California High-Speed Train Project

TECHNICAL MEMORANDUM

Automatic Train Control
Wayside Power Supply Options

TM 3.3.3

Prepared by:	*Signed document on file* Ed Mortlock, Train Control	21 Jun 10 Date
Checked by:	*Signed document on file* Harvey Glickenstein	22 Jun 10 Date
Approved by:	*Signed document on file* Ken Jong, PE, Engineering Manager	25 Jun 10 Date
Released by:	*Signed document on file* Anthony Daniels, Program Director	28 Jun 10 Date

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Note: Signatures apply for the latest technical memorandum revision as noted above.

Prepared by PB
for the California High-Speed Rail Authority

System Level Technical and Integration Reviews

The purpose of the review is to ensure:

- Technical consistency and appropriateness
- Check for integration issues and conflicts

System level reviews are required for all technical memoranda. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the system level technical and integration review by any subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems:	*Signed document on file* Richard Schmedes	21 Jun 10 Date
Infrastructure:	*Signed document on file* John Chirco	23 Jun 10 Date
Operations:	*Signed document on file* Paul Mosier	25 Jun 10 Date
Maintenance:	*Signed document on file* Paul Mosier	25 Jun 10 Date
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ABSTRACT

The California High Speed Train (CHST) Track requires the deployment of an Automatic Train Control (ATC) system that incorporates the functions of Positive Train Control (PTC). Portions of this system will be distributed along the right-of-way. Each location will require a power source.

Where ATC equipment is adjacent to a station or traction power facility, the power source is fairly straightforward in that the feed can be taken from the utility feed to these other facilities. For smaller equipment locations including track circuit equipment at the circuit boundaries, currently estimated at 3,300 foot intervals, obtaining utility power feeds may be impractical and/or cost prohibitive.

The purpose of this technical memorandum is to:

- Identify the types of ATC equipment locations and the power ratings required for each type
- Examine practical alternatives for prime power and UPS provisions
- Develop a matrix of the alternatives with pros and cons for each
- Identify utility power requirements for locations where other alternatives are impractical and develop a set of guidelines to be followed when developing specifications and detailed designs.

The alternatives to be considered include:

- Utility power drop
- Power cabling along the right-of-way from a larger ATC, Traction Power, or station facility
- Solar panels charging batteries
- Wind turbines charging batteries
- Drop feed and step-down transformer from the OCS

1.0 INTRODUCTION

This Technical memorandum addresses the issue of power supplies for Automatic Train Control (ATC) equipment locations.

1.1 PURPOSE OF TECHNICAL MEMORANDUM

The California High Speed Train (CHST) Track requires the deployment of an Automatic Train Control (ATC) system that incorporates the functions of Positive Train Control (PTC). Portions of this system will be distributed along the right-of-way. Each location, however remote, will require a reliable and stable power feed. In a number of cases, a power feed from the local utility will be available and can be brought directly to the train control location, or to another systems facility, including those at passenger stations, Mechanical Maintenance, or Maintenance of Way facilities nearby. In many locations however, the train control location will be in a remote location, including desert and mountain topography, to which it will be physically very difficult and prohibitively expensive to obtain a utility power feed.

The ATC system is operational-critical as well as safety critical, although loss of power cannot lead directly to a hazard arising from incorrect operation of the ATC system, loss of train control function can lead to hazards resulting from the implementation of emergency procedures including train recovery and evacuation. In addition to the prime power feeds, all ATC facilities will be equipped with uninterruptible power equipment consisting of low or no-maintenance batteries.

The purpose of this technical memorandum is to:

- Identify the types of ATC equipment locations and approximate power ratings of each type
- Examine a number of practical alternatives for prime power and UPS provisions for each type of location
- Develop a matrix of the alternatives with pros and cons for each
- Identify utility power requirements for locations where other alternatives are impractical and develop a set of guidelines to be followed when developing specifications and detailed designs.

1.2 STATEMENT OF TECHNICAL ISSUE

There are a limited number of alternatives for power source which are considered feasible, some of which are sustainable:

- Local utility direct power feed
- ATC dedicated power cable along the right-of-way feeding smaller location cases from nearby (larger) ATC, Traction Power, Maintenance, or other facility
- Local drops from the OCS including step down transformers
- Solar panels
- Wind Turbines

A local utility power drop may not be available in remote areas of the Right of Way and could be expensive in many areas, especially if a dedicated pole or pylon line must be built to bring power up to the right of way.

Dedicated cable along the right of way connecting remote locations with power sourced from a passenger station or other facility with its own utility power source will be expensive to install.

Green power sources such as solar and wind turbines are becoming more common in railroad applications, however their reliability must be examined more thoroughly.

Drops from the OCS feeder cables together with a dedicated step down transformer appears to be a convenient way of deriving local power; attention must be given to the need to sustain the ATC system operations during periods when the feeders are switched off.

This TM examines briefly pros and cons of power sources and makes recommendations on how the design should progress.

1.3 GENERAL INFORMATION

1.3.1 Definition of Terms

The terms listed below are ATC related definitions and acronyms. A complete glossary of design terms, abbreviations and acronyms used by the Project is contained in Technical memorandum TM 0.0.a; Design Terms, Abbreviations, and Acronyms.

A

Automatic Train Control	The collective name for the train control subsystems that typically comprise the Automatic Train Protection, the Automatic Train Operation, and Automatic Train Supervision sets of functions that govern train operations on the main tracks.

F

Fiber Optic Cable System	A data transmission technology that relies on light rather than electricity, conveying data through a cable consisting of a central glass core surrounded by layer of plastic.

I

Impedance bond	An electrical device located between the rails consisting of a coil with a center tap used to bypass insulated joints in order to prevent track circuit energy from bypassing the insulated joint while allowing the traction return current to bypass the insulated joint. The center tap can also be used to provide a connection from the rails to the static wire and/or traction power facilities for the traction return current.
Insulated Joint	A joint in the running rail used to prevent track circuit energy on one side of the joint from leaking to the other side of the joint.

M

Main Track:	Those tracks of the railroad, exclusive of switch tracks, yards, and terminals. Main tracks have track circuits and all movements are protected by the ATC system.

T

Track Circuit	A method of determining occupancy of a section of track and/or a broken rail by sending an electrical signal down the track from the transmit to the received end of the section of track and indicating that the section of track is complete and not occupied by detecting a minimum level of the proper signal as the receive end.

W

Wayside Signals	Devices located along the right-of-way for providing information to the locomotive engineers relative to train operations as opposed to the cab signal displays that are located within the control compartment of the rolling stock.

Y

Yard Signal System	The train control system that controls safe movements within the limit of Yard Tracks.
Yard Track:	A section of track used for storage of trains that is auxiliary to the main track and not used by trains that are carrying passengers. Refuge tracks at stations are yard tracks. Yards consist of more than one yard track used for storing trains, inspecting trains, and accessing maintenance facilities. Yard tracks may or may not have track circuits on them.
Yard Transfer Tracks	A section of track used for the transition of trains between the Main and Yard tracks. Transfer Tracks are equipped with both the main line ATC System and Yard Signal System and always have track circuits.

1.3.2 Acronyms

A

ATC	Automatic Train Control

C

C&S	Communications and Signals
CHST	California High Speed Train
CHSTP	California High Speed Train Project

H

HST	High Speed Train

O

OCC	Operations Control Center
OCS	Overhead Contact System

R

ROW	Right-of-Way
R/W	Right-of-Way

S

SCADA	Supervisory Control and Data Acquisition

T

TM	Technical Memorandum

U

UPS	Uninterruptible Power Supply

1.3.3 Units

The California High-Speed Train Project (CHSTP) is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation (Caltrans) and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the U.S. and are also known in the U.S. as "English" or "Imperial" units. In order to avoid any confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

2.0 DEFINITION OF TECHNICAL TOPIC

The technical topic is to examine options for power feeds to ATC facilities and locations, particularly in those remote locations where feeds from local utilities maybe expensive or impractical.

2.1 GENERAL

2.1.1 CHSTP Design Considerations

There are several types of ATC location. The largest in terms of size in power consumption are the interlockings. In some cases an interlocking covering a large site such as a station will consist of several enclosures, the largest of which has a footprint of 20 feet by 8 feet. Other houses will be distributed through the interlockings measuring 8 feet by 10 feet, and there will possibly be some smaller location cases that have a minimal footprint that will be mounted at the trackside in line with the OCS poles.

Power for interlockings will be derived from a utility feed directly or from a distributed feed along the right of way from an adjacent utility feed to a station, substation, or other traction power facility.

The ATC system will also have other location cases along the right of way approximately every 3,300 feet (1,000m) which will house track circuit feeds, track circuit receivers, rectifiers, dc batteries, and cable termination equipment. These track circuit cases will also require a primary power source. The power rating for these track circuit cases will be minimal (<200W) and direct feeds from a utility, especially in the more remote regions of the right of way could be prohibitively expensive.

The purpose of this memorandum is to examine the power source alternatives and list the practical and cost effective options.

2.1.2 CHSTP Design Parameters

The auxiliary power required to feed ATC locations must be highly reliable and support high availability of supply. A single power feed plus batteries at track circuit locations should be sufficient to meet the requirements. At the more complex locations such as interlockings, a redundant means of supply and batteries should be specified. Uninterruptible Power Supplies (batteries) must be specified for all ATC locations that will enable the ATC system to operate in the absence of the primary power source and during the changeover from the primary source to the redundant source.

2.2 LAWS AND CODES

Initial high-speed train (HST) design criteria will be issued in technical memoranda that provide guidance and procedures to advance the preliminary engineering. When completed, a Design Manual will present design standards and criteria specifically for the design, construction, and operation of the CHSTP’s high-speed railway.

Criteria for design elements not specific to HST operations will be governed by existing applicable standards, laws, and codes. Applicable local building, planning, and zoning codes and laws are to be reviewed for the stations, particularly those located within multiple municipal jurisdictions, state rights-of-way, and/or unincorporated jurisdictions.

In the case of differing values, the standard followed shall be that which results in the satisfaction of all applicable requirements. In the case of conflicts, documentation for the conflicting standard is to be prepared and approval is to be secured as required by the affected agency for which an exception is required, whether it be an exception to the CHSTP standards or another agency standards.

2.2.1 Federal Requirements

Title 49 of the CFR governs rail transportation. Other than requiring a separate power supply for automatic cab signal, train stop, or train control device, the CFR does not contain any regulations related to power supplies for train control and signaling equipment. 49CFR regulations for highway grade crossings will not apply as there are no such crossings contemplated at this time.

2.2.2 State Requirements

Compliance with requirements of the State of California code for electrical equipment and systems is required.

2.2.3 Local Codes

Compliance with requirements of local codes for electrical equipment and systems is required, recognizing any exemptions for railroad signal equipment.

2.2.4 AREMA

The AREMA Manual of Recommended Practices for Communications and Signals provides guidelines for backup power supplies, the specifications will refer to these guidelines.

3.0 ASSESSMENT / ANALYSIS

The following sections address the different requirements for power feeds to ATC equipment and locations and also the practical options available. The analysis is presented in the form of a matrix.

Information from other high speed rail operations does not indicate anything unique or special about primary power sources for ATC equipment. The same issues exist for high speed passenger systems in remote locations as they apply to freight railroads in the U.S.

A "green" approach is gathering momentum globally to powering remote locations that are a considerable distance from a utility feed and would require an expensive pole line from the utility company to be installed for the sole purpose of supplying the signal location. Solar power installations are now extensive in railroad and highway applications. In recent years solar panels have been supplemented by wind powered turbines that can be mounted on retractable poles to facilitate maintenance access.

Batteries are a common feature of signaling locations and these continue to be used with solar and wind sources for charging. Battery technology has improved over the years and low maintenance batteries are now being extensively used in railroad applications.

To further supplement the availability of power at an ATC location, the specifications must call for the installation of diesel generators at the facilities which are common with other systems such as stations and yards. At the smaller ATC locations including universal interlocking locations and track circuit cases, a connection will be specified that allows for the connection of a portable diesel generator to be plugged into the house by maintainers in the event that a power failure to the location is projected to exceed the battery life of the UPS supply.

Fluctuations of feed power will be dealt with by specifying power conditioning equipment as part of the ATC system requirements.

3.1 GENERAL

Power supply alternatives are given in the form of a matrix that is contained in the following section.

3.2 POWER SUPPLY OPTIONS

The following ATC location power supply options have been identified.

3.2.1 Dedicated Cable Feeds

Dedicated distribution cable feeds from other facilities that have their own utility feed are a simple way of distributing power along the right of way. As distances increase the volt drop factor becomes significant. Large conductor copper cables are undesirable because of cost and weight. Large copper cables may also prime targets for theft although the security fences and the fact that cables will be contained within a cable trough where they are out of sight may mitigate this concern. Currently the longest distance from an ATC major location is 11 miles (based on half the distance between two adjacent interlockings). If redundant power is to be supplied to each location then feeds must be provided from two separate cables running the full 22 miles between adjacent interlockings. If this is the case, a 22 mile feed will require higher voltages than shorter feeds and this will add to the cost and size of the intermediate locations accommodating a step down transformer. If utility feeds can be made to Traction Power facilities every five miles, then redundant ATC power feed cables would be 5 miles long with a subsequent reduction in voltage and/or conductor size.

Where ATC subsystem power cables are run in the cable trough or in ducts, they should be segregated from other ATC (signal) cables in a divided trough or in a separate duct.

3.2.2 Solar panels

Solar panels are becoming common around the world for powering remote locations on highways and on railroads. In the U.S. the freight railroads use solar power extensively to operate grade crossings and remote signal facilities. Much of the CHSTP right-of-way is in areas with extended hours of high intensity direct sunlight. Solar panel technology continues to improve with respect to efficiency and reliability. This makes the use of solar panels attractive both in remote desert areas and also in mountainous areas where the right-of-way may be in shadow for much of the day. One negative issue for solar panels is the level of maintenance needed for reliable operation. Although panels typically have a 25 year suppliers' guarantee they do require cleaning regularly, especially in rural areas subject to dust and windblown debris and also in urban areas where smog settlement can affect their operation long term.

The AREMA Manual of Recommended Practices for Communications and Signals contains a section for solar panel installations as follows:

> *Consideration of solar power is most appropriate where average system loads are typically less than 1 KW and are predominantly or exclusively dc; and where there are high costs to install or maintain utility service or non-renewable energy sources such as primary batteries. Typical applications include:*
>
> 1. *Highway grade crossings and their approaches.*
> 2. *DC and Coded track circuits.*
> 3. *Signal and signal repeater locations.*
> 4. *Radio base stations and repeaters.*
> 5. *Microwave repeaters.*
> 6. *Emergency wayside telephones.*
> 7. *Defective equipment detectors.*
> 8. *Fiber optic cable systems.*

3.2.3 Wind Turbines

Wind turbines are becoming more common in railroad applications where small devices (2 to 3 feet diameter blades) are mounted on top of the signal system location cases. In combination with the slipstream effects from passing trains at speeds in excess of 200 MPH, turbines may work well in a number of regions, especially in the mountains and central valley where prevailing winds are consistently strong. Wind turbines will be higher in maintenance than other power sources due to the moving parts. Turbine products are being used in railroads for battery charging in remote areas; products exist for a combination of solar panels and turbines mounted together. Examples exist in the U.S (turbines are becoming common in Alaska and Canada where sunlight hours are not long enough during the winter months to charge batteries through solar panels) and in the United Kingdom. No examples of this technology are specifically known to exist in high speed system applications.

As mentioned above, for solar and wind power sources to support the reliability and availability thresholds of the ATC system, it is likely that the two might have to be used in combination. As part of the detailed design process a risk analysis should be conducted to determine what levels of redundancy might be required. A positive aspect of using solar and wind power is that they are both sustainable and add to the "green" quotient for CHST. Some further research is needed to determine the amount of operational experience that high speed rail operators have with small turbine sources of power.

3.2.4 OCS Drops

OCS drops taken from the 25 KV feeders and passed down to the ATC enclosures through drop down transformers mounted on the OCS poles is a convenient means of providing power to the remote locations. Maintenance of the transformers and drop cables is likely less than that required to maintain solar and turbine equipment, although employees qualified in working on high voltage equipment will be required. Consideration must be given to the risks associated with long term shut downs of the feeder sections, although electric trains might not run with OCS power off, diesel and battery powered maintenance vehicles could continue to operate and the ATC system will need to be operable. Dual feeds (one from each feeder at each location together with batteries might be an acceptable solution to power availability.

3.3 ATC LOCATION POWER SUPPLY ALTERNATIVES MATRIX

Table 1 shows various alternatives and options for the provision of power to various ATC locations throughout the CHST Right of Way. The table also contains an estimate for the power load for each type of ATC location.

The following notes refer to Table 1:

1. The running of a power supply cable from a nearby location at which utility power is available must be evaluated on a case by case situation, voltage drop, cable costs, and maintenance have to be taken into account.
2. Local power from a utility is preferable from a stability and reliability standpoint in most cases, however obtaining convenient local utility drops for a reasonable cost at all locations where power is required is unlikely. Certain locations will be prohibitively expensive, and in some cases not practicable. ATC equipment at or near stations will be able to be fed from the station utility supply. ATC at or near substations and other traction power facilities will be able to be fed from the utility supply to those locations.
3. Although convenient, problems will arise when the OCS is isolated for emergencies and maintenance purposes. Although electric trains will not be moving with the OCS isolated, the ATC system will drain batteries and at some point, the signaling system will cease to function until power is restored.
4. Solar power panels are becoming highly efficient and relatively cheap, still most practicable where loads are small such as track circuits and intermediate signal locations.

5. Probably only useful in small load situations, not as efficient as solar as sufficient wind speed is less probable than sunlight in CA. Some concerns that turbines might be damaged in high speed train slipstreams.
6. To back up the primary power feed to each location, a bank of batteries shall be provided. The number of batteries in the field must be kept to a minimum, or multiple location UPSs consolidated as much as possible to ease maintenance demands. The battery type shall meet the environmental requirements and also minimize maintenance over the lifecycle of the ATC equipment.

The term “Distant” for the purposes of remote power feeds shall be assumed to be greater than 2.5 miles.

TABLE 1; ATC EQUIPMENT POWER SUPPLY ALTERNATIVES MATRIX

	APPLICATION								
	Track Circuits	**Wayside Signal Locations**	**Universal Interlockings**	**Interlockings at or near stations and yards**	**Stations**	**Radio Tower**	**Wayside Intrusion Devices**	**Wayside Defect Detectors**	**Notes**
Estimated Power Load Per Location	200W	400W	5KW	10KW	5KW	3KW	200W	200W	
Supply Alternatives									
Power Cable from adjacent location	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	The assumption is that utility power will be available at stations and fed directly to all equipment facilities within the station.	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	1
Power Cable from nearest traction power facility	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	1
Local Power cable feed from utility	Recommended where local power is close	Recommended where local power is close	Recommended where local power is close	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Recommended, assumption is that utility power will be available at all stations.	Possible, if distant then other options must be compared	Not Recommended	Not Recommended	2
Drop from OCS or Negative Feeder	Possible, recommended where local power is distant, consider solar as a back-up.	Possible, recommended where local power is distant, consider solar as a back-up.	Not recommended; maintenance train moves will require reliable interlocking operation when OCS is isolated.	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended; assumption is that utility power will be available at yards.	Not recommended; maintenance train moves will require reliable radio operation when OCS is isolated.	Possible, recommended where local power is distant, consider solar as a back-up.	Possible, recommended where local power is distant, consider solar as a back-up.	3
Solar Power	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Not recommended due to power load from a high number of switch machines; larger load than wayside signal locations	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	4
Wind Turbine (could be used in combination with solar)	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	5
Type of UPS	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	Vital circuits using float charged dc batteries plus diesel generator for longer term outages	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	6

4.0 SUMMARY AND RECOMMENDATIONS

Table 1 indicates that there are several acceptable options for power supply to each type of ATC facility. In order to minimize installation and maintenance costs, flexibility will be allowed in specifications for power sources for each type of ATC location. Table 1 will also be used as an input to the specification language. Reliability and availability thresholds will drive the design by the Contractor(s) for power supply source however some level of consistency is required between sections of the main tracks and yards that may be covered by separate contracts. Maintenance considerations will also be a cost driver (solar panels and wind turbines will require specific maintenance activity) and continuity of maintenance is highly desirable between line sections.

The specifications shall allow for proposals of different methods of power supply to the remote locations, both single and in combination, and shall list the preferred method of powering locations in order of preference. Table 2 shall be included in the specifications; it is intended to provide some degree of standardization across the system in the event of a multiple ATC contract strategy.

Design processes shall include a requirement to conduct risk analyses to determine that the selected means of power source can meet the overall ATC reliability and availability requirements.

The Contractor shall perform an analysis of the various types of primary and secondary power sources and provide a report to the Authority describing the type of source proposed at each location. The Authority will approve acceptable design proposals and shall subsequently direct the Contractor on the power supply configuration to use for that specific ATC contract.

Once the test track ATC design has been approved for power supplies and distribution, the approved designs shall be used to specify requirements in the subsequent contracts or phases of the project (if a single core systems contract is awarded).

Fluctuations of feed power will be dealt with by specifying power conditioning equipment as part of the ATC system requirements.

A single power feed plus batteries at track circuit locations should be sufficient to meet the requirements. At the more complex locations such as interlockings, a redundant means of supply and batteries should be specified

5.0 SOURCE INFORMATION AND REFERENCES

The following source information and references were used in the preparation of this TM.

- American Railway Engineering and Maintenance of Way Association (AREMA) Communications and Signals Manual of Recommended Practices

6.0 DESIGN MANUAL CRITERIA

6.1 INFORMATION FOR INCLUSION IN DESIGN MANUAL

The information in this TM is to be utilized and applied by the Design/Build Contractor.

The following power supply alternatives shall be evaluated by the Contractor and proposed for approval by the Authority. The list is given in the order of preference however the Contractor shall identify specific risks for each location and can propose alternatives and combinations. The Contractor shall identify cost benefits; both installation and life cycle maintenance, for each alternative;

1. Power Cable from adjacent location
2. Power Cable from nearest traction power facility
3. Local Power cable feed from utility
4. Drop from OCS Feeder cable(s)
5. Solar Panels
6. Wind Turbine

All power supplies shall be supplemented by a UPS (battery supply) providing power for each ATC location for a minimum of 8 hours.

A single power feed plus batteries at track circuit locations should be sufficient to meet the requirements. At the more complex locations such as interlockings, a redundant means of supply and batteries should be specified

In addition to UPS, each ATC location (houses and cases) shall be provided with a power socket in which to plug a portable generator to power the ATC and associated communications equipment within the housing and ATC equipment fed from that housing.

Where ATC subsystem power cables are run in the cable trough or in a duct bank, these cables should be segregated from other signal and communications subsystem cables either by means of a divided trough or by using a separate duct.

Fluctuations of feed power will be dealt with by specifying power conditioning equipment as part of the ATC system requirements.

Table 2 identifies alternatives and options for the provision of power to various ATC locations throughout the CHST Right of Way. The table also contains an estimate for the power load for each type of ATC location.

The following notes refer to Table 2:

1. The running of a power supply cable from a nearby location at which utility power is available must be evaluated on a case by case situation, voltage drop, cable costs, and maintenance have to be taken into account.
2. Local power from a utility is preferable from a stability and reliability standpoint in most cases, however obtaining convenient local utility drops for a reasonable cost at all locations where power is required is unlikely. Certain locations will be prohibitively expensive, and in some cases not practicable. ATC equipment at or near stations will be able to be fed from the station utility supply. ATC at or near substations and other traction power facilities will be able to be fed from the utility supply to those locations.

3. Although convenient, problems will arise when the OCS is isolated for emergencies and maintenance purposes. Although electric trains will not be moving with the OCS isolated, the ATC system will drain batteries and at some point, the signaling system will cease to function until power is restored.
4. Solar power panels are becoming highly efficient and relatively cheap, still most practicable where loads are small such as track circuits and intermediate signal locations.
5. Probably only useful in small load situations, not as efficient as solar as sufficient wind speed is less probable than sunlight in CA. Some concerns that turbines might be damaged in high speed train slipstreams.
6. To back up the primary power feed to each location, a bank of batteries shall be provided. The number of batteries in the field must be kept to a minimum, or multiple location UPSs consolidated as much as possible to ease maintenance demands. The battery type shall meet the environmental requirements and also minimize maintenance over the lifecycle of the ATC equipment.

The term “Distant” for the purposes of remote power feeds shall be assumed to be greater than 2.5 miles

TABLE 2; ATC EQUIPMENT POWER SUPPLY ALTERNATIVES MATRIX

	APPLICATION								
	Track Circuits	**Wayside Signal Locations**	**Universal Interlockings**	**Interlockings at or near stations and yards**	**Stations**	**Radio Tower**	**Wayside Intrusion Devices**	**Wayside Defect Detectors**	**Notes**
Estimated Power Load Per Location	200W	400W	5KW	10KW	5KW	3KW	200W	200W	
Supply Alternatives									
Power Cable from adjacent location	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	The assumption is that utility power will be available at stations and fed directly to all equipment facilities within the station.	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	1
Power Cable from nearest traction power facility	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	Possible, if distant then other options must be compared	1
Local Power cable feed from utility	Recommended where local power is close	Recommended where local power is close	Recommended where local power is close	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Recommended, assumption is that utility power will be available at all stations.	Possible, if distant then other options must be compared	Not Recommended	Not Recommended	2
Drop from OCS or Negative Feeder	Possible, recommended where local power is distant, consider solar as a back-up.	Possible, recommended where local power is distant, consider solar as a back-up.	Not recommended; maintenance train moves will require reliable interlocking operation when OCS is isolated.	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended; assumption is that utility power will be available at yards.	Not recommended; maintenance train moves will require reliable radio operation when OCS is isolated.	Possible, recommended where local power is distant, consider solar as a back-up.	Possible, recommended where local power is distant, consider solar as a back-up.	3
Solar Power	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Not recommended due to power load from a high number of switch machines; larger load than wayside signal locations	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	Possible for very remote locations as a back up to distant feeds from remote facilities. Maintenance of solar panels must be taken into consideration.	4
Wind Turbine (could be used in combination with solar)	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Not recommended; power from utility feed, assumption is that utility power will be available at stations and yards.	Not Recommended, assumption is that utility power will be available at stations.	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	Possible but not recommended due to maintenance liability of turbine	5
Type of UPS	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	Vital circuits using float charged dc batteries plus diesel generator for longer term outages	Float charged dc batteries	Float charged dc batteries	Float charged dc batteries	6