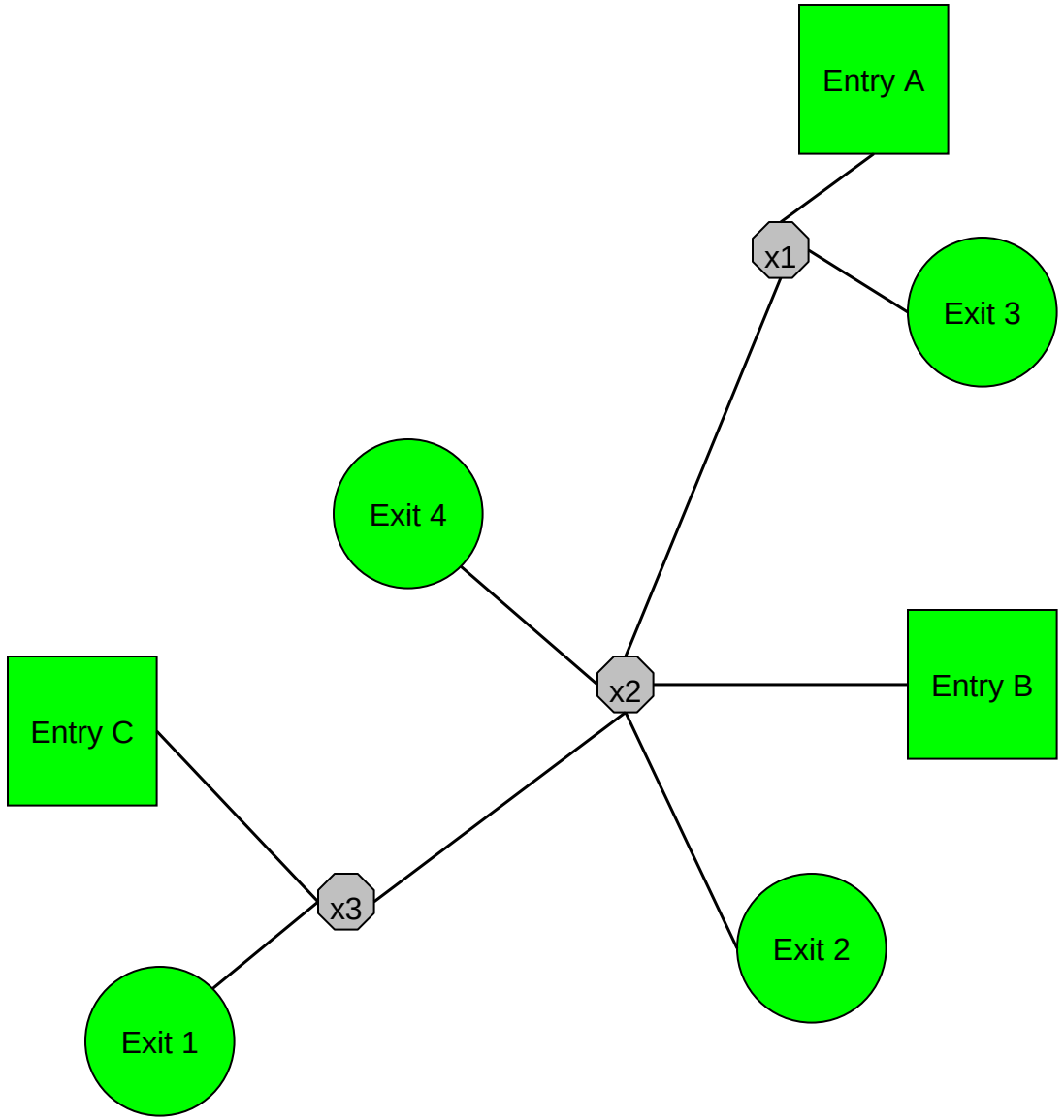
Backhaul “Solver” Example

Gas Transmission Charging Methodology Working Group

2nd March 2006

nationalgrid

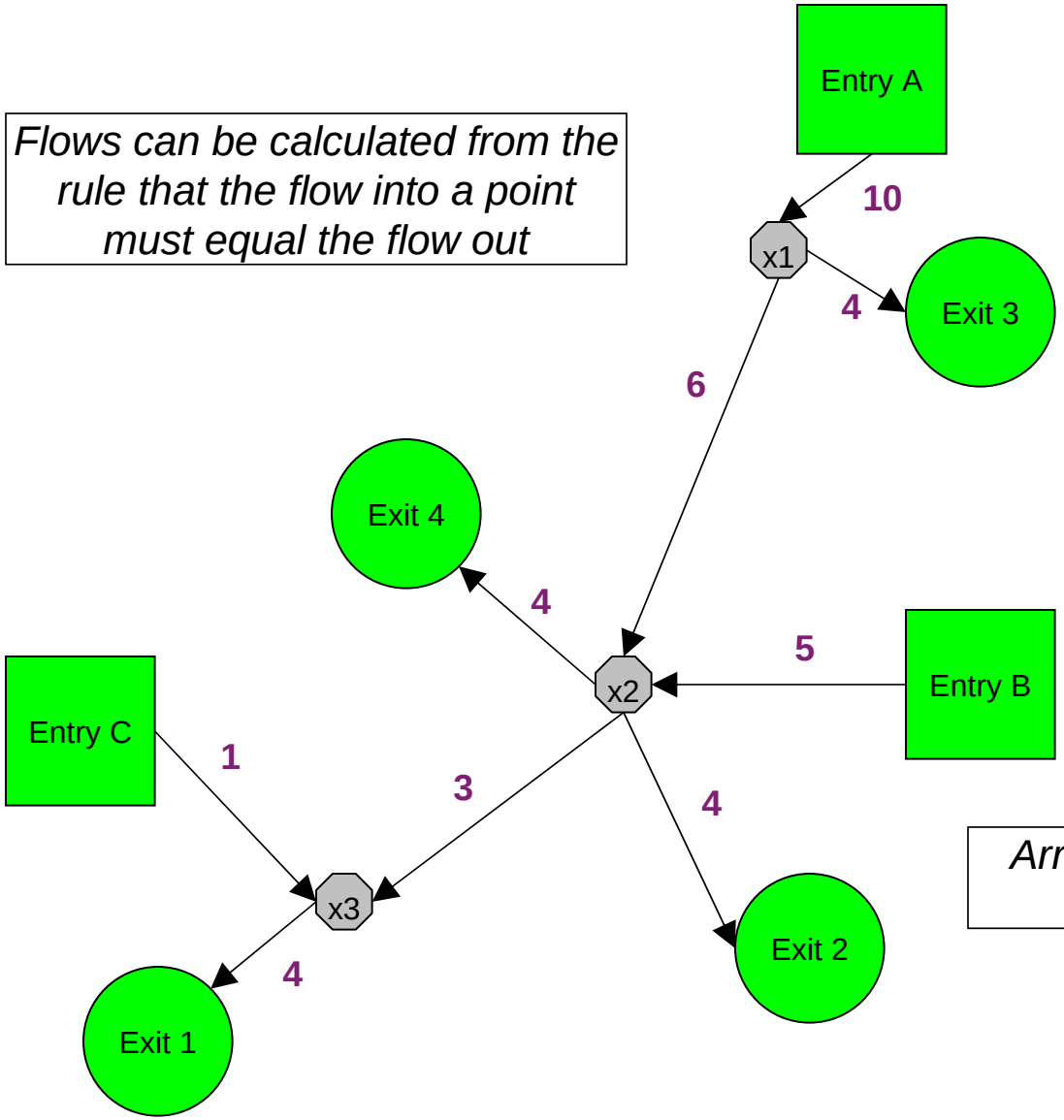
Example Network



nationalgrid

Example Network
Calculate flows from Supply & Demand Data

Flows can be calculated from the rule that the flow into a point must equal the flow out



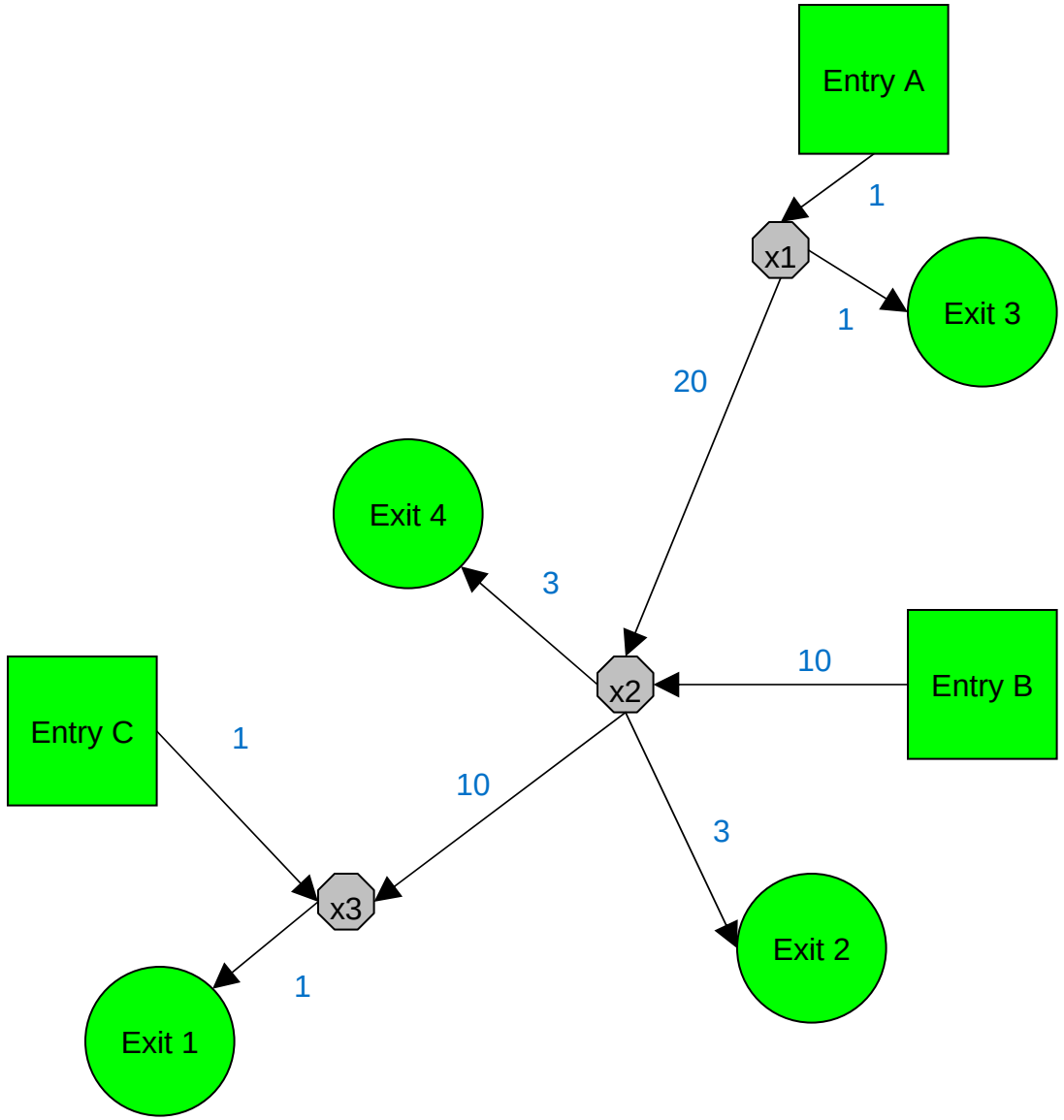
Entry Point	Peak Flow	Exit Point	Peak Day Flow (GWh)
A	10	1	4
B	5	2	4
C	1	3	4
		4	4

Arrows show direction of flow based on peak flow

nationalgrid

Example Network

(calculate reinforcement cost per GWh/day for each pipe section)



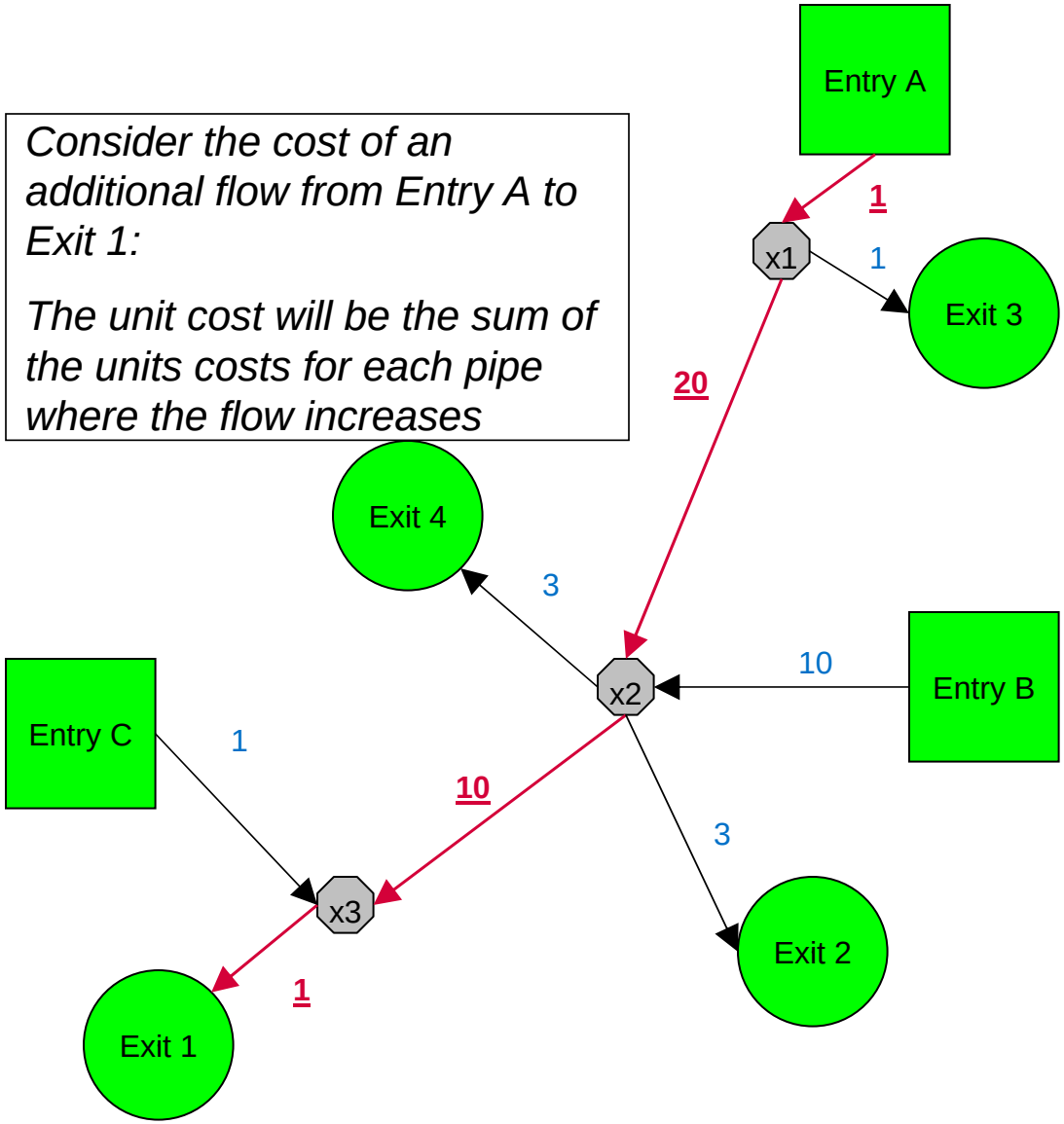
Pipe	Node 1	Node 2	Cost (£/peak day GWh)
1	Entry A	x1	1
2	x1	Exit 3	1
3	x1	x2	20
4	Entry B	x2	10
5	x2	Exit 2	3
6	x2	x3	10
7	X2	Exit 4	3
8	Entry C	x3	1
9	X3	Exit 1	1

nationalgrid

Example Network
Example Route Costs (No backhaul costs)

Consider the cost of an additional flow from Entry A to Exit 1:

The unit cost will be the sum of the units costs for each pipe where the flow increases



	Entry A	Entry B	Entry C
Exit 1	**32**	21	2
Exit 2	24	13	4
Exit 3	2	11	2
Exit 4	24	13	4

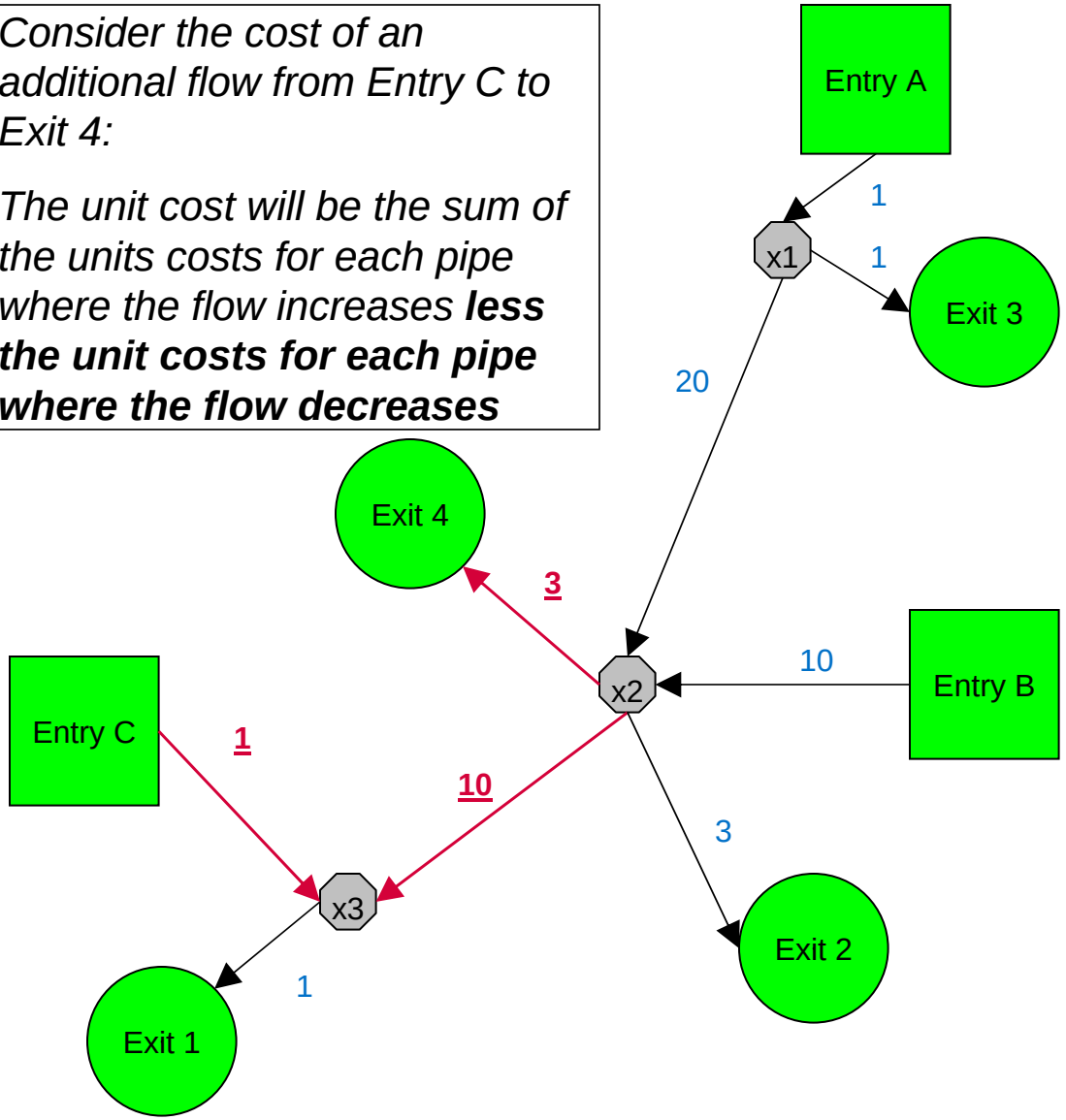
NB Only consider costs for a route if the flow increases

nationalgrid

Example Network
Example Route Cost (inc backhaul costs)

Consider the cost of an additional flow from Entry C to Exit 4:

The unit cost will be the sum of the units costs for each pipe where the flow increases ***less the unit costs for each pipe where the flow decreases***



	Entry A	Entry B	Entry C
Exit 1	32	21	2
Exit 2	24	13	**-6**
Exit 3	2	**-9**	**-28**
Exit 4	24	13	**-6**

nationalgrid

Example Network
Route Cost Matrices (£/peak day GWh)

No Backhaul			
	Entry A	Entry B	Entry C
Exit 1	32	21	2
Exit 2	24	13	4
Exit 3	2	11	2
Exit 4	24	13	4

Backhaul Included			
	Entry A	Entry B	Entry C
Exit 1	32	21	2
Exit 2	24	13	-6
Exit 3	2	-9	-28
Exit 4	24	13	-6

nationalgrid

Solver Concept

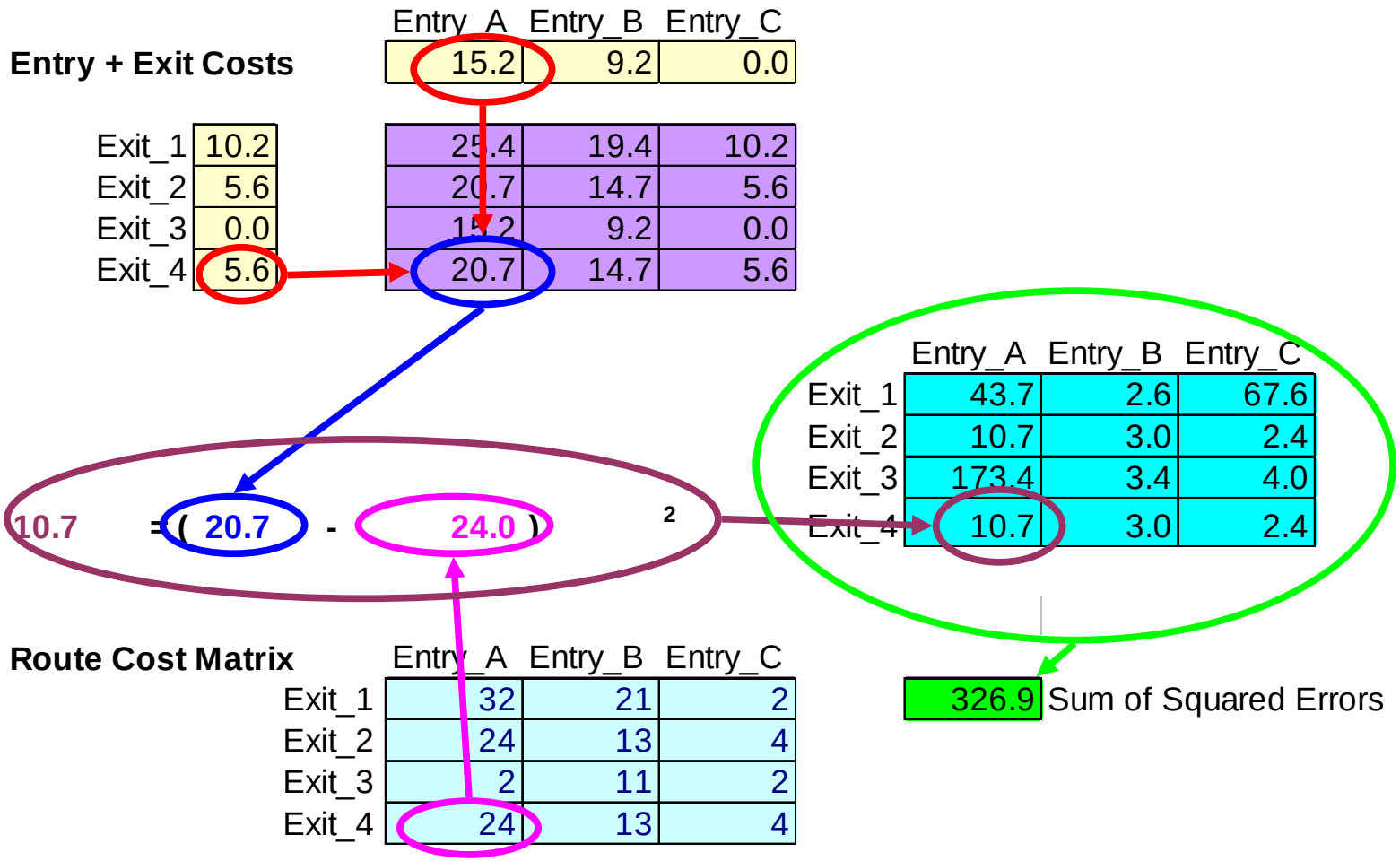
- Find Entry & Exit Costs that minimise the sum of the differences (squared) between each
  - Route Cost, and
  - The relevant Entry + Exit Costs
- For all routes (Sum of Squared Errors ~ SSE)

$$SSE = \sum_{ForallXY} \left[EntryX + ExitY - Route\_Cost\_XY \right]^2$$

- Solver minimise SSE by varying Entry and exit cost estimates
- Constraints
  - All Entry and Exit costs must be greater than or equal to zero

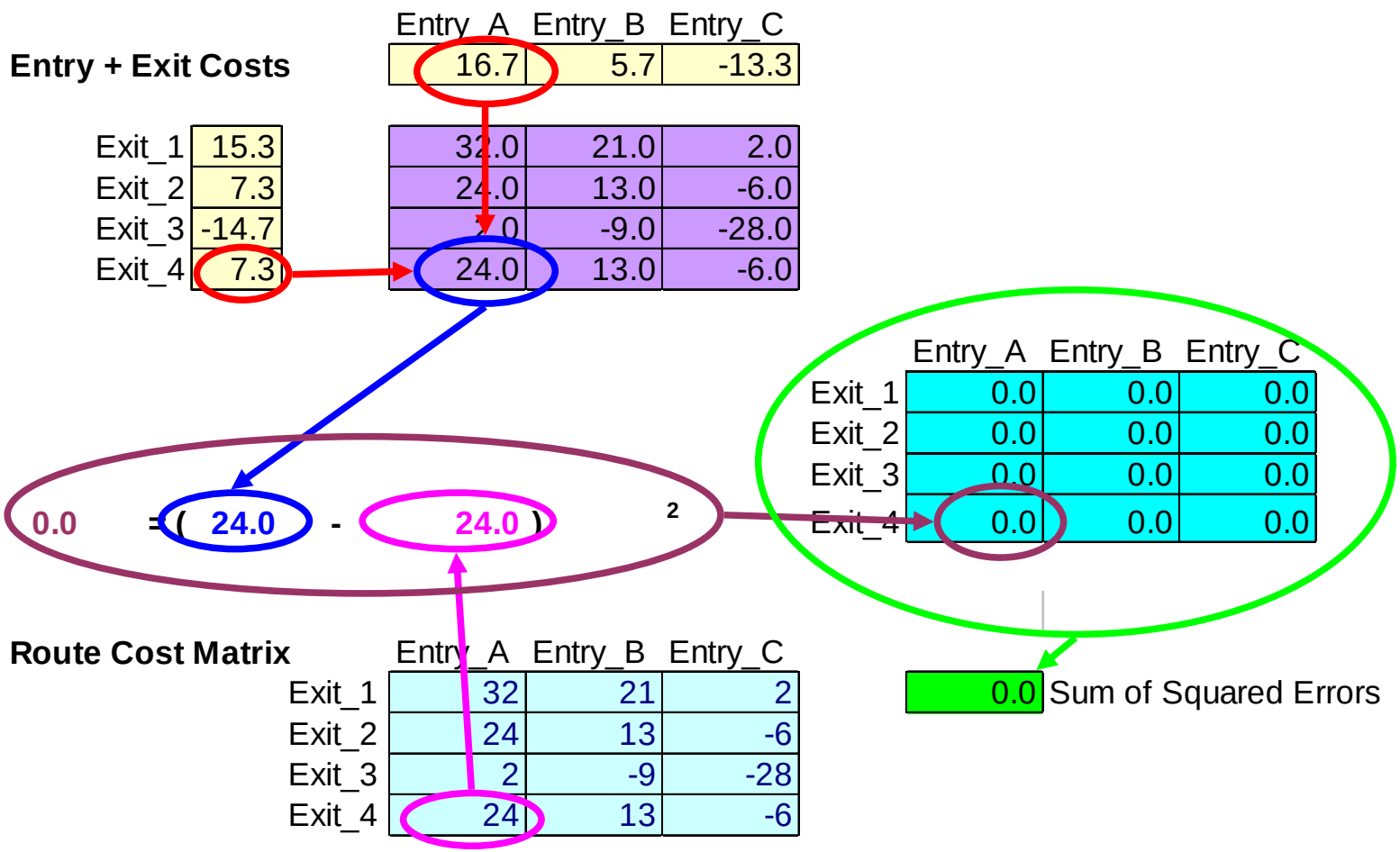
nationalgrid

Solver Solution



nationalgrid

Solver Solution (Backhaul)



nationalgrid

Entry & Exit Solved Cost

Entry A	Entry B	Entry C
15.2	9.2	0

Entry +
Exit

Exit 1	10.2
Exit 2	5.6
Exit 3	0
Exit 4	5.6

25.4	19.4	10.2
20.8	14.8	5.6
15.2	9.2	0
20.8	14.8	3.5

nationalgrid

Entry & Exit Solved Cost

Entry A	Entry B	Entry C
16.7	5.7	-13.3

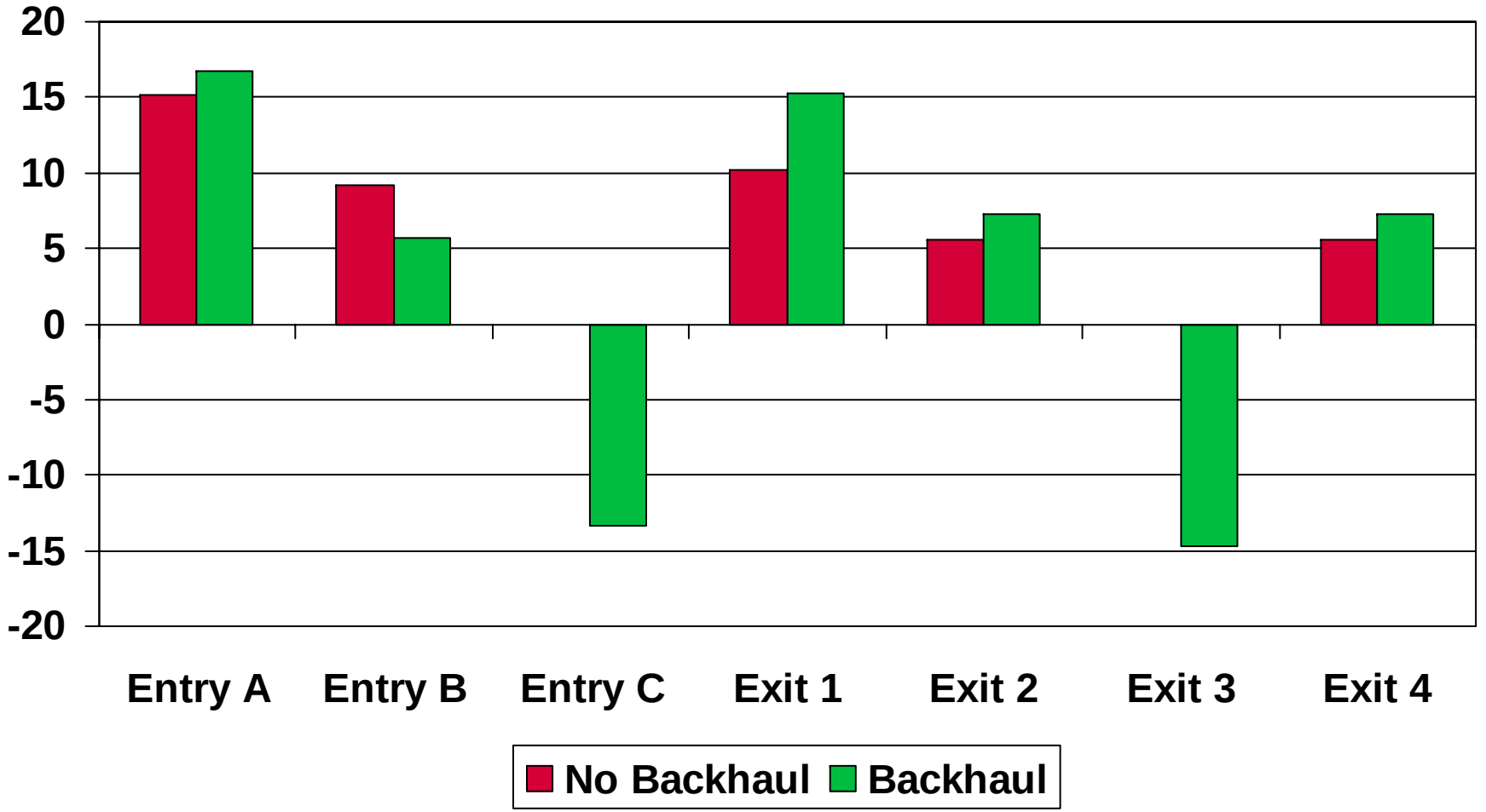
Entry +
Exit

Exit 1	15.3
Exit 2	7.3
Exit 3	-14.7
Exit 4	7.3

32	21	2
24	13	-6
2	-9	-28
24	13	-6

nationalgrid

Impact of Backaul on Marginal costs



nationalgrid