delivery to demand points (Fig. 1).

In this study a solar-hydrogen energy supply chain network is designed with the goal of wider coverage by using advanced storage and delivery technique. The decision of using advanced storage and delivery techniques, such as hydrogen electrolysis, was prioritized in a previous study in order to build a robust supply chain network [17]. The goal was wider use of renewable energy by overcoming the challenges faced in the supply chain. This study uses recommendation from the previous study and data from literature [18-22] to formulate the model for the supply chain network. Thus, solar-hydrogen energy supply chain network is designed with the objective of wider coverage of the supply chain to include rural and distant areas that are hard to be fully provided with electrical power, and to serve versatile purposes. Accordingly, a mixed integer programming model is formulated with the objective of maximization of demand fulfilment. The study uses the common structure of conventional products or service supply chains with multi layers [23-24]. The renewable energy supply chain network consists of plants, storage points, distribution grids, transportation routes, and demand points. The model is then solved using optimization software for real-world scenarios.

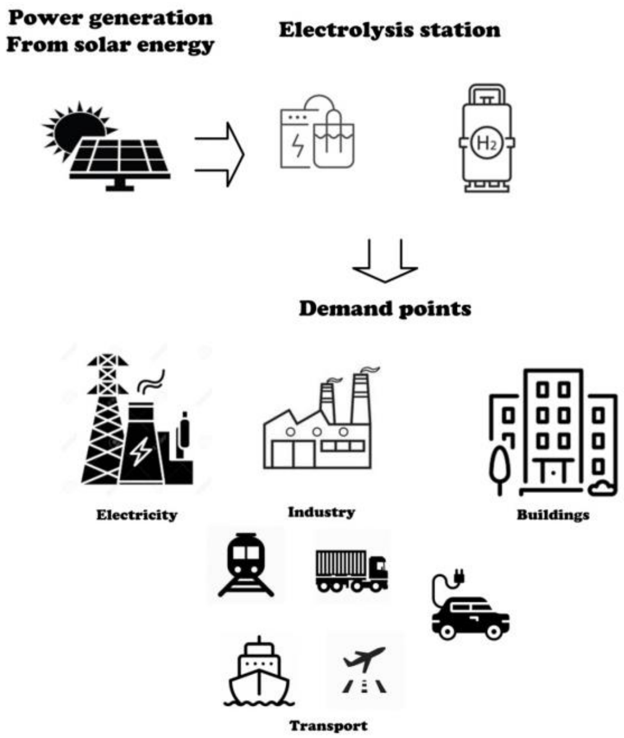

Figure 1. Solar-hydrogen supply chain network.

2. PROBLEM METHODOLOGY

A supply chain network is designed to represent a solar-hydrogen system. The power generated from the solar plant is transferred to the electrolysis station. The electrolysis station includes electrolysers to convert this generated power into hydrogen fuel and then stored in proper form to be transported. The stored hydrogen is then transported to the demand points to be deployed in the appropriate application whether electricity generation, industrial uses, heating buildings, or transportation purposes (figure 1). The solar-hydrogen supply chain network is modeled as a Mixed Integer Nonlinear Programming (MINLP) model. The model is then verified using small problem and validated using two scenarios depending on the number of electrolysis stations and number of demand points. The model is based on some assumptions as follows:

1. The technical aspects of the conversion of power to hydrogen, or storing hydrogen in suitable form for transportation are not the focus of this work.
2. The model is formulated as conventional supply chain for products or services, so any special considerations for the conversion, storage, or transportation of hydrogen are not considered.
3. The electrolysis station can be of a distance from the solar plant, however the how is beyond the scope of this work.
4. The model represents one solar plant that feeds multiple electrolysis stations.
5. Energy flow balance of the electrolysis station is assumed with equal in and out flow neglecting any loses.
6. Energy unit cost includes all costs incurred to produce one unit, excluding the electrolysis station operation and maintenance costs.

2.1. Model

Objective function

Maximize energy units delivered to demand points.

Variables

- $x_{kj}: amount\ of\ energy\ flow\ from\ electrolysis\ station\ k\ to\ destination\ demand\ point\ j$
- $xs_k: amount\ of\ energy\ flow\ from\ the\ solar\ power\ plant\ to\ electrolysis\ station\ k$
- $z_k: \begin{cases} 1 & if\ electrolysis\ station\ is\ established \\ 0 & otherwise \end{cases}$

Parameters

- Capacity of electrolysers *QE*
- Capacity of transportation route (or H_2 batteries/tankers capacity) *Qb*
- Capacity of energy generation of solar panels *QF*
- Demand points levels *Dj*
- Energy unit cost of storage *Uc*
- Available budget for investment *B*
- Cost of transportation c_{kj}
- Cost of maintenance and operation of electrolysis station *Oc*
- Capital and initiation costs *A*
- Number of electrolysers *E*
- Number of demand points *P*

Constraints

- Budget constraint
- Balance of flow constraints
- Demand fulfillment constraints
- Generation and storage capacity constraints
- Storage balance constraint

2.2. Mathematical Model

$$\max Z = \sum_{k=1}^{E} z_k xs_k + \sum_{k=1}^{E}\sum_{j=1}^{P} z_k x_{kj}$$

S.T.

$$\sum_{k=1}^{E}\sum_{j=1}^{P} Oc_E z_k + c_{kj} x_{kj} + Uc x_{kj} \leq B - A \tag{1}$$

$$\sum_{k=1}^{E} xs_k \leq Q_F z_k \tag{2}$$

$$\sum_{j=1}^{P} x_{kj} \leq Q_E z_k \quad k = 1 \cdots E \tag{3}$$

$$\sum_{k=1}^{E} x_{kj} \geq D_j \quad j = 1 \cdots P \tag{4}$$

$$\sum_{k=1}^{E} xs_k = \sum_{k=1}^{E}\sum_{j=1}^{P} x_{kj} \quad (5)$$

$$x_{kj} \leq Qb_{kj} \qquad k = 1 \cdots E, j = 1 \cdots P \quad (6)$$

$$xs_k, x_{kj} \geq 0 \qquad k = 1 \cdots E, j = 1 \cdots P \quad (7)$$

$$z_k = \{0,1\} \qquad k = 1 \cdots E \quad (8)$$

The solar-hydrogen supply chain network is formulated as a mixed integer programming mathematical model to design the configuration of the supply chain. The objective function maximizes the amount of energy flow to demand points to ensure that the main aim of the study of wider coverage of the supply chain by delivering energy to deprived sectors is achieved. The model runs subject to constraints to ensure that flow is balanced between supply chain layers, and supply chain facilities establishment is within the set budget. Accordingly, constraint eq. (1) ensures that all costs of operation and maintenance, transportation, and energy production unit cost are under the set budget after deducting capital and initiation costs. Following this, constraints eq. (2) are to balance the flow from generation plant to electrolysis station is within the capacity of generation from the solar power plant and to ensure there is flow only if the electrolysis station is established. Similarly, constraints eq. (3) are to ensure that there is flow from the electrolysis station to demand point only if it is established and that flow is within the electrolysers' capacity. Additionally, constraints eq. (4) are for fulfillment of demand at a certain point from the flow from electrolysis stations. While constraints eq. (5) ensure that all flow into electrolysers from generation plant is equal to all flow out of the electrolysis stations to demand points. Accordingly, constraints eq. (6) ensure that flow of energy on a route is within capacity of transported batteries on that route. Finally, constraints eq. (7) are for non-negativity of variables, and constraints eq. (8) are for binary variables.

3. RESULTS AND ANALYSIS

The proposed model is verified using a small problem with the specification in Table 1.

Table 1. Verification problem parameters.

Parameter	Value
E	3
P	2
B	1000000
A	300000
Dj	500,700
QF	2000
QE	500
OcE	100000
ckj	5,3,4.5,2.5,5.5,4.6
Uc	7
Qbkj	100,200,350,400,500,650

The problem is solved on LINGO optimization software. LINGO uses a set of built-in solvers that can address a range of problems. This integration property allows internal selection of appropriate solver for the problem seamlessly without compatibility issues between the modeling language and the solver components. Furthermore, LINGO includes a number of solvers to solve nonlinear models, one of which is the global solver. The global solver searches the solution space by converting the nonlinear, non-convex problem to a set of linear sub-problems. Afterwards, the solver uses the branch-and-bound technique to scan the sub-problems' solutions to find the global solution.

LINGO global solver is exploited to solve the proposed model, using a dual-core machine with processor of 2.16 GHz, and the resulted solution is global optimal (Fig. 2). The solution obtained shows that all three electrolysis stations are used to provide energy for the demand points as in Table 2. It can be seen that the 500 units of demand of the first demand point in Table 1 is optimally fulfilled from all three established electrolysis stations. The same applies to demand of second demand point.

```
Global optimal solution found.
Objective value:                              2600.000
Objective bound:                              2600.000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             3
```

Figure 2. Verification problem LINGO solution.

Table 2. Solution variables.

Variable	Value
ZK(1)	1.000000
ZK(2)	1.000000
ZK(3)	1.000000
XSK(1)	300.0000
XSK(2)	500.0000
XSK(3)	500.0000
XKJ(1, 1)	100.0000
XKJ(1, 2)	200.0000
XKJ(2, 1)	350.0000
XKJ(2, 2)	150.0000
XKJ(3, 1)	50.00000
XKJ(3, 2)	450.0000

The results show that the model is able to solve the supply chain network design problem. Accordingly, two problem scenarios are formulated using data generation to validate the model to solve real-world problems. Ranges for data generation for the parameters are found in the literature. Ranges of the parameters along with references are showed in Table 3.

Table 3. Ranges of parameters for the two problem scenarios.

Parameter	Value	Reference
E	Scenario 1: 5 Scenario 2: 10	[25, 26]
P	Scenario 1: 10 Scenario 2: 20	[27]
B	$\$1x10^9$-$4x10^9$	[27]
A	$\$3x10^8$-$1.3x10^9$	[27]
Dj	2-5 MW	[13]
QF	500-1600 MW	[27]
QE	15-20 MW	[25, 26]
OcE	$\$1x10^6$-$2x10^6$	[28]
ckj	$\$500000$-$1x10^6$	[29]
Uc	$1300-3300	[30]
Qbkj	1-2 MW	[31]

As it can be seen in Table 3, the two problem scenarios differ in the number of electrolysis stations that can be established and the number of demand points. According to facilities number, the data generated on MatLab is copied to LINGO to find the optimal solution. The two problem scenarios are solved with global optimal solutions with objective function values of 164 and 340 MW flow of energy for scenarios 1 and 2 respectively (Figs. 3-4).

```
Global optimal solution found.
Objective value:                              164.0000
Objective bound:                              164.0000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
```

Figure 3. Scenario 1 LINGO solution.

```
Global optimal solution found.
Objective value:                              340.0000
Objective bound:                              340.0000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                           153
```

Figure 4. Scenario 2 LINGO solution.

For the two scenarios, all the available electrolysis stations are established and flow of energy is assigned to demand points according to required levels. Fig. 5 shows a representation for the results of scenario 1. Numbers appear on the electrolysis station are the energy units available from the solar plant, while figures on the demand points are the demand levels. Additionally, flow units transferred from electrolysis stations to demand points are presented on the connecting arrows. Clearly, all units available in the electrolysis station 1 are transferred to the demand points and exploited as the mathematical model constrains that all flow into the electrolysis station equals all flow out. At the same time, demand of energy units is abundantly fulfilled from flow out of the electrolysis stations combined as the mathematical model constrains as well. As the figure represents only part of the solution, the LINGO results report shows same logic for other electrolysis stations to demand points flows. Furthermore, same logic prevails for scenario 2 LINGO results.

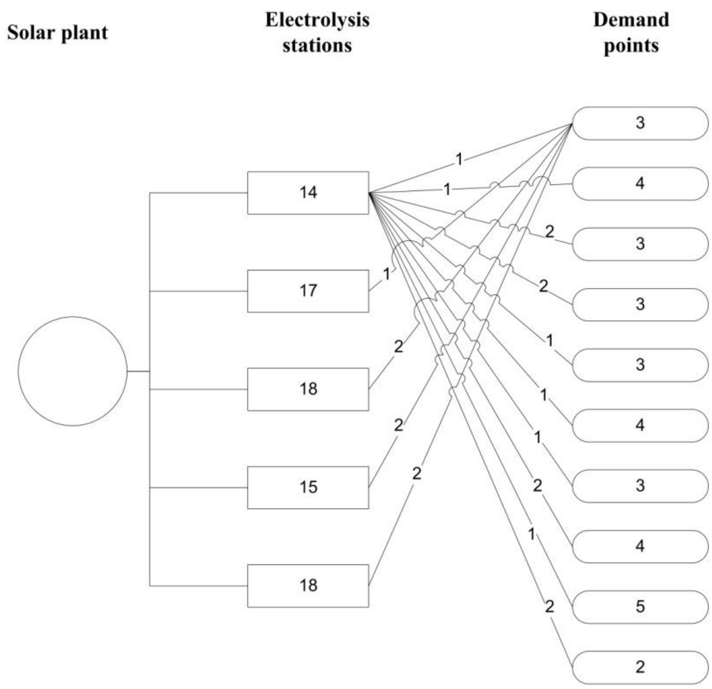

Figure 5. Scenario 1 results representation.

It is worth mentioning that a third scenario problem with 30 electrolysis stations and 50 demand points is attempted. However, after almost 9 hours run, the solver is not able to find an optimal solution. Fig. 6 shows the obtained feasible solution after interrupting the solver. The solution to this case is either to allow more time for the solver to attempt a global optimal solution, or use a heuristic method that is able to solve these types of problems.

```
Feasible solution found.
Objective value:                              408.0000
Objective bound:                              423.2240
Infeasibilities:                              0.000000
Extended solver steps:                         1472197
Total solver iterations:                     107302163
```

Figure 6. Scenario 3 LINGO solution.

6. CONCLUSION

The design of supply chain network for the solar-hydrogen production, storage and transportation is addressed in this study. The objective is to achieve a wider coverage of the supply chain to accelerate the dependency on hydrogen as a clean source of energy, and accordingly drive the costs down. A MINLP (Mixed Integer Nonlinear Programming) model is formulated to represent the problem of focus. The wider coverage is then represented by an objective function with maximization of energy flow till delivery to demand point. The constraints of the model are according to problem assumptions and common practices in the supply chain network design. The proposed model is able to represent the problem, and is verified and validated using several scenarios of problem parameters. Analysis of the LINGO results shows that the intended goals from the mathematical model formulation are achieved. However, it can be noted that demand is fulfilled abundantly with higher levels than required at the demand points. Although this follows the model formulation correctly, further investigation could illustrate how the additional energy units at the demand points are exploited. Moreover, the used optimization software is able to solve all problem instances except one. Accordingly, for larger problem instances the solver might need to run for longer time or use heuristic solution to solve the problem in more feasible time.

For future work, other problem scenarios can be extended to check the ability of the solver to find global optimal solution. Additionally, the problem can be solved using one of the heuristic techniques presented in literature such as Genetic Algorithm (GA), or Successive Shortest Path (SSP). Further research might include easing some of the assumptions to study a different configuration of the solar-hydrogen supply chain, or take other considerations into account regarding the techniques of production, storage, or transportation of hydrogen.

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APPENDIX

LINGO report for scenario 1

```
Global optimal solution found.
Objective value:                              164.0000
Objective bound:                              164.0000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
```

Variable	Value	Reduced Cost
ELECT	5.000000	0.000000
DMDPT	10.00000	0.000000
B	0.3977060E+10	0.000000
A	0.1017851E+10	0.000000
QF	692.0000	0.000000
QE	20.00000	0.000000
OCE	1977501.	0.000000
UC	2427.830	0.000000
ZK(1)	1.000000	-28.00000
ZK(2)	1.000000	-34.00000
ZK(3)	1.000000	-36.00000
ZK(4)	1.000000	-30.00000
ZK(5)	1.000000	-36.00000
XSK(1)	14.00000	0.000000
XSK(2)	17.00000	0.000000
XSK(3)	18.00000	0.000000
XSK(4)	15.00000	0.000000
XSK(5)	18.00000	0.000000
DJ(1)	3.000000	0.000000
DJ(2)	4.000000	0.000000
DJ(3)	3.000000	0.000000
DJ(4)	3.000000	0.000000
DJ(5)	3.000000	0.000000
DJ(6)	4.000000	0.000000
DJ(7)	3.000000	0.000000
DJ(8)	4.000000	0.000000
DJ(9)	5.000000	0.000000
DJ(10)	2.000000	0.000000
XKJ(1, 1)	1.000000	0.000000
XKJ(1, 2)	1.000000	0.000000
XKJ(1, 3)	2.000000	0.000000
XKJ(1, 4)	2.000000	0.000000
XKJ(1, 5)	1.000000	0.000000
XKJ(1, 6)	1.000000	0.000000
XKJ(1, 7)	1.000000	0.000000
XKJ(1, 8)	2.000000	0.000000
XKJ(1, 9)	1.000000	0.000000
XKJ(1, 10)	2.000000	0.000000
XKJ(2, 1)	1.000000	0.000000
XKJ(2, 2)	2.000000	0.000000
XKJ(2, 3)	1.000000	0.000000
XKJ(2, 4)	1.000000	0.000000
XKJ(2, 5)	2.000000	0.000000
XKJ(2, 6)	2.000000	0.000000
XKJ(2, 7)	2.000000	0.000000
XKJ(2, 8)	2.000000	0.000000
XKJ(2, 9)	2.000000	0.000000
XKJ(2, 10)	2.000000	0.000000
XKJ(3, 1)	2.000000	0.000000
XKJ(3, 2)	2.000000	0.000000
XKJ(3, 3)	2.000000	0.000000
XKJ(3, 4)	2.000000	0.000000
XKJ(3, 5)	2.000000	0.000000
XKJ(3, 6)	2.000000	0.000000
XKJ(3, 7)	2.000000	0.000000
XKJ(3, 8)	1.000000	0.000000
XKJ(3, 9)	1.000000	0.000000
XKJ(3, 10)	2.000000	0.000000
XKJ(4, 1)	2.000000	0.000000
XKJ(4, 2)	1.000000	0.000000
XKJ(4, 3)	1.000000	0.000000
XKJ(4, 4)	2.000000	0.000000
XKJ(4, 5)	1.000000	0.000000
XKJ(4, 6)	2.000000	0.000000
XKJ(4, 7)	1.000000	0.000000
XKJ(4, 8)	2.000000	0.000000
XKJ(4, 9)	2.000000	0.000000
XKJ(4, 10)	1.000000	0.000000
XKJ(5, 1)	2.000000	0.000000
XKJ(5, 2)	1.000000	0.000000
XKJ(5, 3)	2.000000	0.000000
XKJ(5, 4)	2.000000	0.000000
XKJ(5, 5)	1.000000	0.000000
XKJ(5, 6)	2.000000	0.000000
XKJ(5, 7)	2.000000	0.000000
XKJ(5, 8)	2.000000	0.000000
XKJ(5, 9)	2.000000	0.000000
XKJ(5, 10)	2.000000	0.000000
CKJ(1, 1)	626002.4	0.000000
CKJ(1, 2)	642310.2	0.000000
CKJ(1, 3)	919143.2	0.000000
CKJ(1, 4)	901050.4	0.000000
CKJ(1, 5)	684980.7	0.000000
CKJ(1, 6)	681405.5	0.000000
CKJ(1, 7)	635870.6	0.000000
CKJ(1, 8)	629734.7	0.000000
CKJ(1, 9)	997197.2	0.000000
CKJ(1, 10)	523131.7	0.000000
CKJ(2, 1)	838166.6	0.000000
CKJ(2, 2)	750842.3	0.000000
CKJ(2, 3)	556644.0	0.000000
CKJ(2, 4)	730657.3	0.000000
CKJ(2, 5)	859315.2	0.000000
CKJ(2, 6)	980301.4	0.000000
CKJ(2, 7)	764450.1	0.000000
CKJ(2, 8)	967708.3	0.000000
CKJ(2, 9)	994793.5	0.000000
CKJ(2, 10)	732857.9	0.000000
CKJ(3, 1)	681898.2	0.000000
CKJ(3, 2)	545167.9	0.000000
CKJ(3, 3)	922101.9	0.000000
CKJ(3, 4)	706853.0	0.000000
CKJ(3, 5)	878679.2	0.000000
CKJ(3, 6)	777016.7	0.000000
CKJ(3, 7)	738120.1	0.000000

CKJ(3, 8)	633295.2	0.000000
CKJ(3, 9)	567638.7	0.000000
CKJ(3, 10)	538850.4	0.000000
CKJ(4, 1)	923296.7	0.000000
CKJ(4, 2)	668521.5	0.000000
CKJ(4, 3)	836996.9	0.000000
CKJ(4, 4)	552216.4	0.000000
CKJ(4, 5)	793682.9	0.000000
CKJ(4, 6)	557401.5	0.000000
CKJ(4, 7)	624672.7	0.000000
CKJ(4, 8)	707086.4	0.000000
CKJ(4, 9)	857733.4	0.000000
CKJ(4, 10)	934835.3	0.000000
CKJ(5, 1)	907713.9	0.000000
CKJ(5, 2)	616224.6	0.000000
CKJ(5, 3)	673167.6	0.000000
CKJ(5, 4)	980306.2	0.000000
CKJ(5, 5)	650656.4	0.000000
CKJ(5, 6)	577098.1	0.000000
CKJ(5, 7)	872218.2	0.000000
CKJ(5, 8)	641447.4	0.000000
CKJ(5, 9)	664419.7	0.000000
CKJ(5, 10)	500666.0	0.000000
QBKJ(1, 1)	1.000000	0.000000
QBKJ(1, 2)	1.000000	0.000000
QBKJ(1, 3)	2.000000	0.000000
QBKJ(1, 4)	2.000000	0.000000
QBKJ(1, 5)	1.000000	0.000000
QBKJ(1, 6)	1.000000	0.000000
QBKJ(1, 7)	1.000000	0.000000
QBKJ(1, 8)	2.000000	0.000000
QBKJ(1, 9)	1.000000	0.000000
QBKJ(1, 10)	2.000000	0.000000
QBKJ(2, 1)	1.000000	0.000000
QBKJ(2, 2)	2.000000	0.000000
QBKJ(2, 3)	1.000000	0.000000
QBKJ(2, 4)	1.000000	0.000000
QBKJ(2, 5)	2.000000	0.000000
QBKJ(2, 6)	2.000000	0.000000
QBKJ(2, 7)	2.000000	0.000000
QBKJ(2, 8)	2.000000	0.000000
QBKJ(2, 9)	2.000000	0.000000
QBKJ(2, 10)	2.000000	0.000000
QBKJ(3, 1)	2.000000	0.000000
QBKJ(3, 2)	2.000000	0.000000
QBKJ(3, 3)	2.000000	0.000000
QBKJ(3, 4)	2.000000	0.000000
QBKJ(3, 5)	2.000000	0.000000
QBKJ(3, 6)	2.000000	0.000000
QBKJ(3, 7)	2.000000	0.000000
QBKJ(3, 8)	1.000000	0.000000
QBKJ(3, 9)	1.000000	0.000000
QBKJ(3, 10)	2.000000	0.000000
QBKJ(4, 1)	2.000000	0.000000
QBKJ(4, 2)	1.000000	0.000000
QBKJ(4, 3)	1.000000	0.000000
QBKJ(4, 4)	2.000000	0.000000
QBKJ(4, 5)	1.000000	0.000000
QBKJ(4, 6)	2.000000	0.000000
QBKJ(4, 7)	1.000000	0.000000
QBKJ(4, 8)	2.000000	0.000000
QBKJ(4, 9)	2.000000	0.000000
QBKJ(4, 10)	1.000000	0.000000
QBKJ(5, 1)	2.000000	0.000000
QBKJ(5, 2)	1.000000	0.000000
QBKJ(5, 3)	2.000000	0.000000
QBKJ(5, 4)	2.000000	0.000000
QBKJ(5, 5)	1.000000	0.000000
QBKJ(5, 6)	2.000000	0.000000
QBKJ(5, 7)	2.000000	0.000000
QBKJ(5, 8)	2.000000	0.000000
QBKJ(5, 9)	2.000000	0.000000
QBKJ(5, 10)	2.000000	0.000000

LINGO report for scenario 2

```
Global optimal solution found.
Objective value:                              340.0000
Objective bound:                              340.0000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                           153
```

Variable	Value	Reduced Cost
ELECT	10.00000	0.000000
DMDPT	20.00000	0.000000
B	0.2517468E+10	0.000000
A	0.3489290E+09	0.000000
QF	538.0000	0.000000
QE	17.00000	0.000000
OCE	1439827.	0.000000
UC	2202.780	0.000000
ZK(1)	1.000000	-68.00000
ZK(2)	1.000000	-68.00000
ZK(3)	1.000000	-68.00000
ZK(4)	1.000000	-68.00000
ZK(5)	1.000000	-68.00000
ZK(6)	1.000000	-68.00000
ZK(7)	1.000000	-68.00000
ZK(8)	1.000000	-68.00000
ZK(9)	1.000000	-68.00000
ZK(10)	1.000000	-68.00000
XSK(1)	17.00000	0.000000
XSK(2)	17.00000	0.000000
XSK(3)	17.00000	0.000000
XSK(4)	17.00000	0.000000
XSK(5)	17.00000	0.000000
XSK(6)	17.00000	0.000000
XSK(7)	17.00000	0.000000
XSK(8)	17.00000	0.000000
XSK(9)	17.00000	0.000000
XSK(10)	17.00000	0.000000
DJ(1)	2.000000	0.000000
DJ(2)	5.000000	0.000000
DJ(3)	5.000000	0.000000

DJ(4)	4.000000	0.000000
DJ(5)	3.000000	0.000000
DJ(6)	5.000000	0.000000
DJ(7)	2.000000	0.000000
DJ(8)	3.000000	0.000000
DJ(9)	2.000000	0.000000
DJ(10)	4.000000	0.000000
DJ(11)	4.000000	0.000000
DJ(12)	2.000000	0.000000
DJ(13)	4.000000	0.000000
DJ(14)	3.000000	0.000000
DJ(15)	2.000000	0.000000
DJ(16)	5.000000	0.000000
DJ(17)	2.000000	0.000000
DJ(18)	4.000000	0.000000
DJ(19)	5.000000	0.000000
DJ(20)	4.000000	0.000000
XKJ(1, 1)	1.000000	0.000000
XKJ(1, 2)	2.000000	0.000000
XKJ(1, 3)	1.000000	0.000000
XKJ(1, 4)	0.000000	0.000000
XKJ(1, 5)	1.000000	0.000000
XKJ(1, 6)	1.000000	0.000000
XKJ(1, 7)	1.000000	0.000000
XKJ(1, 8)	0.000000	0.000000
XKJ(1, 9)	2.000000	0.000000
XKJ(1, 10)	0.000000	0.000000
XKJ(1, 11)	0.000000	0.000000
XKJ(1, 12)	0.000000	0.000000
XKJ(1, 13)	0.000000	0.000000
XKJ(1, 14)	0.000000	0.000000
XKJ(1, 15)	0.000000	0.000000
XKJ(1, 16)	2.000000	0.000000
XKJ(1, 17)	2.000000	0.000000
XKJ(1, 18)	1.000000	0.000000
XKJ(1, 19)	2.000000	0.000000
XKJ(1, 20)	1.000000	0.000000
XKJ(2, 1)	1.000000	0.000000
XKJ(2, 2)	2.000000	0.000000
XKJ(2, 3)	1.000000	0.000000
XKJ(2, 4)	2.000000	0.000000
XKJ(2, 5)	1.000000	0.000000
XKJ(2, 6)	1.000000	0.000000
XKJ(2, 7)	1.000000	0.000000
XKJ(2, 8)	2.000000	0.000000
XKJ(2, 9)	0.000000	0.000000
XKJ(2, 10)	0.000000	0.000000
XKJ(2, 11)	0.000000	0.000000
XKJ(2, 12)	0.000000	0.000000
XKJ(2, 13)	0.000000	0.000000
XKJ(2, 14)	0.000000	0.000000
XKJ(2, 15)	0.000000	0.000000
XKJ(2, 16)	1.000000	0.000000
XKJ(2, 17)	2.000000	0.000000
XKJ(2, 18)	1.000000	0.000000
XKJ(2, 19)	2.000000	0.000000
XKJ(2, 20)	0.000000	0.000000
XKJ(3, 1)	0.000000	0.000000
XKJ(3, 2)	1.000000	0.000000
XKJ(3, 3)	0.000000	0.000000
XKJ(3, 4)	2.000000	0.000000
XKJ(3, 5)	1.000000	0.000000
XKJ(3, 6)	0.000000	0.000000
XKJ(3, 7)	0.000000	0.000000
XKJ(3, 8)	2.000000	0.000000
XKJ(3, 9)	0.000000	0.000000
XKJ(3, 10)	0.000000	0.000000
XKJ(3, 11)	0.000000	0.000000
XKJ(3, 12)	0.000000	0.000000
XKJ(3, 13)	1.000000	0.000000
XKJ(3, 14)	2.000000	0.000000
XKJ(3, 15)	2.000000	0.000000
XKJ(3, 16)	1.000000	0.000000
XKJ(3, 17)	1.000000	0.000000
XKJ(3, 18)	1.000000	0.000000
XKJ(3, 19)	2.000000	0.000000
XKJ(3, 20)	1.000000	0.000000
XKJ(4, 1)	0.000000	0.000000
XKJ(4, 2)	0.000000	0.000000
XKJ(4, 3)	0.000000	0.000000
XKJ(4, 4)	0.000000	0.000000
XKJ(4, 5)	0.000000	0.000000
XKJ(4, 6)	1.000000	0.000000
XKJ(4, 7)	0.000000	0.000000
XKJ(4, 8)	0.000000	0.000000
XKJ(4, 9)	0.000000	0.000000
XKJ(4, 10)	2.000000	0.000000
XKJ(4, 11)	2.000000	0.000000
XKJ(4, 12)	1.000000	0.000000
XKJ(4, 13)	2.000000	0.000000
XKJ(4, 14)	1.000000	0.000000
XKJ(4, 15)	1.000000	0.000000
XKJ(4, 16)	1.000000	0.000000
XKJ(4, 17)	2.000000	0.000000
XKJ(4, 18)	2.000000	0.000000
XKJ(4, 19)	1.000000	0.000000
XKJ(4, 20)	1.000000	0.000000
XKJ(5, 1)	0.000000	0.000000
XKJ(5, 2)	0.000000	0.000000
XKJ(5, 3)	0.000000	0.000000
XKJ(5, 4)	0.000000	0.000000
XKJ(5, 5)	0.000000	0.000000
XKJ(5, 6)	0.000000	0.000000
XKJ(5, 7)	0.000000	0.000000
XKJ(5, 8)	0.000000	0.000000
XKJ(5, 9)	0.000000	0.000000
XKJ(5, 10)	1.000000	0.000000
XKJ(5, 11)	2.000000	0.000000
XKJ(5, 12)	1.000000	0.000000
XKJ(5, 13)	2.000000	0.000000
XKJ(5, 14)	1.000000	0.000000
XKJ(5, 15)	2.000000	0.000000
XKJ(5, 16)	1.000000	0.000000
XKJ(5, 17)	2.000000	0.000000
XKJ(5, 18)	1.000000	0.000000
XKJ(5, 19)	2.000000	0.000000
XKJ(5, 20)	2.000000	0.000000
XKJ(6, 1)	0.000000	0.000000
XKJ(6, 2)	0.000000	0.000000
XKJ(6, 3)	0.000000	0.000000
XKJ(6, 4)	0.000000	0.000000
XKJ(6, 5)	0.000000	0.000000
XKJ(6, 6)	0.000000	0.000000
XKJ(6, 7)	0.000000	0.000000
XKJ(6, 8)	0.000000	0.000000
XKJ(6, 9)	0.000000	0.000000
XKJ(6, 10)	1.000000	0.000000
XKJ(6, 11)	2.000000	0.000000
XKJ(6, 12)	2.000000	0.000000
XKJ(6, 13)	2.000000	0.000000

XKJ(6, 14)	1.000000	0.000000
XKJ(6, 15)	2.000000	0.000000
XKJ(6, 16)	1.000000	0.000000
XKJ(6, 17)	1.000000	0.000000
XKJ(6, 18)	2.000000	0.000000
XKJ(6, 19)	1.000000	0.000000
XKJ(6, 20)	2.000000	0.000000
XKJ(7, 1)	0.000000	0.000000
XKJ(7, 2)	0.000000	0.000000
XKJ(7, 3)	1.000000	0.000000
XKJ(7, 4)	0.000000	0.000000
XKJ(7, 5)	0.000000	0.000000
XKJ(7, 6)	2.000000	0.000000
XKJ(7, 7)	0.000000	0.000000
XKJ(7, 8)	0.000000	0.000000
XKJ(7, 9)	0.000000	0.000000
XKJ(7, 10)	0.000000	0.000000
XKJ(7, 11)	2.000000	0.000000
XKJ(7, 12)	2.000000	0.000000
XKJ(7, 13)	1.000000	0.000000
XKJ(7, 14)	1.000000	0.000000
XKJ(7, 15)	2.000000	0.000000
XKJ(7, 16)	2.000000	0.000000
XKJ(7, 17)	1.000000	0.000000
XKJ(7, 18)	2.000000	0.000000
XKJ(7, 19)	1.000000	0.000000
XKJ(7, 20)	0.000000	0.000000
XKJ(8, 1)	0.000000	0.000000
XKJ(8, 2)	0.000000	0.000000
XKJ(8, 3)	0.000000	0.000000
XKJ(8, 4)	0.000000	0.000000
XKJ(8, 5)	0.000000	0.000000
XKJ(8, 6)	0.000000	0.000000
XKJ(8, 7)	0.000000	0.000000
XKJ(8, 8)	0.000000	0.000000
XKJ(8, 9)	0.000000	0.000000
XKJ(8, 10)	1.000000	0.000000
XKJ(8, 11)	2.000000	0.000000
XKJ(8, 12)	2.000000	0.000000
XKJ(8, 13)	2.000000	0.000000
XKJ(8, 14)	1.000000	0.000000
XKJ(8, 15)	2.000000	0.000000
XKJ(8, 16)	1.000000	0.000000
XKJ(8, 17)	2.000000	0.000000
XKJ(8, 18)	2.000000	0.000000
XKJ(8, 19)	2.000000	0.000000
XKJ(8, 20)	0.000000	0.000000
XKJ(9, 1)	0.000000	0.000000
XKJ(9, 2)	0.000000	0.000000
XKJ(9, 3)	2.000000	0.000000
XKJ(9, 4)	0.000000	0.000000
XKJ(9, 5)	0.000000	0.000000
XKJ(9, 6)	0.000000	0.000000
XKJ(9, 7)	0.000000	0.000000
XKJ(9, 8)	0.000000	0.000000
XKJ(9, 9)	0.000000	0.000000
XKJ(9, 10)	0.000000	0.000000
XKJ(9, 11)	1.000000	0.000000
XKJ(9, 12)	2.000000	0.000000
XKJ(9, 13)	2.000000	0.000000
XKJ(9, 14)	1.000000	0.000000
XKJ(9, 15)	2.000000	0.000000
XKJ(9, 16)	1.000000	0.000000
XKJ(9, 17)	2.000000	0.000000
XKJ(9, 18)	2.000000	0.000000

XKJ(9, 19)	2.000000	0.000000
XKJ(9, 20)	0.000000	0.000000
XKJ(10, 1)	0.000000	0.000000
XKJ(10, 2)	0.000000	0.000000
XKJ(10, 3)	0.000000	0.000000
XKJ(10, 4)	0.000000	0.000000
XKJ(10, 5)	0.000000	0.000000
XKJ(10, 6)	0.000000	0.000000
XKJ(10, 7)	0.000000	0.000000
XKJ(10, 8)	0.000000	0.000000
XKJ(10, 9)	0.000000	0.000000
XKJ(10, 10)	1.000000	0.000000
XKJ(10, 11)	2.000000	0.000000
XKJ(10, 12)	1.000000	0.000000
XKJ(10, 13)	2.000000	0.000000
XKJ(10, 14)	2.000000	0.000000
XKJ(10, 15)	1.000000	0.000000
XKJ(10, 16)	2.000000	0.000000
XKJ(10, 17)	2.000000	0.000000
XKJ(10, 18)	1.000000	0.000000
XKJ(10, 19)	1.000000	0.000000
XKJ(10, 20)	2.000000	0.000000
CKJ(1, 1)	883055.9	0.000000
CKJ(1, 2)	999919.6	0.000000
CKJ(1, 3)	628733.0	0.000000
CKJ(1, 4)	942907.2	0.000000
CKJ(1, 5)	524860.8	0.000000
CKJ(1, 6)	665827.9	0.000000
CKJ(1, 7)	864776.8	0.000000
CKJ(1, 8)	749350.9	0.000000
CKJ(1, 9)	773329.8	0.000000
CKJ(1, 10)	612319.7	0.000000
CKJ(1, 11)	561490.3	0.000000
CKJ(1, 12)	742606.0	0.000000
CKJ(1, 13)	937021.2	0.000000
CKJ(1, 14)	820712.6	0.000000
CKJ(1, 15)	724118.6	0.000000
CKJ(1, 16)	568571.9	0.000000
CKJ(1, 17)	570579.6	0.000000
CKJ(1, 18)	991297.9	0.000000
CKJ(1, 19)	985942.1	0.000000
CKJ(1, 20)	714446.3	0.000000
CKJ(2, 1)	878019.3	0.000000
CKJ(2, 2)	779295.3	0.000000
CKJ(2, 3)	878327.2	0.000000
CKJ(2, 4)	987960.1	0.000000
CKJ(2, 5)	520937.0	0.000000
CKJ(2, 6)	675501.8	0.000000
CKJ(2, 7)	738324.0	0.000000
CKJ(2, 8)	587467.7	0.000000
CKJ(2, 9)	677952.3	0.000000
CKJ(2, 10)	944234.7	0.000000
CKJ(2, 11)	534576.5	0.000000
CKJ(2, 12)	546373.7	0.000000
CKJ(2, 13)	602902.1	0.000000
CKJ(2, 14)	807599.5	0.000000
CKJ(2, 15)	636716.0	0.000000
CKJ(2, 16)	873892.7	0.000000
CKJ(2, 17)	652863.2	0.000000
CKJ(2, 18)	882722.2	0.000000
CKJ(2, 19)	626442.9	0.000000
CKJ(2, 20)	835508.0	0.000000
CKJ(3, 1)	565957.1	0.000000
CKJ(3, 2)	971224.2	0.000000
CKJ(3, 3)	722291.6	0.000000

CKJ(3, 4)	678997.7	0.000000
CKJ(3, 5)	584900.5	0.000000
CKJ(3, 6)	749537.0	0.000000
CKJ(3, 7)	726083.1	0.000000
CKJ(3, 8)	533108.0	0.000000
CKJ(3, 9)	943940.8	0.000000
CKJ(3, 10)	953892.1	0.000000
CKJ(3, 11)	891327.2	0.000000
CKJ(3, 12)	735971.8	0.000000
CKJ(3, 13)	898071.2	0.000000
CKJ(3, 14)	937823.7	0.000000
CKJ(3, 15)	836125.8	0.000000
CKJ(3, 16)	535191.4	0.000000
CKJ(3, 17)	562235.9	0.000000
CKJ(3, 18)	712683.1	0.000000
CKJ(3, 19)	891332.9	0.000000
CKJ(3, 20)	794573.3	0.000000
CKJ(4, 1)	736067.9	0.000000
CKJ(4, 2)	516894.2	0.000000
CKJ(4, 3)	590036.8	0.000000
CKJ(4, 4)	965909.8	0.000000
CKJ(4, 5)	795382.0	0.000000
CKJ(4, 6)	753167.8	0.000000
CKJ(4, 7)	609219.4	0.000000
CKJ(4, 8)	976025.5	0.000000
CKJ(4, 9)	681129.8	0.000000
CKJ(4, 10)	729273.4	0.000000
CKJ(4, 11)	915405.1	0.000000
CKJ(4, 12)	895332.5	0.000000
CKJ(4, 13)	720511.4	0.000000
CKJ(4, 14)	812016.9	0.000000
CKJ(4, 15)	977754.1	0.000000
CKJ(4, 16)	831739.3	0.000000
CKJ(4, 17)	633245.5	0.000000
CKJ(4, 18)	861577.4	0.000000
CKJ(4, 19)	780538.9	0.000000
CKJ(4, 20)	986490.3	0.000000
CKJ(5, 1)	650436.3	0.000000
CKJ(5, 2)	748510.2	0.000000
CKJ(5, 3)	641977.1	0.000000
CKJ(5, 4)	537104.0	0.000000
CKJ(5, 5)	555698.6	0.000000
CKJ(5, 6)	537653.5	0.000000
CKJ(5, 7)	998096.0	0.000000
CKJ(5, 8)	799798.8	0.000000
CKJ(5, 9)	894484.0	0.000000
CKJ(5, 10)	930634.3	0.000000
CKJ(5, 11)	913534.1	0.000000
CKJ(5, 12)	968461.9	0.000000
CKJ(5, 13)	517926.7	0.000000
CKJ(5, 14)	569855.4	0.000000
CKJ(5, 15)	862721.0	0.000000
CKJ(5, 16)	936047.1	0.000000
CKJ(5, 17)	687051.6	0.000000
CKJ(5, 18)	608093.8	0.000000
CKJ(5, 19)	788005.1	0.000000
CKJ(5, 20)	512823.4	0.000000
CKJ(6, 1)	521752.5	0.000000
CKJ(6, 2)	966724.6	0.000000
CKJ(6, 3)	700826.0	0.000000
CKJ(6, 4)	892460.4	0.000000
CKJ(6, 5)	621314.3	0.000000
CKJ(6, 6)	804271.4	0.000000
CKJ(6, 7)	946591.9	0.000000
CKJ(6, 8)	814709.9	0.000000
CKJ(6, 9)	962073.4	0.000000
CKJ(6, 10)	997902.3	0.000000
CKJ(6, 11)	575044.9	0.000000
CKJ(6, 12)	512398.5	0.000000
CKJ(6, 13)	955632.1	0.000000
CKJ(6, 14)	573998.7	0.000000
CKJ(6, 15)	544971.5	0.000000
CKJ(6, 16)	857846.8	0.000000
CKJ(6, 17)	587507.2	0.000000
CKJ(6, 18)	579860.8	0.000000
CKJ(6, 19)	739466.1	0.000000
CKJ(6, 20)	974365.8	0.000000
CKJ(7, 1)	870535.1	0.000000
CKJ(7, 2)	836166.7	0.000000
CKJ(7, 3)	535172.6	0.000000
CKJ(7, 4)	653052.7	0.000000
CKJ(7, 5)	968416.5	0.000000
CKJ(7, 6)	928468.5	0.000000
CKJ(7, 7)	945423.7	0.000000
CKJ(7, 8)	794293.5	0.000000
CKJ(7, 9)	581293.2	0.000000
CKJ(7, 10)	588022.6	0.000000
CKJ(7, 11)	873781.8	0.000000
CKJ(7, 12)	972642.9	0.000000
CKJ(7, 13)	828989.9	0.000000
CKJ(7, 14)	771916.0	0.000000
CKJ(7, 15)	798826.5	0.000000
CKJ(7, 16)	617301.4	0.000000
CKJ(7, 17)	909883.9	0.000000
CKJ(7, 18)	894247.8	0.000000
CKJ(7, 19)	794529.8	0.000000
CKJ(7, 20)	718129.9	0.000000
CKJ(8, 1)	774869.7	0.000000
CKJ(8, 2)	676484.3	0.000000
CKJ(8, 3)	997895.6	0.000000
CKJ(8, 4)	682481.8	0.000000
CKJ(8, 5)	983087.2	0.000000
CKJ(8, 6)	512370.4	0.000000
CKJ(8, 7)	888919.6	0.000000
CKJ(8, 8)	720091.1	0.000000
CKJ(8, 9)	815250.0	0.000000
CKJ(8, 10)	657012.3	0.000000
CKJ(8, 11)	960907.6	0.000000
CKJ(8, 12)	611662.3	0.000000
CKJ(8, 13)	687243.1	0.000000
CKJ(8, 14)	654072.2	0.000000
CKJ(8, 15)	518911.2	0.000000
CKJ(8, 16)	802584.8	0.000000
CKJ(8, 17)	917932.2	0.000000
CKJ(8, 18)	794126.1	0.000000
CKJ(8, 19)	681727.4	0.000000
CKJ(8, 20)	569942.6	0.000000
CKJ(9, 1)	558266.9	0.000000
CKJ(9, 2)	990608.7	0.000000
CKJ(9, 3)	770846.2	0.000000
CKJ(9, 4)	543254.9	0.000000
CKJ(9, 5)	628048.1	0.000000
CKJ(9, 6)	604887.5	0.000000
CKJ(9, 7)	657304.9	0.000000
CKJ(9, 8)	951875.8	0.000000
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CKJ(9, 10)	581118.0	0.000000
CKJ(9, 11)	571806.1	0.000000
CKJ(9, 12)	532026.5	0.000000
CKJ(9, 13)	927322.7	0.000000

CKJ(9, 14)	987228.4	0.000000
CKJ(9, 15)	964512.6	0.000000
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CKJ(9, 18)	742248.6	0.000000
CKJ(9, 19)	734836.9	0.000000
CKJ(9, 20)	583914.1	0.000000
CKJ(10, 1)	541429.2	0.000000
CKJ(10, 2)	816580.6	0.000000
CKJ(10, 3)	655489.5	0.000000
CKJ(10, 4)	733177.0	0.000000
CKJ(10, 5)	605534.7	0.000000
CKJ(10, 6)	500722.9	0.000000
CKJ(10, 7)	898805.6	0.000000
CKJ(10, 8)	684023.7	0.000000
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CKJ(10, 10)	857489.2	0.000000
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CKJ(10, 12)	844358.6	0.000000
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CKJ(10, 14)	633042.4	0.000000
CKJ(10, 15)	566035.4	0.000000
CKJ(10, 16)	672105.2	0.000000
CKJ(10, 17)	877195.0	0.000000
CKJ(10, 18)	944619.3	0.000000
CKJ(10, 19)	855218.2	0.000000
CKJ(10, 20)	623237.5	0.000000
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QBKJ(1, 5)	2.000000	0.000000
QBKJ(1, 6)	1.000000	0.000000
QBKJ(1, 7)	1.000000	0.000000
QBKJ(1, 8)	1.000000	0.000000
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QBKJ(1, 14)	1.000000	0.000000
QBKJ(1, 15)	2.000000	0.000000
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QBKJ(1, 17)	2.000000	0.000000
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QBKJ(2, 6)	1.000000	0.000000
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QBKJ(3, 9)	1.000000	0.000000
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QBKJ(6, 3)	1.000000	0.000000

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