

The India Electricity Simulation Tool Instructor's Guidebook

How to Guide Players and Policy Discussions

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The India Electricity Simulation tool provides a friendly, non-confrontational setting where participants can study and explore the fundamental economic concepts and principles guiding competitive electricity markets. The tool simulates different player-driven interactions between distribution and generating companies under various market designs and structures. The outcomes of different policy scenarios can be compared and reflected upon to support ongoing and future public policy discussions.

This tool is part of a broader learning experience, and this guidebook is one of several. For more information, visit raponline.org.

Bostian Consulting LLC programmed the simulation tool; it is freely available online at <https://ies.bostian.consulting/home>.

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Glossary

Buildable Capacity – Capacity that could be built either under contract or as a **Merchant Plant**.

Day-Ahead Planning – A **Stage** where decisions related to scheduling or power procurement for the following day are made.

Discom – A distribution company

Existing Capacity – Capacity that has already been built by previous decision-makers. This capacity either will be tied up in a **Legacy Contract** or will operate as a **Merchant Plant**.

Genco – A generating company

Legacy Contract – A long-term Power Purchase Agreement entered into by the previous decision-makers.

Long-Term Planning – A **Stage** where decisions related to long-term power procurement and investment in capacity are made.

Merchant Plant – A plant that is built and operated without any long-term financial guarantee or contract.

Parameter Set – A **Parameter Set** reflects the market structure and position of the different players in a simulation. There are five distinct **Parameter Sets** in the tool.

Real-Time Balancing – A **Stage** where decisions related to real-time dispatch of scheduled energy as well as balancing requirements are made.

Scenario – A Scenario reflects the policy case intended to be simulated. There are five Scenarios available in the tool, and each has distinct differences in the market design.

Screen – The computer Screen showing what decisions a **Discom** or **Genco** must make at that time. Each **Stage** has at least two Screens, one each for **Discoms** and **Gencos**. A **Stage** may have more than two Screens.

Simulation Event – A session of gameplay where the participants make decisions as **Discoms** and **Gencos** to simulate different interactions that take place in a wholesale power market as per their respective roles. Each session features the policy case of the chosen **Scenario**.

Stage – The time period of decision-making in the simulation event. There are three possible stages that can be played in a given **Simulation Event: Long-Term Planning, Day-Ahead Planning, and Real-Time Balancing**.

State Genco – A sibling generation company present in each Discom's service territory that is an automated computer player.

About the Simulation

The India Electricity Simulation tool provides an environment where wholesale power market transactions can be simulated to reflect real-world outcomes as closely as possible under different scenarios. The intent is not to replicate the exact operations but to offer an avenue where stakeholders and policymakers can test various market designs, understand the various interactions and evaluate the outcomes of their decisions.

Running the India Electricity Simulation tool requires assigning human participants (or teams of participants) to assume the roles of nine power sector entities as three Discoms and six Gencos. (There are also three State Genco entities, but these entities are automated computer players.) Since the tool is online, participants need not be in the same physical place to play together, although any team may find it easiest to cooperate in person.

The players have different objectives, depending on their assigned role(s). The Discoms seek to serve their customer load at the lowest possible price, and the Gencos seek to run their generator portfolio as profitably as possible. A cost has been assigned to load shedding to reflect the implicit political and economic cost. As players advance through the tool's various Stages, they must make decisions about how to interact with the other players to pursue their objectives. The decisions players must make will depend on the overall market design and the policy rules of the chosen Scenario. Additionally, players may be influenced by the different starting conditions of the chosen Parameter Set.

By playing multiple Scenarios with different Parameter Sets, participants can experience how different policy rules and market conditions impact their decision-making process and affect their success in pursuing their objectives.

Participants may benefit from studying or discussing economic theory prior to playing. Economic theory can predict the results of different market decisions and therefore can guide participants in decision-making. In [past workshops](#) featuring the India Electricity Simulation tool, RAP and its partners first presented lectures that are now available as free [online videos](#).

The simulation tool is designed to bridge the gap between theoretical economic concepts and practical public policy discussions through an experimental economics approach. After playing, participants will have a greater understanding of the economic implications of different market policy rules and policies to protect against unfair market structures.

Your Role as an Instructor

The India Electricity Simulation tool is a way for you as an Instructor to guide participants in public policy discussions about different market policy rules. This guidebook explains how to operate the tool and how to choose between different tool settings.

You have four basic tasks:

- Set up an Instructor Account.
- Set up a Simulation Event.
- Guide participants through the Simulation Event.
- Lead a discussion on the results and the implications for public policy.

Set up your account and any Simulation Event(s) well in advance of having participants sit down to play. The basic “how to” is explained in the appendices.

Before setting up a Simulation Event, however, you must decide on the tool settings. Different settings are conducive to different policy discussions, so the ultimate question you face is: *what do you want your participants to learn?*

The next section explains the simulation tool and its possible settings and makes recommendations for different learning objectives.

Understanding the Simulation Tool

The Purpose of the Tool

Before choosing particular settings, you will need to understand what the simulation tool does.

In real life, Discoms and Gencos interact to buy and sell electricity. The time-scale of these interactions varies. Some interactions play out over the long-term: a Genco may need years to build a new generating plant, and a Discom may contract to buy power from that plant for years following its construction. Other interactions last only a short period of time, with decisions made for the following day or hours or minutes.

Moreover, there are various market designs and structures which shape the decision making of Discoms and Gencos in a wholesale electricity market. The simulation tool makes it possible for players to experience how different policy rules and different market conditions affect their decision-making and their success as a Discom or Genco. In this way, players can experience the difference between, for example, bilateral day-ahead scheduling and having a centralised auction for scheduling resources. Players can also experience first-hand the impacts of different market conditions, like having a world with more or fewer flexible resources or having a world where one player has established unhealthy market dominance or even operating in a world where you build your company from scratch!

The simulation tool asks players to assume the roles of Discoms and Gencos and to make the same kind of long- and short-term decisions that these entities face in the real world. However, the tool takes only moments as opposed to decades or days, to reveal the outcomes of different player decisions.

The Language of the Tool

To choose the settings you want, you need to consider the options at different layers of the tool. Here is a hierarchical explanation of some relevant vocabulary, which is also listed in the Glossary:

- The tool allows you to create one or more Simulation Events.
 - In a Simulation Event, you may add one or more simulations.
 - For each simulation, you must choose a Package.
 - A Package combines exactly one Scenario (policy rules) and exactly one Parameter Set (starting conditions), which together apply for the entire session.
 - Some Packages have more Stages than others.
 - You can create multiple simulations to allow players to experience and compare different policy designs.
 - Note that players may change roles between two different simulations, so a player can be a Discom in one and a Genco for the

next. However, a player cannot change roles during a simulation

Tip: *We recommend one Simulation Event per meeting of participants. For instance, if you are using the tool as part of a workshop create one Simulation Event for that workshop. If you are hosting multiple workshops, create separate Simulation Events for each individual workshop.*

We recommend that you limit each Simulation Event to 4 simulations for easy comparison between the different packages.

To create each session in a Simulation Event, you must assign that session one specific Package. There are 18 possible Packages.

To choose a Package, you need to understand the significance of the Stages, the Scenarios, and the Parameter Sets.

Understanding the Stages and Screens

There are three Stages:

- Long-Term Planning
- Day-Ahead Planning
- Real-Time Balancing

The simulation is programmed with three representative days to reflect a typical day of three seasons (high-load summer, moderate-load monsoon, low-load winter). These conditions may differ from those experienced in real life.

Decisions made during Long-Term Planning affect the Discoms and Gencos throughout the rest of the session where decisions made during Day-Ahead Planning and Real-Time Balancing only affect participants during that particular simulation day.

A typical Package proceeds as follows:

- Long-Term Planning (occurs once)
 - Discoms and Gencos interact to determine capacity procurement and construction.
- Day-Ahead Planning (occurs three times, once for each simulation day)
 - Discoms and Gencos interact to determine power procurement for one 15-minute time-block on a day-ahead time horizon.
- Real-Time Balancing (occurs three times, once for each simulation day)
 - Discoms and Gencos interact to balance the grid for the same 15-minute

time-block

- Display of simulation results

Tips: *Expect a complete session to take about 45-75 minutes. The time may vary depending on how quickly participants make decisions and scenario chosen.*

For a faster session, consider using a Package with fewer Stages.

In each Stage, Discoms and Gencos see two different Screens: Genco Evaluation and Discom Evaluation.

Depending on the Scenario, participants may proceed through these screens simultaneously or consecutively.

Note that participants cannot advance to the next Screen until all decisions for all participants have been made.

Tip: *If the session is not progressing to the next Screen, check that all decisions have been made by all players. Look out for a red tab on the top-right of the screen for pending decisions.*

Key Takeaways:

- A typical Package has three possible Stages.
- A Long-Term Planning Stage always has at least three Screens, two for Gencos and one for Discoms.
- The Day-Ahead Planning and Real-Time Balancing Stages always have exactly two Screens, one for Gencos and one for Discoms.
- Participants only see their own Screens.
- Participants cannot advance to the next Screen unless all decisions have been made by all participants.
- The results Screens are displayed at the end of all Stages and can be viewed by all participants.

Understanding the Scenario Options

The simulation tool currently offers five different Scenario options. Each Scenario imposes different policy rules and market design for each of the three Stages.

Scenario 1 features a completely decentralized bilateral market with DSM. This Scenario is designed to reflect the current policy context in India.

- During Long-Term Planning, Gencos and Discoms enter into long-term power purchase agreements (PPAs).
 - Gencos bilaterally submit long-term contract offers to each Discom to finance new capacity construction.
 - Discoms have a choice to accept or reject these offers as per their evaluation of their procurement portfolio. If they accept the contract, then they promise to pay the fixed cost to the generator for all days of the simulation, and the energy charge as per the quantum of energy dispatched on each day.
 - However, if rejected, Gencos would still get an opportunity to build the same capacity as Merchant Plants.
- During Day-Ahead Planning, Discoms self-schedule from their own portfolio of contracted generators as well as the merchant generators in their service territory who have offered to sell power bilaterally.
 - Gencos who own Merchant Plants must submit their offers to Discoms in the respective territories of the Merchant Plants.
 - Discoms have to adhere to the technical constraints imposed by the system operator while scheduling generators. In other words, Discoms cannot trade with other Discoms.
- During Real-Time Balancing, the Deviation Settlement Mechanism assigns financial penalties or rewards based on the grid frequency to encourage the necessary adjustments.
 - Discoms can adjust the schedule of their contracted plants.
 - Gencos can adjust the schedules of the Merchant Plants.

Note that Discoms aim to serve their real-time load net of any renewable energy generation. Thus, the Gencos offer only dispatchable capacity (labeled Coal or Gas-CC, though other dispatchable capacity exists in real life).

The variation Discoms see in planning between the forecasted schedule and the real-time demand reflects the need for better load forecasting and better supply forecasting.

Scenario 2 envisions a completely centralized market where everything from capacity procurement to real-time balancing happens through a central marketplace. Scenario 2 is under-works.

Tip: You can simulate Scenario 5, which is a good option to simulate decentralized capacity procurement with centralized day-ahead and real-time markets.

The next four Scenarios reflect market designs in between the above two extremes.

- Scenarios 3 and 4 feature a unique policy rule during Long-Term Planning or Day-Ahead Planning, respectively. Scenario 3 supplements bilateral negotiations by allowing Discoms to negotiate among themselves (see the discussion of the Discom Resale Screen above). Scenario 4 allows bilateral negotiations for scheduling contracted plants, but imposes a mandatory centralised auction on a portion of the Discom's load.
- Scenario 5 features bilateral negotiations during Long-Term Planning and centralised auctions for both other Stages.
- Scenario 6 features centralised auctions during Real-Time Balancing and bilateral negotiations for both other Stages.

The following table summarises these Stage by Stage distinctions:

Scenario	Long-Term Planning	Day-Ahead Planning	Real-Time Balancing
1	Bilateral	Bilateral	Deviation Settlement Mechanism
3	Bilateral + Discom Resale	Bilateral	Deviation Settlement Mechanism
4	Bilateral	Bilateral + Centralised Auction	Deviation Settlement Mechanism
5	Bilateral	Centralised Auction	Centralised Auction
6	Bilateral	Bilateral	Centralised Auction

Simulating different Scenarios enables participants to experience different policy rules. Consider which Scenario most closely aligns to your learning objectives.

We recommend starting with Scenario 1, the current business-as-usual policy case. This Scenario can be useful for introducing participants to the current market design and for evaluating the pros and cons of the current design. Then we recommend running Scenario 5, which most closely matches the proposed market reforms in India.

Tip: Start with Scenario 1, then run Scenario 5. These two provide a contrast between the current market design and the proposed reforms.

Key Takeaways:

- There are two possible market design options for each Stage:
 - Bilateral negotiations, or during Real-Time Balancing through the Deviation Settlement Mechanisms (DSM),¹
 - a centralized auction.

Understanding the Parameter Set Options

The simulation tool offers five different Parameter Sets. Each Parameter Set positions the participants differently at the beginning of the session. How participants begin the session can advantage or disadvantage them. The chosen parameters may also affect how favorably or unfavorably one views a different Scenario.

In real life, there are several parameters that can affect the outcome of a policy in addition to the policies in place (e.g., market concentration). To understand a Scenario, one should examine it under the lens of varying starting conditions.

Before we get into the details of the five parameter sets, there are certain common elements which apply to them all.

- The simulation has a 31800 MW power system which includes both existing and buildable capacity.
- The load profile for each of the three representative days remains the same across all scenarios and parameter sets. The peak system load is 27000 MW with a probability of 4%
- All long-term contract offers will be on average cost basis and the break-up of fixed cost and energy charge will be calculated automatically.

As of this writing, the five Parameter Sets are only available for Scenarios 1 and 5. The other Scenarios come only with the default Parameter Set.

1. The Default

The default Parameter Set offers neither a perfectly level playing field nor a grossly disparate market.

- Discom 3 has around 82 percent Legacy Contracts whereas the other two Discoms have less than 40 percent Legacy Contracts.
- State Gencos contribute to more than 80 percent of the total Legacy Contracts in the set.
- The range of Genco's cost structures are widespread i.e. some plants have low

¹ The simulation tool is currently programmed according to the 2014 DSM Regulations with the administered price vector. The Central Electricity Regulatory Commission is considering revised regulations as of the time of this writing.

If participants are unfamiliar with the DSM, it may be helpful to have them review the 2014 Regulations.

variable costs while some plants have very high variable costs.

- System Capacity Info:
 - 18800 MW existing and 13000 MW buildable capacity
 - 25400 MW coal and 6400 MW gas capacity

This Parameter Set aims to reflect possible real-world conditions where participants begin in a range of starting conditions, none specifically better or worse than any other.

2. Level Playing Field

This Parameter Set is designed to simulate the outcomes of a policy case where all players in the market are on a level playing field and begin the simulation with a fair start.

- All Gencos have around 11 percent share of total capacity.
- All Gencos have 70 percent coal and 30 percent gas plants.
- All Discoms have around 45 percent Legacy Contracts
- All players have a similar cost structure and number of Legacy Contracts.
- System Capacity Info:
 - 16200 MW existing and 15600 MW of buildable capacity
 - 25500 MW existing and 6300 MW gas capacity

The objective is to provide the participants with an easy entry point into the simulation, allowing them to understand and familiarize themselves with the rules, player roles, and simulation interface. Additionally, it allows them to experiment with and apply the economic concepts before more complexities are introduced to the simulation.

***Tip:** For first-time participants, choose a Package with the Level Playing Field Parameter Set.*

3. Market Power: Generation

This Parameter Set is designed to create a market structure dominated by a single Genco (National Genco) to simulate the influence of market power on different policy cases.

- National Genco has over 25 percent share of total capacity and the rest have between 8 – 10 percent.
- National Genco has around 60 percent legacy contracts and the rest have between 14 - 18 percent.
- National Genco's average variable cost for coal plants is 10 percent lower than the rest. All Gencos have similar average variable costs for gas plants.
- All Discoms have the same total capacity available to them. However, Discom 3

has around 65 percent legacy contracts and the rest have around 40 percent.

- System Capacity Info:
 - 7600 MW existing and 14200 MW buildable capacity.
 - 25400 MW coal and 6400 MW gas capacity

The objective is to simulate whether market power can be exercised and how it may affect the outcome.

4. Inflexible Generators

This Parameter Set is designed to reflect grid inflexibility through less flexible capacity available to Discoms.

- Discoms have only 7 - 15 percent flexible capacity available.
- Gencos have only 13 - 17 percent flexible capacity available.
- Load deviation ranges from 12 percent to 33 percent of forecast load, depending on the type of day.
- Average variable cost of flexible plants is roughly two times that of inflexible plants.
- System Capacity Info:
 - 18600 MW existing and 13200 buildable capacity
 - 28200 MW coal and 3600 MW gas capacity

The objective is to simulate the consequences of grid inflexibility as the penetration of intermittent sources of generation increases. This Parameter Set highlights the need to adopt good forecasting techniques to minimise the deviation between actual load and forecasted load. This would reduce the burden of correcting a highly imbalanced grid on the system operators.

Remember, Discoms aim to serve their real-time load net of renewable generation. Without good forecasting, Discoms may experience significant deviations from the day-ahead schedule to serving real-time load.

5. No Long-term Contracts

This Parameter Set is designed to allow participants to build their own portfolio without too many Legacy Contracts.

- Discoms have only one Legacy Contract with their respective State Gencos for coal generation and two Legacy Contracts with other Gencos for gas generation. Therefore, they have around 15 percent capacity in Legacy Contracts.
- Gencos have no Legacy Contracts (except the State Gencos).

- Gencos have around 85 percent buildable capacity.
- System Capacity Info:
 - 8400 MW existing and 23400 MW buildable capacity.
 - 25500 MW coal and 6300 MW gas capacity.

The objective is to simulate and study the long-term strategies of players who face the responsibility of developing their own portfolio completely. Their long-term strategies will have a direct effect on the outcomes in the day-ahead and real-time markets.

***Note:** If in a day-ahead centralized market, the requested load is higher than the installed capacity in the system then the market may pro-rate the available generation amongst the three Discoms.*

Understanding the Package Options

The simulation tool offers 18 Packages. For each session in your Simulation Event(s), you must select one of these 18 Packages.

As discussed above, there are five different Scenario options. These five are available with the default Parameter Set (5), plus two Scenarios may be played using the additional four Parameter Sets ($2 \times 4 = 8$).

The remaining five Packages have been streamlined as modular Stages. These five Packages skip either the Long-Term Planning Stage or both the Long-Term Planning Stage and the Day-Ahead Planning Stage. You can have participants play only the Long-Term Planning Stage or only the Long-Term Planning Stage and the Day-Ahead Planning Stage by stopping the simulation early.

Playing only one Stage or only two of the three Stages may help introduce participants to the simulation tool, or may help participants understand particular Stage(s) better.

***Tip:** Play a modular Package or stop a session early to introduce participants to the simulation tool interface or to study particular Stage(s) in greater detail.*

The following table lists the 18 Packages and describes which Scenario, Parameter Set, and Stage(s) each offers.

Package	Scenario	Parameter Set	Stages
1: Business as Usual	1	Default	All
1a: Long-Term Fast Forward	1	Default	Day-Ahead Planning and Real-Time Balancing
1b: Level Playing Field	1	Level Playing Field	All
1c: Genco Market Power	1	Market Power: Generation	All
1d: Inflexible Generators	1	Inflexible Generators	All
1e: No Long-Term Contracts	1	No Long-term Contracts	All
1f: Compressed and Fast-Forward	1	Default	Real-Time Balancing
3: Resale of Long-Term Contracts	3	Default	All
4: Partial Day-Ahead Auctions	4	Default	All
4a: Compressed and Fast-Forward	4	Default	Day-Ahead Planning and Real-time Balancing
5: Auctions during Day-Ahead and Real-Time	5	Default	All
5a: Long-Term Fast Forward	5	Default	Day-Ahead Planning and Real-Time Balancing
5b: Level Playing Field	5	Level Playing Field	All
5c: Genco Market Power	5	Market Power: Generation	All
5d: Inflexible Generators	5	Inflexible Generators	All
5e: No Long-Term Contracts	5	No Long-term Contracts	All
6: Auctions during Real-Time	6	Default	All
6a: Compressed and Fast-Forward	6	Default	Real-Time Balancing

As mentioned earlier, each package can be differentiated by policy Scenario, Parameter Set, and number of Stages. As an instructor, you must choose the package depending upon the objective and learning outcome that you aim to achieve by the end of the simulation.

Note: There is three types of information in the simulation: public, private and unknown. The simulation is designed to have incomplete information as to reflect the real-world situation closely. Flow of information may vary depending upon the scenario.

Recommendations for Instructing First-Time Participants

The simulation tool has a lot of information for new players to process. As an instructor it is important for you to familiarise the players with all of the information, rules, and the interface before moving onto strategic decision-making.

Therefore, we recommend that you start with Scenario 1. Scenario 1 is designed to reflect India's current power market design as closely as possible. Hence, it serves as the business-as-usual case. There is long-term bilateral contracting similar to existing PPAs: a bilateral self-scheduling day-ahead stage followed by the Deviation Settlement Mechanism to manage real-time imbalances in the grid.

There are seven packages under Scenario 1. For first-time participants it's best to simulate package 1b: Level Playing Field, which offers a simple introduction to the tool since all players start at the same level with no strategic advantages. There is no market leader or dominant player and hence participants can focus on exploring the simulation interface and understanding the information presented.

Similarly, Scenario 5 is designed to reflect a centralised market with bilateral long-term procurement. Therefore, the long-term procurement still takes place bilaterally; however, players have to transact for their day-ahead and real-time energy needs through a central market.

There are six Packages under Scenario 5, and Package 5b: Level Playing Field can be simulated for new players. The interface remains largely the same as Scenario 1; however, the players have to make different decisions in Scenario 5 since the design for day-ahead and real-time Stages is different. Hence, to start with, we recommend that you simulate the level playing field set to allow participants to absorb the change in rules without worrying about strategic decision-making.

Modular Packages

The tool also offers a few modular Packages which can simulate specific Stages under different market designs. These modular Packages are useful to run quick simulations and focus the learning on just specific stages.

For example, you can simulate the long-term Stage of any full simulation package and simply end the session after the long-term Stage if your objective is to focus only on investment decisions, long-term contracts, type of capacity to build, etc.

***Note:** If you decide to end a simulation midway, the summary results will not be computed. You can only review the progress up to the point where you stopped.*

There is a total of five modular Packages which can simulate the day-ahead and real-time Stages together as well as individually under different market scenarios.

There are three Packages which skip through the long-term procurement stage and players only have to make day-ahead and real-time decisions. You can simulate the following Packages when long-term decisions are not part of the focus. This can help participants experience an environment in which they have to operate based on the decisions made by others.

- 1a: Long-Term Fast Forward
 - Designed under Scenario 1, this Package simulates bilateral day-ahead interactions and real-time balancing as per the DSM. Participants will play through three simulation days.
- 4a: Compressed and Fast Forward
 - Designed under Scenario 4, this Package simulates bilateral and centralised day-ahead interactions and real-time balancing as per the DSM. Participants will play through only one simulation day.
- 5a: Long-Term Fast Forward
 - Designed under Scenario 5, this Package simulates centralised day-ahead and real-time interactions. Participants will play through three simulation days.
- Important lessons: when to run a plant; which plants to run (flexibility); auctions and exchanges; bidding strategies, etc.

There are two Packages which skip through the long-term procurement and day-ahead procurement stage. Players only have to make Real-Time Balancing decisions for the monsoon simulation day. You can run these packages to focus on the imbalance management closer to real-time.

- 1f: Compressed and Fast Forward
 - Designed under Scenario 1, this package simulates only the DSM. Participants will play through only one simulation day.
- 6a: Compressed and Fast Forward
 - Designed under Scenario 6, this package simulates only the interactions of a centralised real-time market. Participants will play through only one

simulation day.

- Important lessons: importance of flexibility; importance of good forecasting; auctions for balancing; ancillary services; benefits of larger balancing areas; etc.

Recommendations for Instructing Experienced Participants

As mentioned earlier, there are a total of 18 Packages that can be simulated. Once the participants are familiar with the interface and the information presented in the different Stages, the instructor can conduct sessions that try to address specific policy questions and require participants to evaluate various factors before making decisions.

Each Scenario has one full simulation Package which is paired with the default Parameter Set. Instructors can use this Package to simulate the outcomes of each market design in an environment which has different elements of the real-world market structure. You can refer to the section above which describes the characteristics of the default set in detail as well as the design of each of the five Scenarios.

- 1: Business as Usual
- 3: Resale of Long-Term Contracts
- 4: Partial Day-Ahead Auction
- 5: Auctions during Day-Ahead and Real-Time
- 6: Auctions during Real-Time

The remaining four Parameter Sets can be simulated only with Scenario 1 & 5. These two Scenarios provide a good comparison between two different market designs which are relevant in the Indian context.

Level-Playing Field

- As described above, Package 1b and 5b provide a good entry point to these two policy scenarios as they are packaged with the level-playing field set. Although the level playing field set is ideal for new participants as an introduction, it is equally useful to understand various other decision-making behaviors and their outcomes, too.
- These two Packages project an ideal market structure where no Genco has dominant control over generation and no Discom is big enough to exercise monopsony power. So the simulation can lead to interesting results every time since all players begin at the same level and the outcomes would be—to a large extent—a product of their own decision-making and not any external factor. Therefore, it is easy to isolate the effect of a player's strategy on the outcome. Multiple sessions of this Package would help participants understand and assess the outcomes of their own strategies.
- A few questions to ask: Can competition drive Gencos to adopt a marginal cost bidding strategy? To a certain extent, can Discoms fare equally in such a market structure?

Market Power Generation

- Package 1c and 5c simulate the outcomes of a market dominated by one Genco. The players start off with a different set of resources and must operate in a market which is unfairly structured.
- You can compare the interactions of the players in such an environment in both the policy scenarios to understand how their strategies and decisions change from a decentralised market scenario to a scenario with markets.
- These two Packages are also important from a regulator's and a policymaker's perspective since it allows each to understand the potential for gaming. Market monitoring and market power mitigation are really important to ensure that there are no disruptions to the market design.
- A few questions to ask: How can Discoms strategise against market power? Can the dominant Genco offer expensive LT contracts/higher bids to Discoms? Can the dominant Genco influence the market clearing price?

Inflexibility

- Package 1d and 5d simulate the outcome of a market heavily dependent upon inflexible generators. The Discoms have very few opportunities to include flexible generators in their portfolio and similarly, the system operator has to manage a grid without flexible resources. The burden of balancing is on the Discom in Scenario 1, whereas in Scenario 5 the system operator is responsible for a balanced grid.
- From a system operator's point of view, flexibility is going to be crucial as we look to integrate intermittent resources into the grid. The capabilities of different generators will help the system operator co-optimize ancillary services with the day-ahead and real-time markets. This package can illustrate how difficult it is to maintain a balanced grid when there are few flexible resources available to access.
- You can simulate these Packages to assess and evaluate the value of good quality forecasting and the need for different capabilities in the system. The comparison between two Scenarios can help you understand which design is effective in dispatching low-cost flexible resources in real-time.
- A few questions to ask: Is load shedding/curtailment inevitable with an inflexible generation portfolio? Will Discoms end up overprocuring to avoid load shedding? Can forecasting help reduce the need to maintain various flexible resources?

No Long-Term Contracts

- Package 1e and 5e simulate a case where Discoms and Gencos have to make their own long-term decisions. Other parameter sets give the players only half an opportunity to build their portfolio, since several decisions have already been made at the start of the simulation. These packages allow players to make all their long-term decisions and reflect upon the results of their decisions at the end.
- Long-term contracts have always been the way forward for Gencos as well as Discoms. Failure to enter into a contract can potentially break down a power

plant's entire revenue model. It is important to study the outcomes of a Scenario where Discoms and Gencos rely on the market for a substantial portion of their electricity transaction. It is important to hedge against the volatilities of the market, but is signing long-term contracts the only the way out?

- Important questions to ask: Is there an optimal portfolio mix of contracted and merchant generators? Can markets help the Discoms make an informed decision regarding LT contracts? Can Gencos earn more through the market or signing more contracts?

Formulas and Things to Keep in Mind

- Long-term contracts are designed to reflect the current PPA structure as closely as possible which is a two-part tariff structure. The fixed costs are paid by the Discom, regardless of whether the plant is used for generation. There is an energy charge component which is paid by the Discom for every kWh of generation dispatched/scheduled. The capacity factor is assumed to be 80% when calculating number of units for energy charge. Here's the formula for Total Fixed Cost (TFC), Energy Charge (EC) and expected generation over 3 days at 80% CF.

$$TFC (\text{₹}) = \left(\frac{\text{Capacity (MW)} \times 1000 \times 3 (\text{Days})}{4 (\text{Timeblock})} \right) \times \left(\frac{FC (p/kW/hour)}{100} \right)$$

$$\text{Units at 80\% CF (kWh)} = \text{Capacity (MW)} \times 1000 \times \frac{1}{4} \times 80\% \times 3 (\text{Days})$$

$$EC (p/kWh) = \frac{(\text{Avg.Price Offer}/100 \times \text{Units}) - TFC}{\text{Units}} \times 100$$

- The three State Genco Affiliates of each Discom are designed to exhibit a pre-defined bidding strategy in centralized markets. They will always submit bids equal to their contracted energy charge. Although in theory this is a suboptimal bidding strategy, we have designed it to reflect the imperfections of market participant behavior.
- In the results summary, an *Auction* graph will reflect all the supply offers and the corresponding demand when simulating a centralized market design. It is important to keep in mind that the x-axis (horizontal axis) reflects the total installed capacity of the plants and not the dispatched generation. It is possible that this may lead to a mismatched graph, therefore, be aware!
- In a centralized real-time market, it may happen that the fleet is not able to ramp up to meet the requested load or there is insufficient capacity in the system itself. In this case, the market will pro-rate the available power in real-time amongst the three Discom as per their request. This can be a good learning point about resource adequacy and flexibility in the system.

Appendix A: How to Set Up an Instructor Account

Before participants can play, you need to set up a Simulation Event. To do so, you must have an Instructor Account.

You will need to first create your account and then receive Instructor Account status.

Go to <https://ies.bostian.consulting/home>. This is the tool's homepage.

Click on “Register for an Account,” and fill out the fields, including a good email address. After you submit this information, you'll receive an email with a confirmation code. Go back to the “Register for an Account” page (or the “Log In” page) and click on “Confirm Account” (at the bottom of the page). Enter the same email address and your confirmation code. If you do not receive the code, click on “Resend Code.”

You can now log in! Go to the “Log In” page, and enter your email and password. You should now see the “My Simulation Events” page. This is where all the Simulation Events will appear.

To get instructor access you may contact Dheer Patel at the Regulatory Assistance Project (RAP) via email at dpatel@raponline.org.

Appendix B: How to Set Up a Simulation Event

The following instructions provide a walkthrough of creating and running an event.

Checklist:

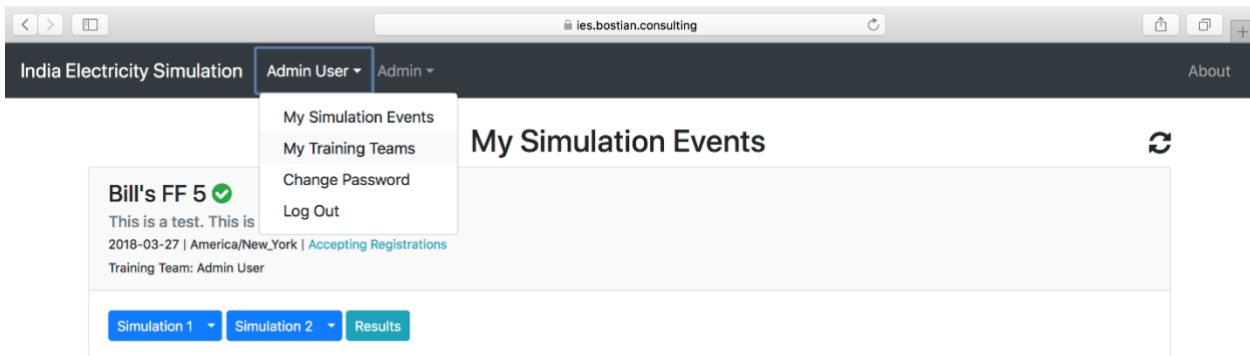
To-Do before the Simulation Event

- Create a new Simulation Event.
- Assign the Instructor Team.
- Add a Simulation package.
- Create the Decision-Making Team for the Simulation.
- Open the Simulation Event for Registration.
- Invite users to register.
- Assign registrants to Roles.

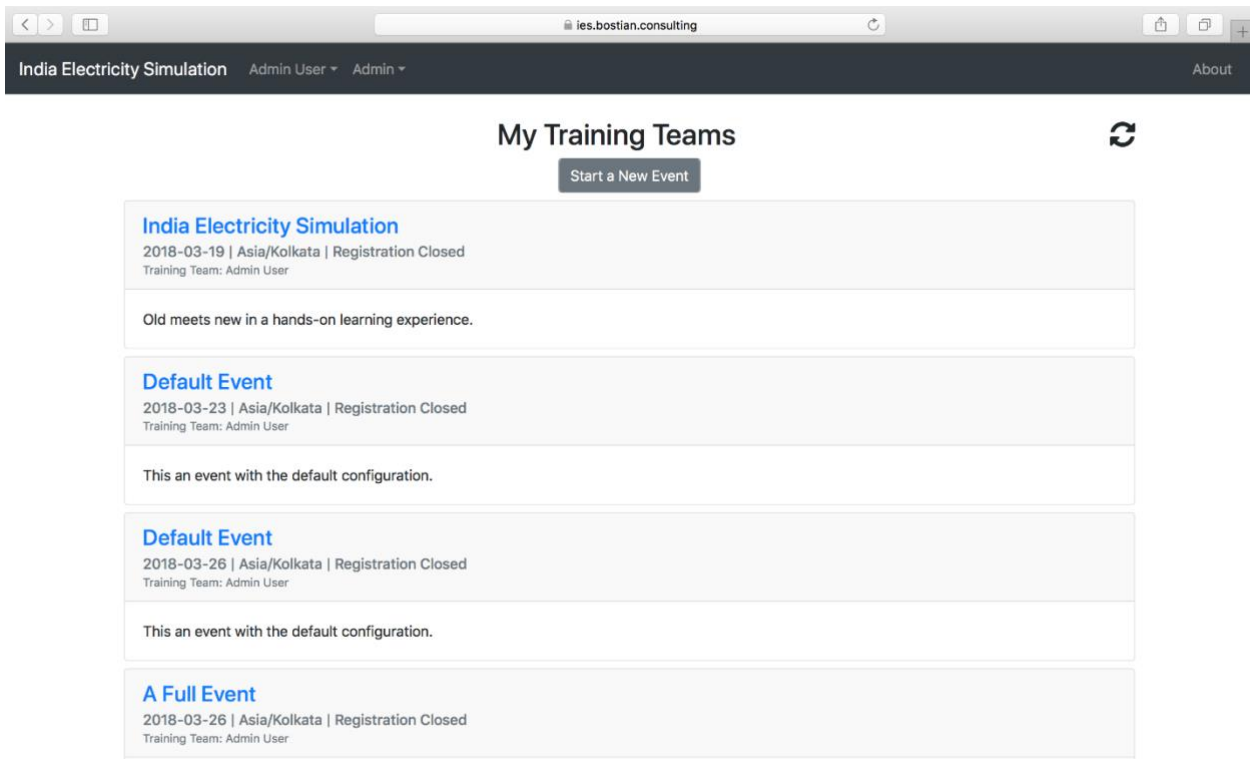
Creating a New Simulation Event

- Log in at <https://ies.bostian.consulting/sign-in>.
- The landing page after login is My Simulation Events. To access the instructor features, click User Name > My Training Teams.

My Simulation Events contains all the Simulation Events that the user is currently enrolled in.



My Training Teams contains all the Simulation Events for which the user currently has instructor status.



- To begin a new Simulation Event, click on the Start a New Event button.

- Fill out the New Simulation Event form.

Create a New Simulation Event

Title
RAP - Team Sessions - Mumbai

Description
Policy scenarios under no LT contracts.

Timezone
Asia/Calcutta

Date
02/01/2019

Registration Code
12345

Accepting Registrations?
Yes

Submit Reset

The *Title* will be visible to registrants. The *Description* will not. It is advisable to stick to a format for *Title* to make it easier to track down your events later once you have a list of several events on your screen.

The example in the screenshot uses the following template:

Name of the Organisation – Event Type – Location

Examples:

- RAP – Workshop – New Delhi
- RFF – Trial Sessions – Chicago

- UVA – Policy Discussion – Virginia

This template is recommended, as all users of the tool can see all Simulation Events that are open for registration.

The *Date* (together with *Timezone* and *Registration Code*) controls when the Simulation Event will appear in users' *My Simulation Events* as a registerable event.

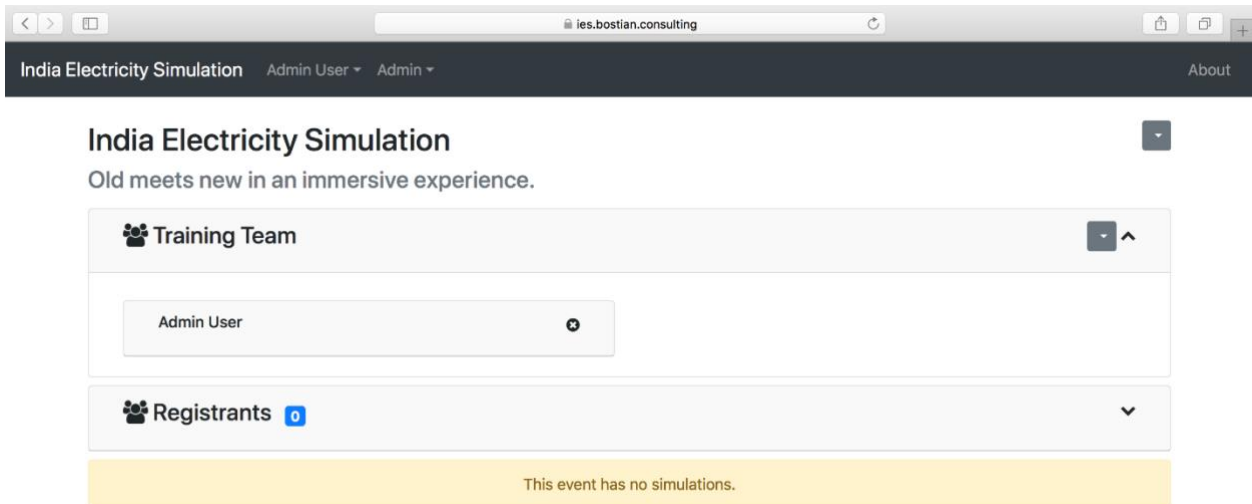
These values are editable later.

The Simulation Event can be deleted *as long as there are no decision-making teams in place*.

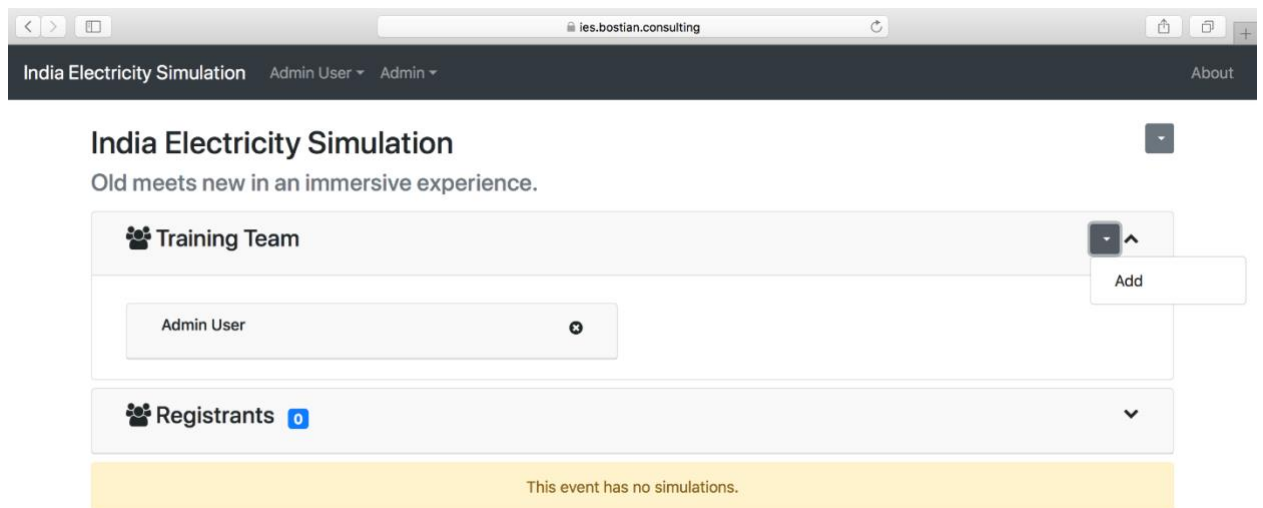
Assigning an Instructor Team

If you have a co-Instructor, you should assign them to your Instructor Team.

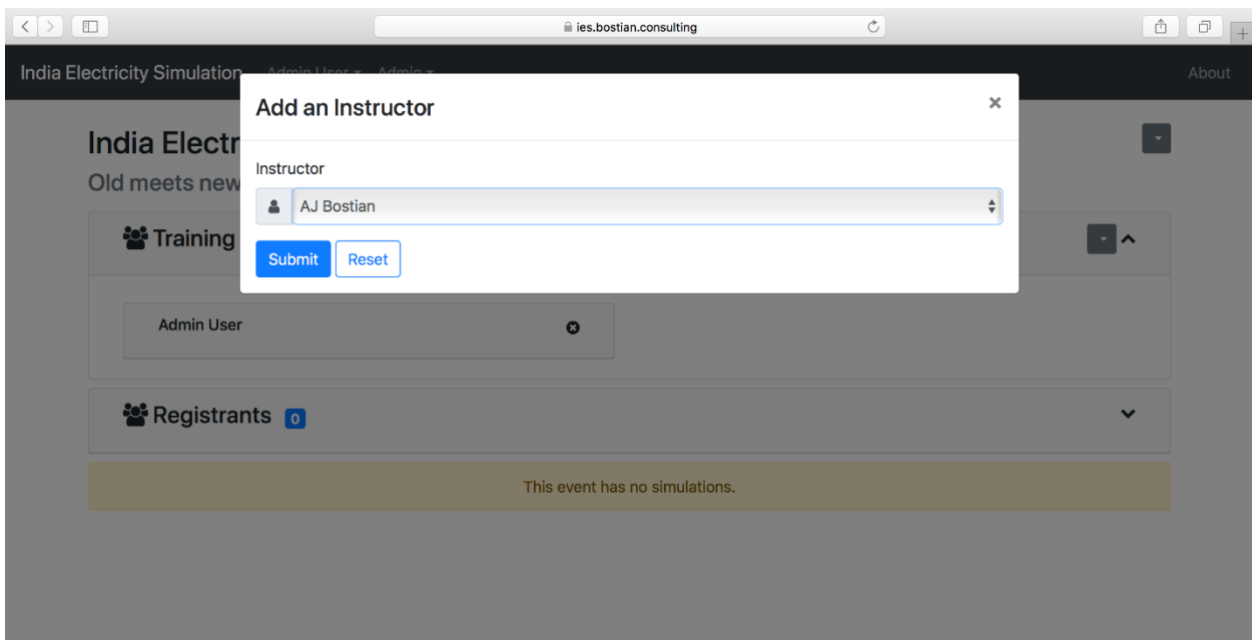
- Once the Simulation Event is created, you can view it in My Training Teams. Select your Simulation Event to view the event's management page.
- Expand the Training Team menu.



- From the dropdown menu, click Add.



- Select the user you want to add from the Add Instructor form.



Only users with instructor privileges will appear in the list.

Users must request instructor privileges from outside the app.

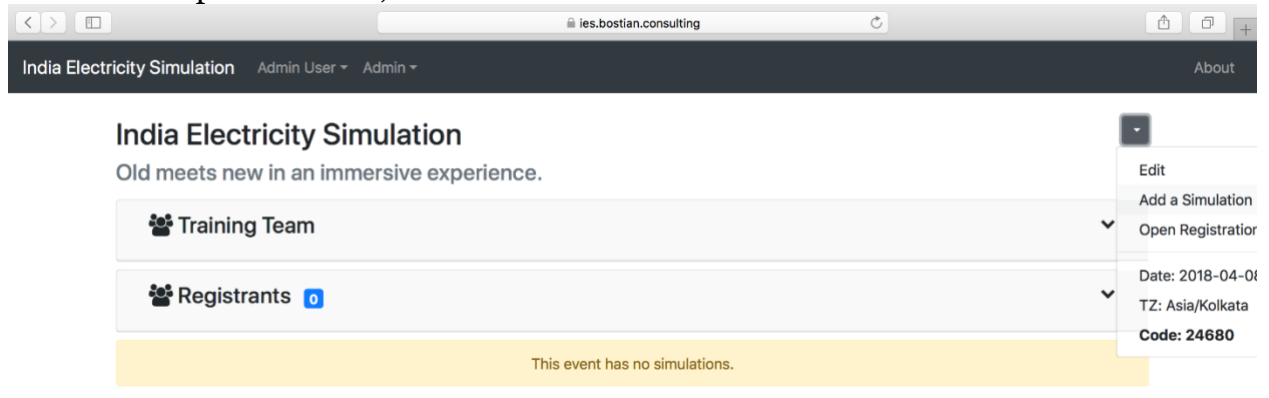
Instructors can be added and removed at any time.

- Instructors can be removed by clicking the **X** next to their name.
- You will be prompted to confirm this action.

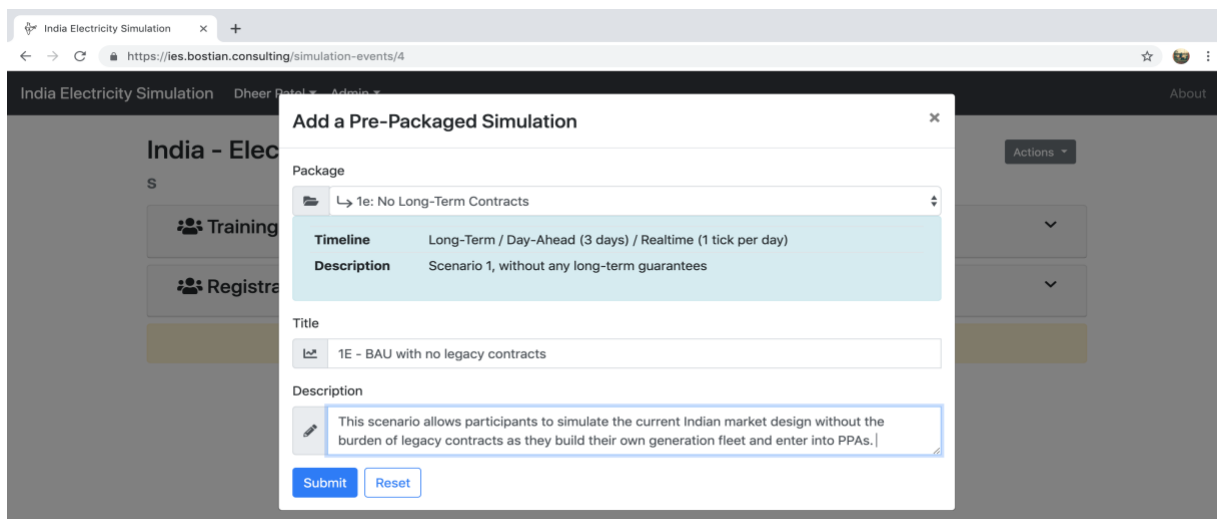
Tip: We recommend you add RAP as a co-instructor in all simulation events. This makes it easier for us to guide you through any technical difficulties and evaluate results better.

Adding a Simulation Package

- Go to the Simulation Event's management page.
 - The management page can always be accessed from My Training Teams.
- From the dropdown menu, select Add Simulation.



- Fill out the Add a Simulation Package form.

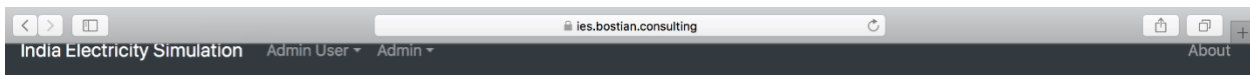


The *Title* will be visible to registrants. The *Description* will not.

Tip: Always add the package number in the title which helps you identify the scenario easily. Refer to the screenshot for an example.

The title and description can be edited later on, however it is important to note the package number either in the title or the description while setting up the session.

A Simulation Package can be deleted *as long as there are no decision-making teams in place.*

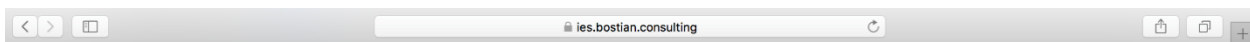


India Electricity Simulation

Old meets new in an immersive experience.

- Training Team
- Registrants 0
- India as It Exists Today
A simulation with bilateral contracts, and the deviation-settlement mechanism.

- Expand the **Registrants** option and refresh to make sure all registered participants are reflected in the list.
- Expand the simulation menu to view the setup components.

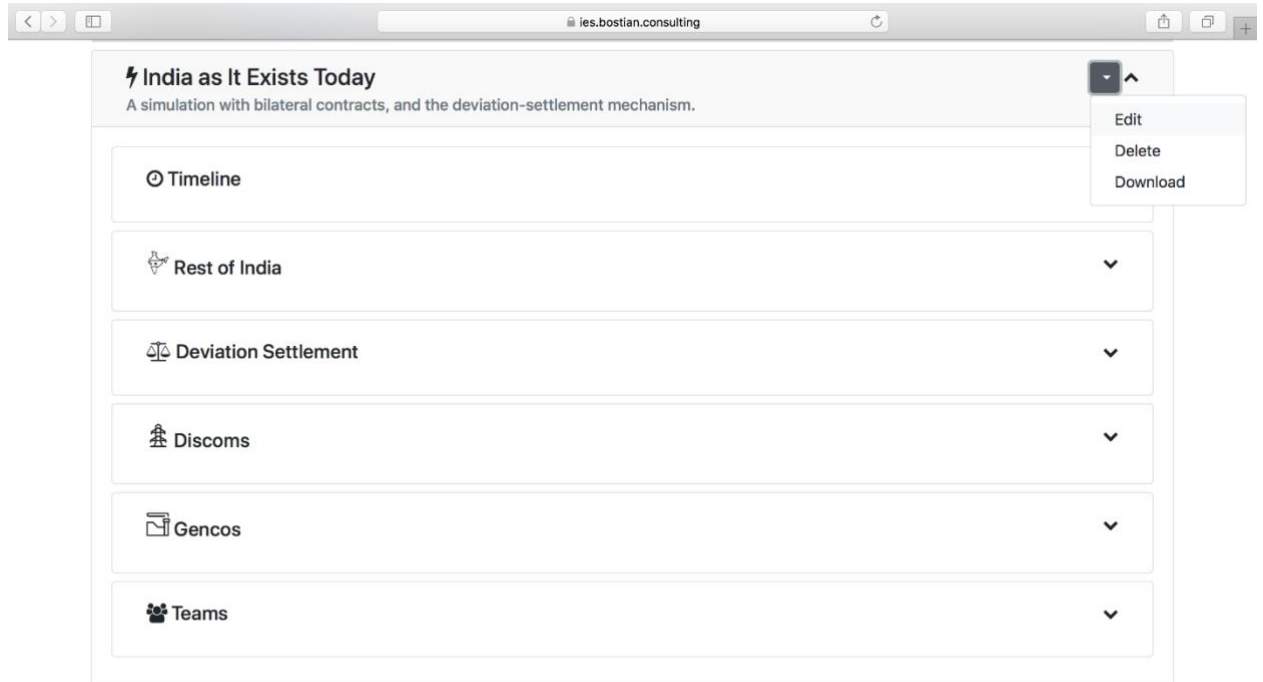


India as It Exists Today

A simulation with bilateral contracts, and the deviation-settlement mechanism.

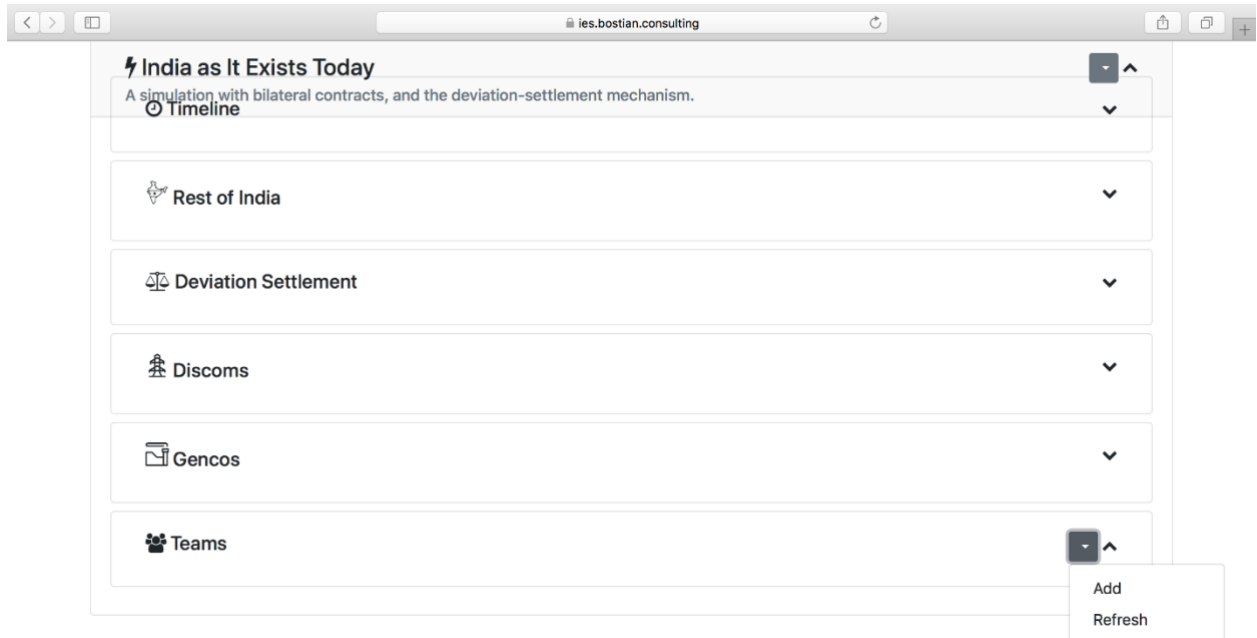
- Timeline
- Rest of India
- Deviation Settlement
- Discoms
- Gencos
- Teams

- The simulation can be modified slightly from the dropdown menu. The only editable fields are the *Title* and *Description*.

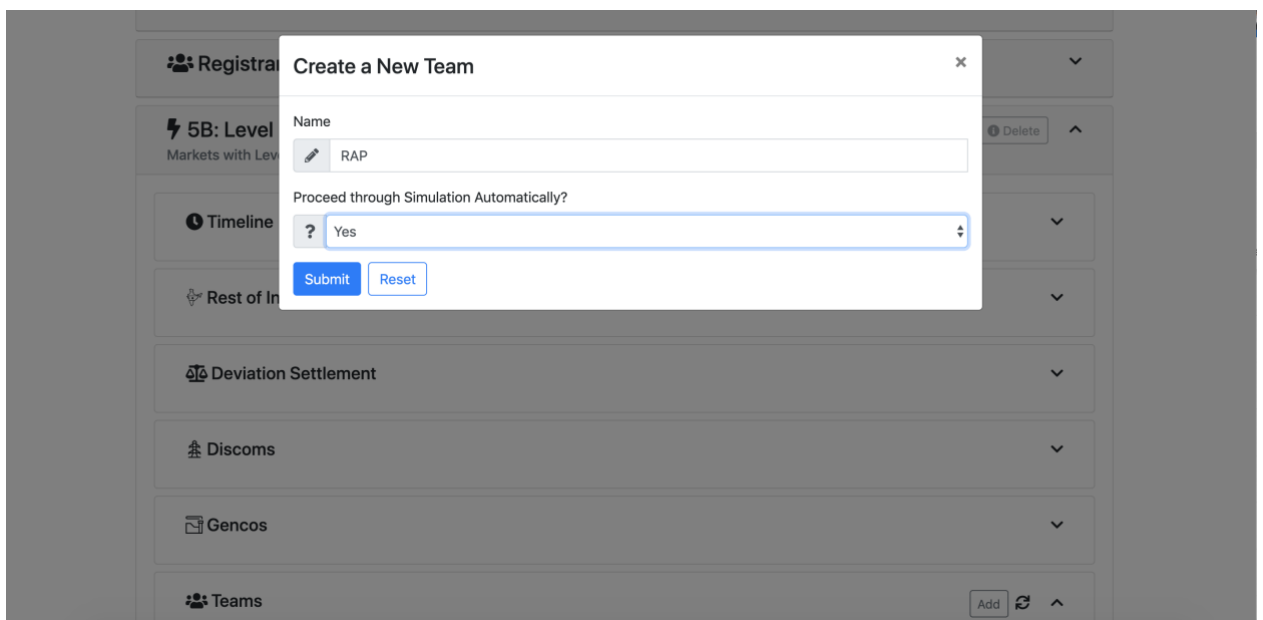


Creating a Decision-Making Team

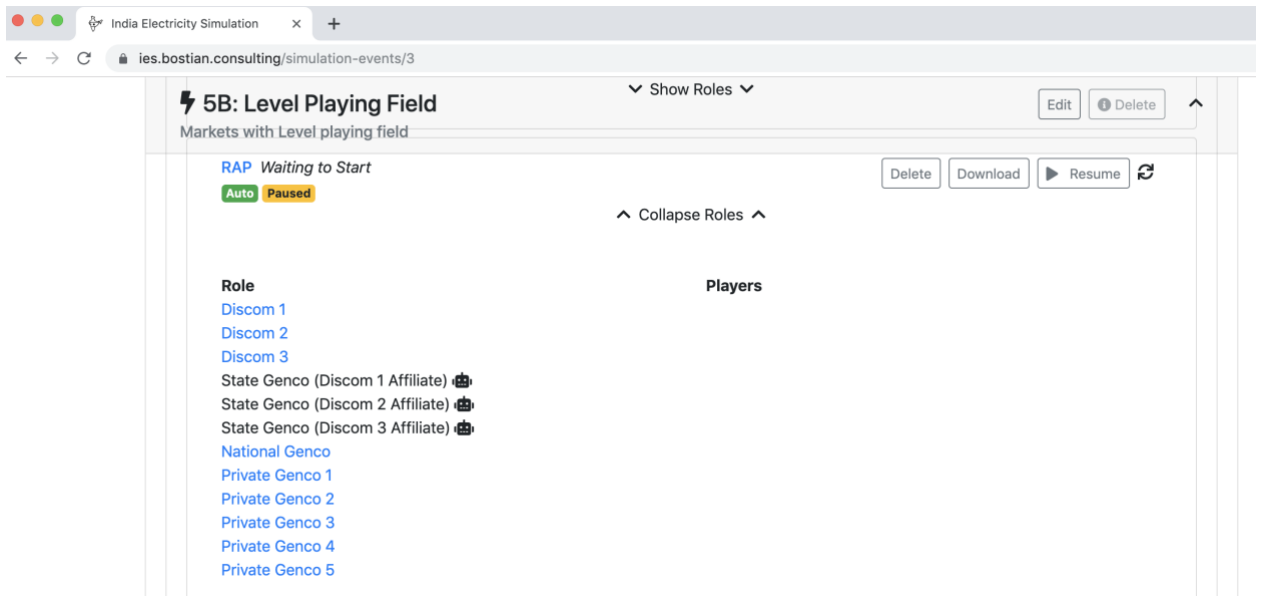
- Expand the simulation menu to view the setup components.
- Expand the *Teams* menu.
- From the dropdown menu, click *Add*.



- Fill out the New Team form.
 - The team's Name should be something descriptive.
 - Proceed Automatically should be enabled by default. Otherwise, the person running the event will need to manually step the simulation through each stage.

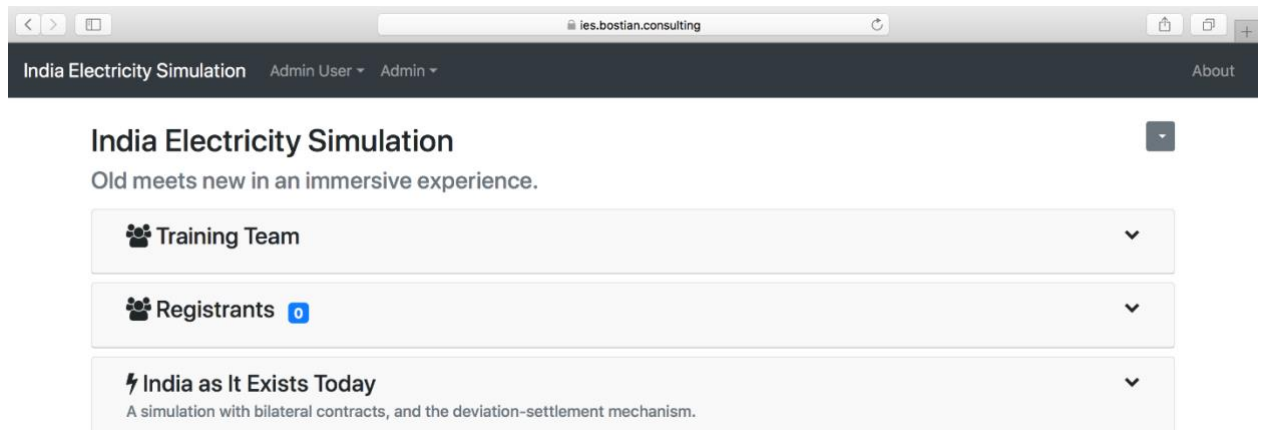


- The Team and the Stage will appear in the list of teams.
 - The Stage does not automatically refresh. Manual refreshing can be performed with the refresh icon.
 - A new Team will always start Paused. This status can be changed using the Resume option.

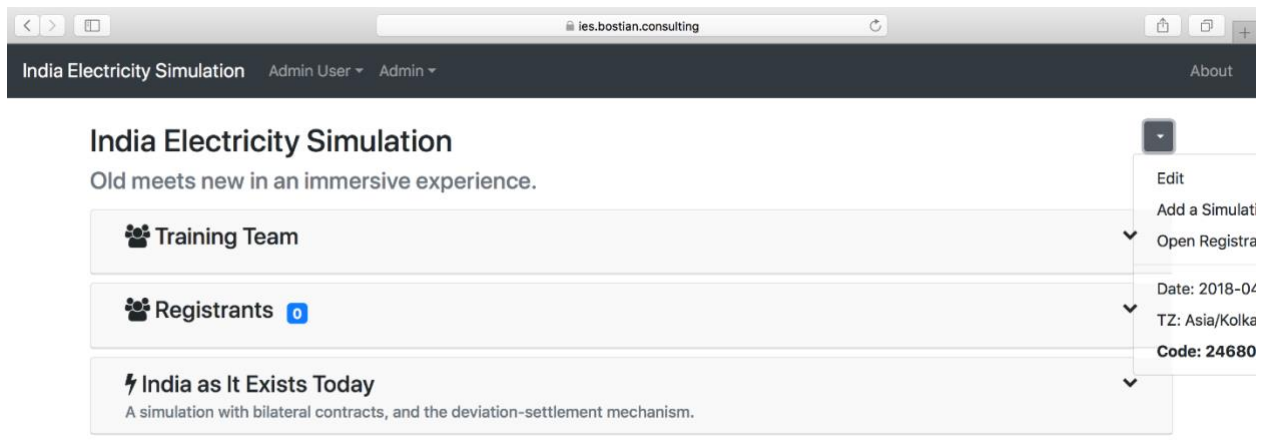


Opening the Simulation Event for Registration

- Go to the Simulation Event's management page.
 - The management page can always be accessed from My Training Teams.

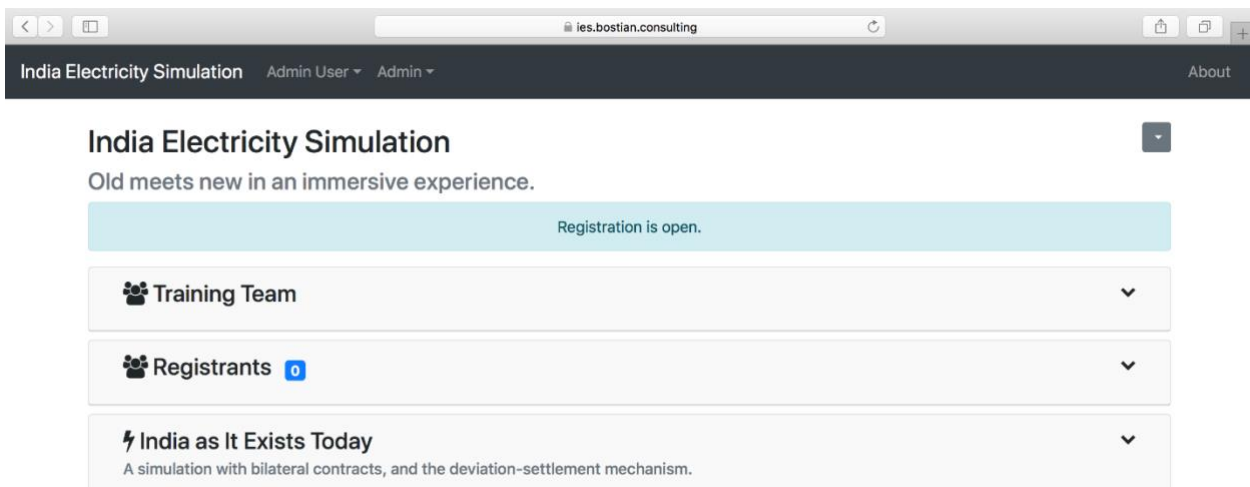


- From the dropdown menu, select Open Registration.



- Make sure to also note the Registration Code from this menu. To register, users will need to enter this code.

- When registration is open, a blue notification bar will appear.

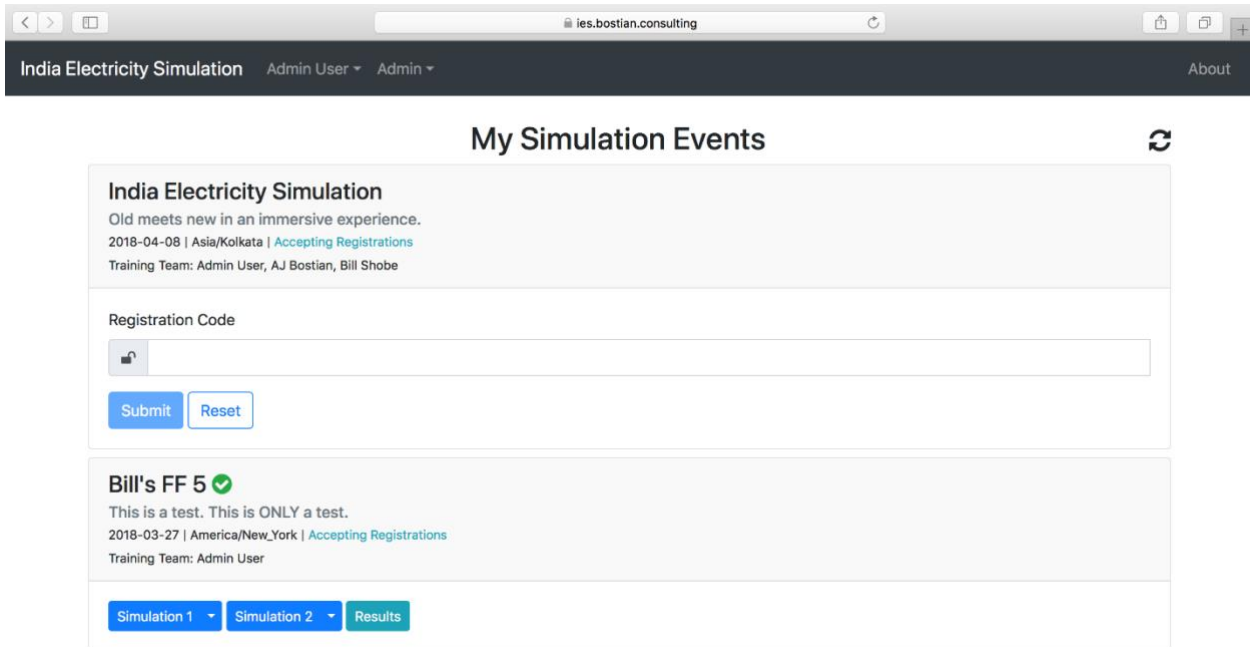


- If necessary, registration can be re-opened.

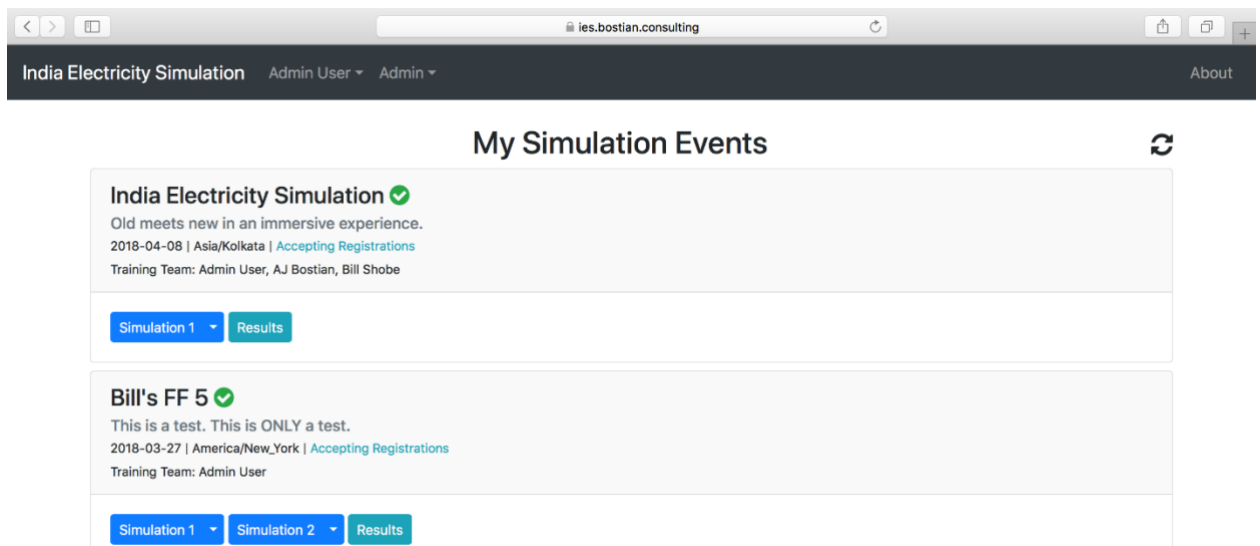
As long as registration is open, **all users of the app will see the opportunity to register** (although they cannot do so without the code). Please make sure to close registration as soon as possible.

Inviting Users to Register

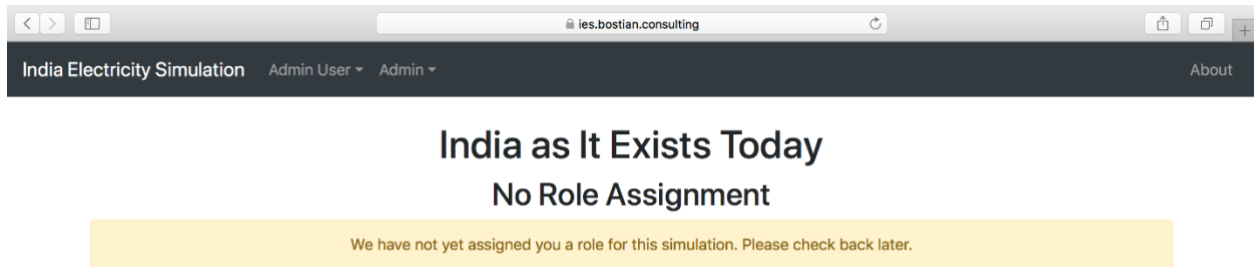
- When registration is open, users will see the Simulation Event appear under their landing page My Simulation Events. This registration opportunity appears to every user of the app. Members of the Training Team can also register.



- To register, the user will need the Registration Code that the instructor chose during setup. This code should be sent only to the people that you want to invite to this specific simulation event.
- After successfully registering with the correct Registration Code, the code box will turn into a list of simulations.

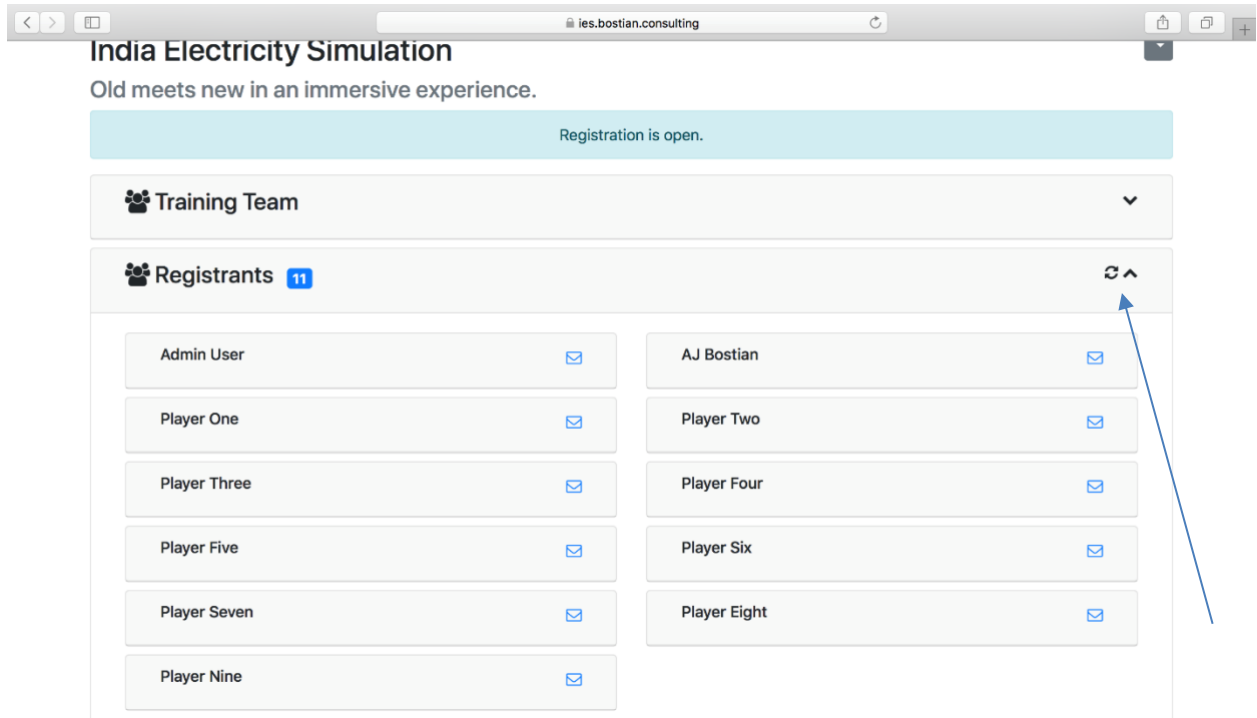


If the user tries to begin a simulation at this point, he or she will receive an error because they have not yet been assigned a role.

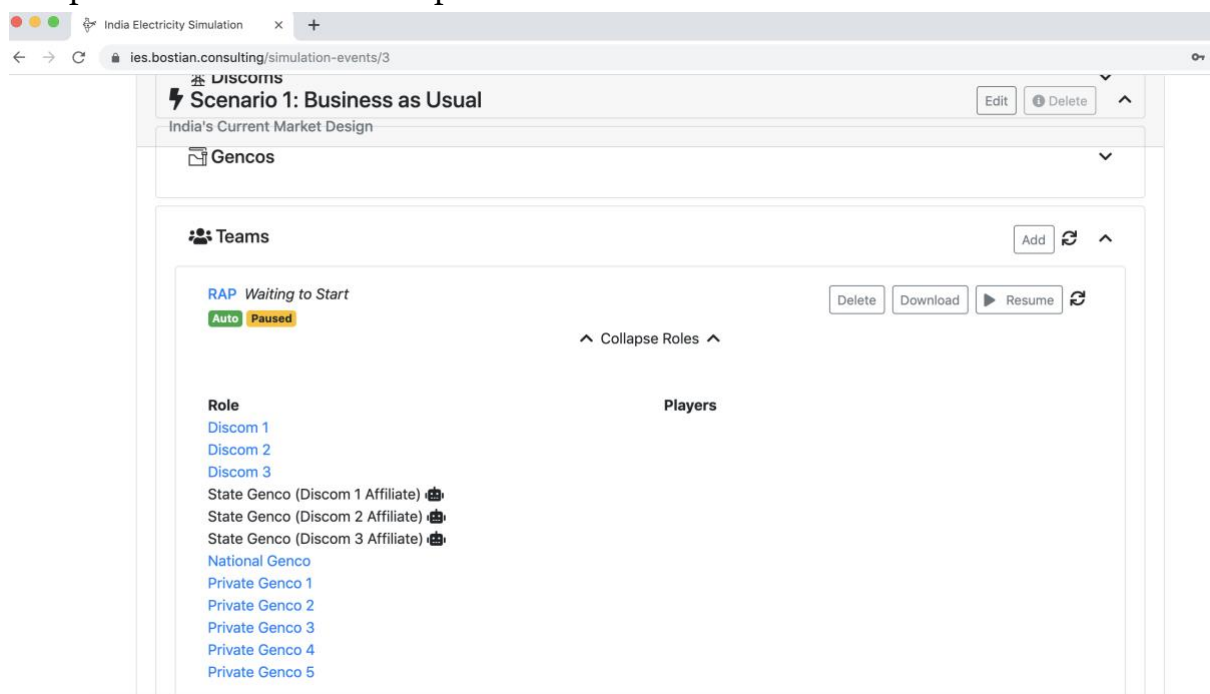


Assigning Registrants to Roles

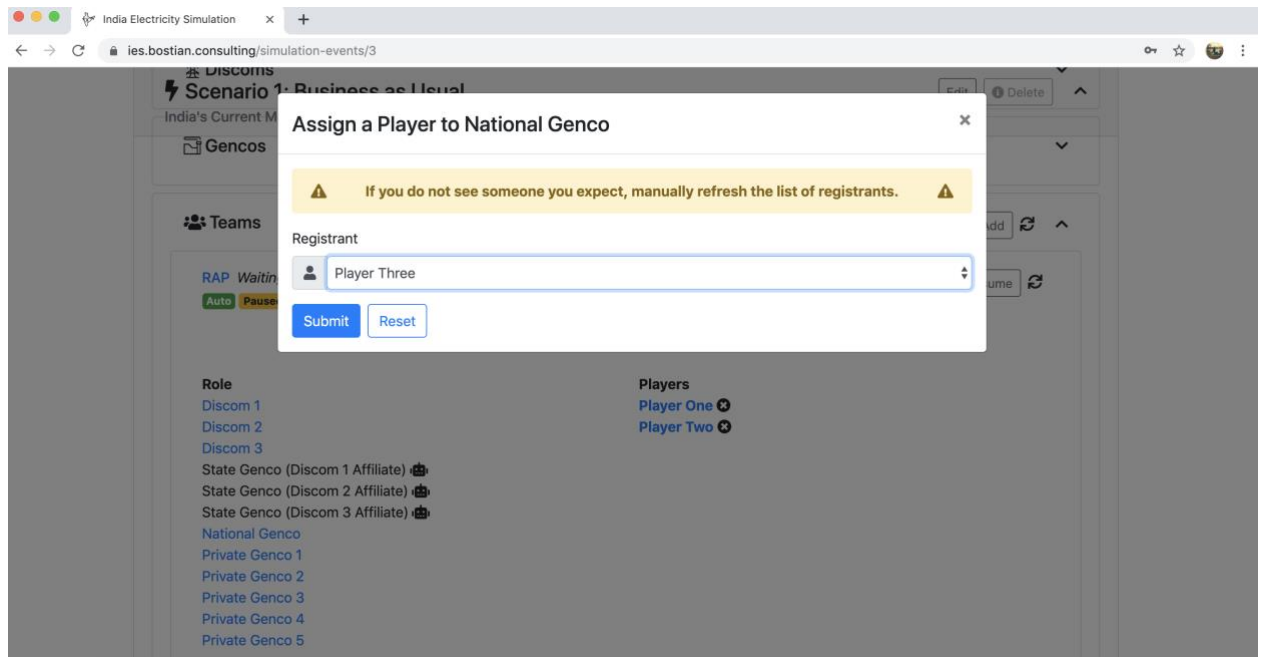
- Go to the Simulation Event's management page and open the Registrants menu. The management page can always be accessed from My Training Teams.
- The list of registrants does not refresh automatically. Use the refresh icon to refresh the list.



- Open the simulation and expand the Teams menu.



- Assign a Registrant to a Role by clicking on the Role Name (e.g., Discom 1), and selecting a Registrant from the list.
- When a Role is played by a group of registrants instead of solo, assign every registrant in the group to the Role.



- Every Role should have at least one Registrant.
- For a Role with multiple registrants, the registrant serving as Decision-Maker is listed in bold.
- A Registrant can be removed from a Role by clicking the X next to the name.
- You will be prompted to confirm this removal.
- A Registrant can be given Decision-Maker status by clicking on his or her name.
- The old decision-maker will no longer be able to make decisions on behalf of the group. This status can be changed while the Simulation is in-progress.
- Once all Roles are assigned, you can click Resume and the simulation will begin. Participants can start making decisions. If they cannot see the simulation page, request them to refresh the page.