



INFORMATIVE BULLETIN 1.3

Year 3 of 3, Mexico's carbon market first simulation exercise. End of sim 1.

December 18 to 22, 2017

Background:

- On December 4th the first online simulation exercise was started. It consists of three groups participating in simultaneous simulations with the same parameters and market rules; teams A, B and C. In total 80 people are actively participating in this first exercise.
- This bulletin contains:
 - The parameters of this first simulation for reference.
 - The results up to the third and last year of this simulation of each of the three teams, including notes on market behavior
 - Recommendations for the participants to consider for the participation in the following online simulation exercise.
 - A comparative table of results on this first simulation exercise for the three teams with notes.
 - **Total marginal compliance costs (for the 3 years) for each participant and comparison with the costs of compliance of each facility when run by an AI “bot”. Only the virtual company names are presented.**

THE PARTICIPANTS WILL BE INFORMED ON THE DATE FOR THE DISCUSSION SESSION OF THE RESULTS OF THIS FIRST MARKET SIMULATION EXERCISE.

Simulation parameters for Teams A, B and C

First online simulation exercise

Initial cap	355,850,000 tons
Emission reduction goal	3%/year (9% over three years)
BAU emissions	Year 1 + 2 to 6%/year
Free allowances	80%
ETS duration and schedule	3 virtual years (one virtual year from Mon at 10:00 AM until Friday at 10:00 AM and closed until next Monday). ¹
Regulated companies in ETS ²	242 (28 – 36 human humans and ~ 204 - 214 AI bots) ³
Banking limit	100% of current year compliance obligation
Maximum offsets	10% of compliance obligation (designated, “Mexico”)
Auction floor and ceiling price limits	\$40 - 300/ton
Auctions	4/virtual year - 1/actual day, each commences at ~10:00 AM and runs for approximately 3:50 hours. Offering current & future year allowances.
Fine for each missing allowance	\$300 + 1 allowance (from next year)
Exchange and OTC volatility limit	Maximum bid/offer price deviation of 10% from last trade
Bulletins	Emailed at beginning and end of each year and as warranted

¹ Due to an accident made on CarbonSim admin the exercise for Team A was rebooted and year 1 of the simulation ran for 10 hours during Dec 7, while year 1 of teams B and C was ran during 4 days. Starting Monday, December 11 all three exercises ran at the same speed and on the same Schedule again.

² Note – Participants control virtual installations with fictitious information (emissions, marginal abatement cost curves, capital, etc.).

³ Each system is comprised of 242 regulated units. The relative number of human vs AI participants varies by system.

Team A Results for Year 3

Metric	Year 3 of 3	Total (Y1 - Y3)
Forecast Emissions for all Economic Sectors	383,381,083	1,108,560,267
Allowances Sold by Government	22,864,185	174,839,062
Allowances Surrendered to Government	\$290,245,393.00	909,751,275
Auction Revenue Collected by Government	\$936,159,950	\$12,792,563,127
Average Allowance Sale Price	\$40.94	\$73.17
Offsets Surrendered to Government	6,899,943	23,864,113
Average Offsets Sale Price (This system)	\$54.08	\$82.77
Abatement Undertaken	62,401,761	134,257,401
Emission Reduced	69,301,704	158,121,514
Forecast emissions less abatement undertaken	314,079,379	950,438,753
Number of Compliance Penalties applied	0	3
Value of Govt. Penalties Applied	\$0	\$190,166,100
Average abatements undertaken in Year 1	2.1	
Marginal Cost of Compliance Range (Lo - High \$/ton)	(-\$213.00) – 266.58	

Market Color

- In all, the Y3 compliance rate was 100%. Those participants that remained engaged throughout this exercise found that compliance was easily achievable. Of greater challenge, was the meeting the objective with a low compliance cost and ending the year with a zero long/short position.
- As the year progressed, participants with surplus positions found that the markets grew increasingly soft (more sell side interest than buy) for all products in all markets.
- Most participants ended the year perfectly in balance. And five (5) participants ended the year long, ranging from 262,000 to nearly 13 million tons. These companies also suffer an economic penalty as the monies spent on these surplus tons increase their marginal cost of compliance.
- Table 1 summarizes the results and compares participant performance against a set of cohorts that were run through the same sim on artificial intelligence.



Exchange market graph
Prices for the different products that were traded during virtual years 1 - 3.

- Year 1 allowances
- Year 2 allowances
- Year 3 allowances
- Offsets (Mexico)

Team A Results

Auctions results Team A:

Year	Auction #	Vintage	Total volume offered	Clearing Price	Total volume awarded	
Year 1	#1	year 1	17,258,725	61	17,258,725 (100%)	
		year 2	13,379,960	59	13,379,960 (100%)	
	#2	year 1	17,258,725	77	17,258,725 (100%)	
		year 3	10,796,275	76.02	10,796,275 (100%)	
	#3	year 1	17,258,725	86	17,258,725 (100%)	
	#4	year 1	17,258,725	151.41	17,258,725 (100%)	
	Year 2	#1	year 2	13,379,960	79	13,379,960 (100%)
			year 3	10,796,275	73.29	10,796,275 (100%)
#2		year 2	13,379,960	80	13,379,960 (100%)	
#3		year 2	13,379,960	40	13,379,960 (100%)	
#4		year 2	13,379,960	40.02	7,827,587 (59%)	
Year 3	#1	year 3	10,796,275	42	10,796,275 (100%)	
	#2	year 3	10,796,275	40	9,940,643 (92%)	
	#3	year 3	10,796,275	40	2,094,067 (19%)	
	#4	year 3	10,783,325	40	33,200 (0%)	

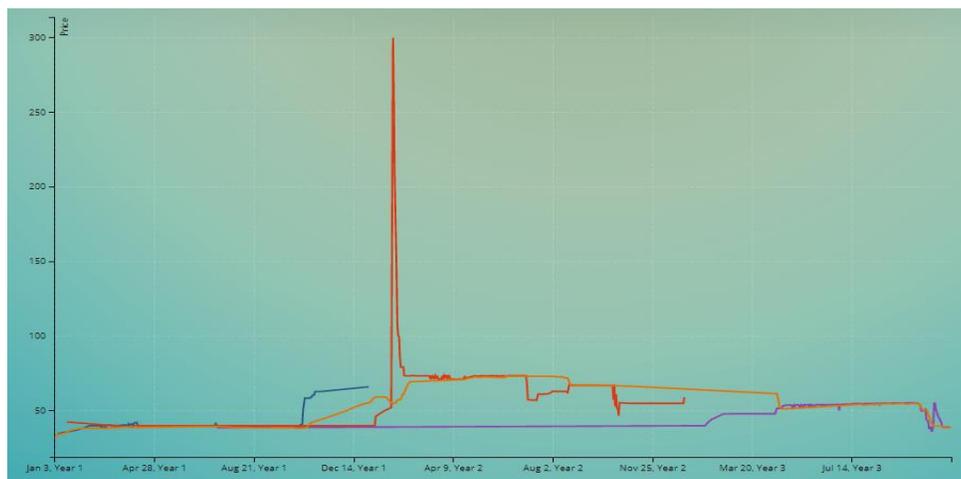
The total volume of allowances offered through auctions was **200,699,400** allowance of which **25,860,338 (13%)** remained unsold. The price range at the actions was **40 to 151.41**. As the simulation advanced the auctions were less used and clearing prices remained at or close to the minimum. In team A the clearing prices of the auctions were the highest.

Team B Results for Year 3

Metric	Year 3 of 3	Total (Y1 - Y3)
Forecast Emissions for all Economic Sectors	382,673,203	1,107,579,102
Allowances Sold by Government	\$18,642,822.00	138,136,904
Allowances Surrendered to Government	\$280,024,339	\$872,026,062
Auction Revenue Collected by Government	\$745,712,880.00	\$6,256,293,194.34
Average Allowance Sale Price	40	45
Offsets Surrendered to Government	\$6,583,129.00	\$22,016,304.00
Average Offsets Sale Price (This system)	51	\$52.82
Abatement Undertaken	72,745,524	152,027,352
Emission Reduced	79,328,653	174,043,656
Forecast emissions less abatement undertaken	303,344,550	933,535,446
Number of Compliance Penalties applied	5	30
Value of Govt. Penalties Applied	\$3,025,619,400.00	\$8,484,753,900.00
Average abatements undertaken in Year 1	1.8	
Marginal Cost of Compliance Range (Lo - High \$/ton)	\$1.30 – 239.37	

Market Color

1. Those participants that remained engaged throughout this exercise found that compliance was achievable with a minimum of effort. Of greater challenge, perhaps, was the meeting the objective of ending the year with a zero long/short position.
2. In all, the Y3 compliance rate was 98%. Most participants ended the year perfectly in balance. Five (5) participants ended the year out of compliance and were forced to pay an economic penalty of \$300 per ton (in comparison to market prices as low as \$20/ton). And one (1) participant ended the year long with a ~9.7 million ton surplus. This company also suffered an economic penalty as the money spent on these surplus tons increase their marginal cost of compliance.
3. As the year progressed, participants with surplus positions found that the markets grew increasingly soft (more sell side interest than buy) for all products in all markets.
4. Table -1 summarizes the results and compares participant performance against a set of cohorts that were run through the same sim on artificial intelligence.



Exchange market graph
Prices for the different
products that were traded
during virtual years 1 - 3.

- Year 1 allowances
- Year 2 allowances
- Year 3 allowances
- Offsets (Mexico)

Team B Results

Auctions results Team B:

Year	Auction #	Vintage	Total volume offered	Clearing Price	Total volume awarded
Year 1	# 1	year 1	17,258,725	40	17,258,725 (100%)
		year 2	13,379,960	40	13,379,960 (100%)
	# 2	year 1	17,258,725	40	17,258,725 (100%)
		year 3	10,796,275	40	10,796,275 (100%)
	# 3	year 1	17,258,725	40	17,258,725 (100%)
# 4	year 1	17,258,725	68.58	17,258,725 (100%)	
Year 2	#1	year 2	13,379,960	40	8,455,473 (63%)
		year 3	10,796,275	62.01	10,796,275 (100%)
	# 2	year 2	13,379,960	40	4,170,642 (31%)
	# 3	year 2	13,379,960	40	1,238,741 (9%)
# 4	year 2	13,379,960	40	1,621,816 (12%)	
Year 3	# 1	year 3	10,796,275	40	8,930,145 (83%)
	# 2	year 3	10,796,275	40	7,480,315 (69%)
	# 3	year 3	10,796,275	40	1,503,794 (14%)
	# 4	year 3	10,783,325	40	728,568 (7%)

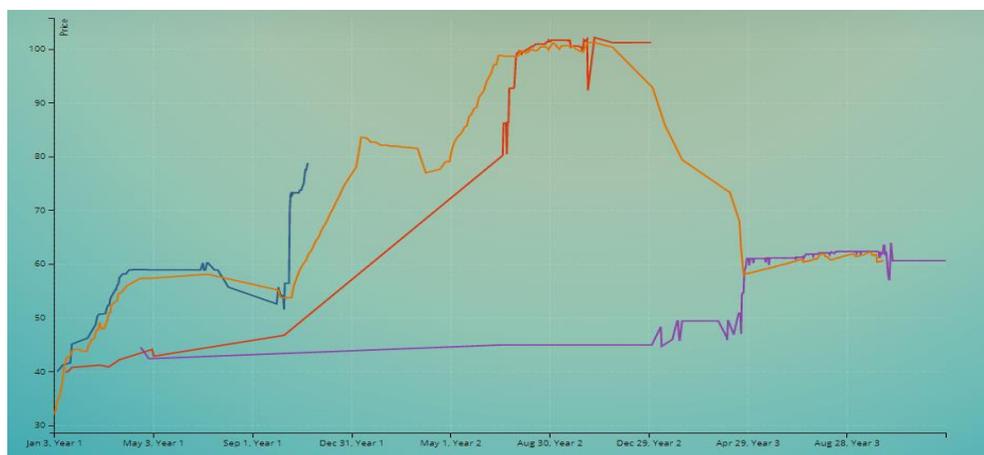
The total volume of allowances offered through auctions was **200,699,400** allowance of which **62,562,496 (31%)** remained unsold. The price range at the actions was **40 to 68.58**. As the simulation advanced the auctions were less used and clearing prices remained at the minimum. The prices only raised on the last auction from year 1 (as participants struggled to get enough allowances to end the year in compliance and during the only year 3 vintage auction during year 2 as participants planned ahead for compliance of the last year.

Team C Results for Year 3

Metric	Year 3 of 3	Total (Y1 - Y3)
Forecast Emissions for all Economic Sectors	383,395,145	1,108,552,232
Allowances Sold by Government	31,325,127	160,325,153
Allowances Surrendered to Government	\$295,007,401.00	910,168,686
Auction Revenue Collected by Government	\$1,253,005,080.00	\$7,695,533,313
Average Allowance Sale Price	\$40.00	\$48.00
Offsets Surrendered to Government	7,523,427	22,406,182
Average Offsets Sale Price (This system)	\$60.91	\$69.98
Abatement Undertaken	58,914,649	123,163,816
Emission Reduced	66,438,076	145,569,998
Forecast emissions less abatement undertaken	316,957,069	962,982,234
Number of Compliance Penalties applied	2	14
Abatement Undertaken	58,914,649	123,163,816
Average abatements implemented in Year 1	2.5	
Marginal Cost of Compliance Range (Lo - High \$/ton)	\$0.15 – 418.22	

Market Color

- Those participants that remained engaged throughout this exercise found that compliance was achievable with a minimum of effort. Of greater challenge, perhaps, was the meeting the objective of ending the year with a zero long/short position.
- In all, the Y3 compliance rate was 99%. Most participants ended the year perfectly in balance. Two (2) of participants ended the year short – ranging from ~163k to ~10.8 million tons Sadly, these participants, which could have achieved compliance by paying as little as \$4.43 per ton, were instead fined \$300 per missing ton.
- As the year progressed, participants with surplus positions found that the markets grew increasingly soft (more sell side interest than buy) for all products in all markets.
- Table -1 summarizes the results and compares participant performance against a set of cohorts that were run through the same sim on artificial intelligence.



Exchange market graph
Prices for the different products that were traded during virtual years 1 - 3.

- Year 1 allowances
- Year 2 allowances
- Year 3 allowances
- Offsets (Mexico)

Team C Results

Auctions results Team C:

Year	Auction #	Vintage	Total volume offered	Clearing Price	Total volume awarded
Year 1	# 1	year 1	17,258,725	40	17,258,725 (100%)
		year 2	13,379,960	40.13	13,379,960 (100%)
	# 2	year 1	17,258,725	40	17,258,725 (100%)
		year 3	10,796,275	55.31	10,796,275 (100%)
	# 3	year 1	17,258,725	40	16,638,882 (96%)
# 4	year 1	17,258,725	83.93	17,258,725 (100%)	
Year 2	# 1	year 2	13,379,960	40	11,045,524 (83%)
		year 3	10,796,275	73.09	10,796,275 (100%)
	# 2	year 2	13,379,960	40	5,801,200 (43%)
	# 3	year 2	13,379,960	40	5,385,719 (40%)
# 4	year 2	13,379,960	40	3,380,016 (25%)	
Year 3	# 1	year 3	10,796,275	40	10,397,967 (96%)
	# 2	year 3	10,796,275	40	9,267,823 (86%)
	# 3	year 3	10,796,275	40	3,069,999 (28%)
	# 4	year 3	10,783,325	40	8,589,338 (80%)

The total volume of allowances offered through auctions was **200,699,400** of which **23,593,889 (12%)** remained unsold. The price range at the actions was **40 to 83.93**. As the simulation advanced the auctions were less used and clearing prices remained at the minimum. The prices only raised on the last two auctions from year 1 as participants struggled to get enough allowances to end the year in compliance and during the only year 3 vintage auction during year 2 as participants planned ahead for compliance of the last year.

Teams A, B and C Results Comparison

Metric	System To Date (Y1 – Y3 totals)			Average
	A	B	C	
Forecast Emissions for all Economic Sectors	1,108,560,267	1,107,579,102	1,108,552,232	1,108,230,534
Allowances Sold by Government	174,839,062	138,136,904	160,325,153	157,767,040
Allowances Surrendered to Government	\$909,751,275	\$872,026,062	\$910,168,686	\$897,315,341
Auction Revenue Collected by Government	\$12,792,563,127	\$6,256,293,194	\$7,695,533,313	\$8,914,796,545
Average Allowance Sale Price	\$73.17	\$45.00	\$48.00	\$55.39
Offsets Surrendered to Government	23,864,113	22,016,304.00	22,406,182	22,762,200
Average Offsets Sale Price (This system)	\$82.77	\$52.82	\$69.98	68.52
Abatement Undertaken	134,257,401	152,027,352	123,163,816	136,482,856
Emission Reduced	158,121,514	174,043,656	145,569,998	159,245,056
Forecast emissions less abatement undertaken	950,438,753	933,535,446	962,982,234	948,985,478
Number of Compliance Penalties applied	3	30	14	15.67
Value of Govt. Penalties Applied	\$190,166,100	\$8,484,753,900	123,163,816	\$2,932,694,605
Average Year 1 Abatements Undertaken	2.1	1.8	2.5	2.13
Range of Overall Marginal Cost of Compliance (\$/tCO ₂ e)	(-213.00) – 266.58	\$1.30 – 239.37	\$0.15 – 418.22	

Market Color:

- The above table synthesizes the Y1 and Y2 results of the three teams. Marked differences are noted with **yellow highlight**.
- Table 1 facilitates a comparison of companies between teams and an exercise that was run entirely on artificial intelligence (e.g., without human participants).
- Over the course of the entire simulation, Teams A and B posted widely different results, in particular with respect to:
 - Resources spent in allowance auctions (Team A spent most, B the least)
 - Allowance and offset unit prices (again, Team A is spent the most, B the least).
 - Abatements undertaken (B reduced emissions the most, C the least).
 - Non-compliance (A had the fewest, B the most)
- Government auction revenues and allowance prices were nearly 2x greater for Team A than B.
 - Team A participants paid significantly greater prices for offset than did Team C and B participants.
 - Team B participants reduced the most emissions.
 - The range of compliance costs was widest for Team A (~\$480) and the narrowest for Team B (\$238).
- The differences in marginal costs of compliance – both within and between the teams – is quite significant.
 - While many participants implemented strategies that were below the prevailing market price, some implemented strategies that both reduce costs (e.g., fuel) as well as provide an opportunity to free up allowances which are sold at a premium to the monies spent on the abatement strategy.
 - In contrast, other participants implemented strategies that produced costs that well above market prices which suggests that a superior performance could have been realized had participants elected to implement different strategies.
- Across all three teams there was a sell off of surplus product as participants sought to end the year – and the simulation – in balance. This sell-off resulted in lower prices for all products. In fact, the stark contrast between Y3 prices and abatement cost highlights the idea that participants could have improved their economic performance had they been more selective with abatements (which can have high costs and which are irreversible) and made greater use of the market (which allow for small expenditures of monies and without the need to make large capital outlays for projects that have lifetimes well in excess of the simulation).
- Faced with an identical challenge the participants in the three teams have implemented carbon portfolio management strategies with different results – at least in years 1 and 2. As noted in above, all three Teams witnessed a sell off towards the end of Y3.
- A high rate of compliance was achieved for all teams. Participants that were unable to comply likely faced a common challenge – a lack of actions necessary to resolve compliance shortfalls.
- Those that ended the year short paid a dear price -- \$300 per missing ton - in contrast to the Y3 prices, which closed out at prices as low as \$4.43 (Team C), \$12 (Team A), \$20/ton (Team B).
- As prices fell in Y3 participants with long positions found it increasingly difficult to find buyers – at any price.

Table 1 - OVERALL MARGINAL COST OF COMPLIANCE COMPARISON BETWEEN TEAMS A - C AND AI

Overall Marginal Cost of Compliance (\$/tCO₂e)⁴

Company Name	Unit #	AI	A	B	C
BAJA CALIFORNIA POWER CO.	1	\$10.34	\$6.16	\$6.45	\$181.67
CEMENTO MEXCENTURY	2	\$6.04	\$13.07	\$132.72	\$9.29
CHIAPAS ELECTRICIDAD	3	\$8.78	\$17.18	\$7.02	\$9.10
CHIHUAHUA GAS NATURAL Y ELECTRICIDAD	4	\$11.00	\$20.78	\$6.96	\$11.09
COAHUILA POWER COMPANY	5	\$9.20	\$20.02	\$19.86	\$6.62
COLIMA GAS COMPANY	6	\$4.15	(\$4.45)	\$71.25	\$18.85
DURANGO ELECTRICITY HOLDINGS	7	\$10.55	\$22.44	\$78.72	\$7.27
ELECTICIDAD DE OAXACA Y ASOCIADOS	8	\$11.79	\$7.15	\$40.52	\$120.18
ELECTRICIDAD MEXICANA	9	\$7.88	\$46.49	\$148.26	\$8.10
GAS Y ENERGÍA DE SALTILLO	10	\$10.01	(\$213.00)	\$80.83	\$102.45
GRUPO DE ELECTRICIDAD MICHOACÁN 1	11	\$10.71	\$18.85	\$9.31	\$9.94
GRUPO DE ELECTRICIDAD MICHOACÁN 2	12	\$8.52	\$34.15	\$11.42	\$14.64
GRUPO DE ELECTRICIDAD MICHOACÁN 3	13	\$17.33	\$29.15	\$113.56	\$328.04
GRUPO DE ELECTRICIDAD SONORA	14	\$9.77	\$80.90	\$9.52	\$2.65
GRUPO DE LEÓN ELECTRICIDAD 1	15	\$9.83	\$6.84	\$104.59	\$31.56
GRUPO DE LEÓN ELECTRICIDAD 2	16	\$6.24	\$14.90	\$11.10	\$12.64
GRUPO DE LEÓN ELECTRICIDAD 3	17	\$11.57	\$14.50	\$146.16	\$10.00
GRUPO DE LEÓN ELECTRICIDAD 4	18	(\$0.56)	(\$18.46)	\$1.30	\$0.15
GRUPO ELÉCTRICO DE SINALOA	19	\$10.57	\$246.58	\$60.01	\$34.91
JALISCO ELECTRICIDAD	20	\$7.01	\$26.83	\$11.30	\$7.74
LUZ Y GAS DE LA REPÚBLICA	21	\$12.71	\$15.49	\$21.00	\$191.88
MÉRIDA ELECTRICIDAD	22	\$11.80	\$21.52	\$239.37	\$91.37
MEXICALI UNIDO GAS Y LUZ	23	\$12.86	\$14.11	\$7.02	\$67.40
MEXICAN IRON AND STEEL CO.	24	\$4.69	\$6.58	\$132.64	\$2.62
MEXPETROCHEM SA DE CV 1	25	\$1.72	\$6.11	\$20.30	\$418.22
MEXPETROCHEM SA DE CV 2	26	\$6.79	\$11.49	\$17.86	\$8.91
MORELOS ELECTRICITY	27	\$10.03	\$11.12	\$127.77	\$12.25
NAYARIT POWER PLANT	28	\$9.29	\$233.43	\$9.83	\$138.57
PETRÓLEOS MONTERREY	29	\$8.02	\$141.80	\$126.05	\$52.43
PLANTA DE ENERGÍA DE CANCÚN	30	\$9.12	\$77.22	\$7.54	\$58.41
PODER FEDERAL	31	\$9.32	\$17.44	\$76.01	\$11.65
QUINTANA ROO ELECTRICIDAD	32	\$11.29	\$90.09	\$8.86	\$11.52
SINALOA ELECTRICITY HOLDING	33	\$9.08	\$46.51	\$7.02	\$9.89
SONORA GAS Y LUZ	34	\$9.60	\$16.96	\$4.70	\$56.37
ZAPOPAN ENERGY LTD. CO. 1	35	\$9.79	\$27.70	\$83.48	\$90.55
ZAPOPAN ENERGY LTD. CO. 2	36	\$11.71	\$4.62	\$47.90	\$11.53
ZAPOPAN ENERGY LTD. CO. 3	37	\$10.47	\$70.70	\$26.92	\$13.03
ZAPOPAN ENERGY LTD. CO. 4	38	\$10.82	\$4.32	\$10.68	\$6.64

⁴ Note Teams A – C and the artificial intelligence (AI) / bot-only simulation were run using similar parameters - 3 year term, 80% free allowances, 9% total emission reduction. However, where the Teams A – C simulation ran over an elapsed time of 3 weeks, the AI sim was run over an hour. Owing to the peculiarities of the actions of participants within each simulation we caution participants against reading too much into the comparisons.

Recommendations for teams A, B and C

The recommendations provide here should be considered by those who wish to participate in the next simulation exercise (details about which will be provided in the coming days). Reflecting on this first simulation, participants should give consideration to the following:

1. Remember that the objective is to implement a carbon portfolio management strategy that results in annual compliance at the lowest possible cost. To meet this primary objective - comply at the lowest possible cost - implement a strategy that includes the following elements:
 - Before doing any abatements or trades, write down the expected shortfall in Y1, Y2...Yx (the last year of the simulation exercise). Understand that the shortfall is a function of the initial gap between:
 - The forecast compliance obligation and the initial allocation
 - Y1 emissions and BAU. And next year's (Yn) BAU emissions equals the prior year (Yp) emissions plus 2 – 5% of Yp emissions.
 - In the absence of any actions, you will be short by at least this amount at the beginning of the next year.
 - Abate early in year 1. Select those abatements that can be implemented in a time frame that allows you to build, operate, and generate a profit from the implementation of the abatement such that your forecast compliance obligation will be profitably reduced during the course of the simulation. After implementing abatements in Y1, do not implement additional abatements, at least not without an economically sound reason to do so.
 - Temper abatement decisions with the understanding that abatements, unlike allowance transactions, are irreversible and require the expenditure of a significant amount of capital (initially and for ongoing O&M). In contrast, allowances and offsets can be secured in discrete increments. Further, whereas investments made in allowances and offsets can generally be recovered (by offering and then reselling the products into the market), the same cannot be said for capital investments in abatements (there is no means to recover the scrap value of capital invested in an abatement).
 - Actively manage and adjust your long/short positions using all of the markets. Participate in auctions that frequently have clearing prices lower to those found in the secondary market.
2. Understand and act as if markets -- and prices -- move. Know that at times there is a balanced market, with a healthy supply and demand. At other times, there will be an imbalance -- e.g., with great demand but little supply or vice versa. As such, in the absence of market certainty, give careful consideration to the prudence of making large moves that have the consequence of producing large surpluses or shortfalls. Instead, it may be prudent to make marginal adjustments that have the effect of resolving shortfalls and surpluses. While participants may be tempted to resolve long/short positions in single trades, it can be risky doing so, especially if the market moves.
3. Given the difference in markets participants may wish to (a) look for arbitrage opportunities where they buy low in one market and sell high in another and (b) avoid out of market unfavorable transactions (e.g., buyers paying more or sellers selling for less, than the market price).
4. Given the severe noncompliance cost (\$300 plus a 1 ton debit from the next year's allocation) and the opportunity to resolve compliance shortfalls at prices that are significantly discounted, never end the year short.
5. While there is value in banking rolling forward allowances from one year to the next, participants get no economic benefit to ending the simulation long. In fact, monies spent on end of simulation surplus allowances represent a direct penalty on a participant's bottom line.
6. While market orders are convenient, participants should give consideration to the use of stop loss and limit orders. Such orders provide participants with a measure of control that is not available with market orders.
7. Where offsets are less expensive – and so long as the offset limit has not been reached, give strong consideration to purchasing and using offsets.
8. OTC sometimes can be used when there are no transactions in the Exchange Market. Use the envelope on the top right corner to communicate with other participants, in order to negotiate transactions.