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CSP Historical Library Archive Extension Project Final Report

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ABSTRACT

This work details the development of a concentrating solar power (CSP) and thermal (CST) library archive. This work included digitization of one-of-a-kind documents that could be degraded or destroyed over time. Sandia National Laboratories (SNL) National Solar Thermal Test Facility (NSTTF) and Sandia's Technical Library departments collaborated to establish and maintain the first and only digital collection in the world of Concentrating Solar Power (CSP) related historical documents. These date back to the CSP program inception here at Sandia in the early 1970's thru to the present.

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a. *Federal Agency*	U.S. Department of Energy – SETO	
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Signature of Certifying Official *Date*

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1. BACKGROUND

Proper documentation management of concentrating solar power (CSP) and thermal (CST) documents and media is critical for ensuring wide-spread information dissemination of previous work, as well as safeguarding one-of-a-kind documents that could be unintentionally degraded or destroyed over time. The Sandia National Laboratories (SNL), National Solar Thermal Test Facility (NSTTF) and Technical Library departments have been collaborating as part of this U.S. Department of Energy (DOE) effort to establish, and maintain, the first and only digital collection in the world of Concentrating Solar Power (CSP) related historical documents. These date back to the CSP program inception here at Sandia in the early 1970's thru to the present. The unclassified, unrestricted (UUR) collection comprised of internally generated Sandia documents as well as a significant number of external reports are searchable via both a Sandia developed website and the U.S. DOE Office of Scientific & Technical Information (OSTI) document repository. DOE is currently championing efforts for wide-spread dissemination of the collection to foster strong research and development within U.S. research institutions as well as to reduce the propensity of repeated research, which can impact strategic funding to needed work. The Library Archive team at SNL has also facilitated extended library archive work to further this digitization and archival effort. The developed novel and external-facing website for the archive, includes the integration of other important historical CSP documents by both U.S. and international partners, including Australia, South Africa and Germany. The results of this effort is expected to advance this transformative project and make the CSP collection accessible to the CSP and solar-thermal global R&D communities, which includes commercial groups who intend to promote the success of CSP in the U.S. and globally.

2. PROJECT OBJECTIVES

The project objectives for this effort include three primary thrusts: 1. Completion of the CSP digital historical archive, 2. Execution of a marketing plan for the archive and 3. Completion of digitization of SNL-external CSP documents. Here, the team will first complete the CSP library archive that will provide a unique, digital resource of CSP historical documents for academic, government and industrial research and development (R&D) personnel. The archive communications plan will be developed from an SNL communications strategy for garnering as much visibility as possible, primarily from CSP researchers. Finally, to enhance the comprehensibility of the digital archive, SNL will work with external-SNL CSP entities to provide CSP historical documents for digitization and inclusion.

Figure 1. Historical paper-based document and media library at SNL NSTTF.

3. PROJECT DISCUSSION - ARCHIVE DEVELOPMENT

CSP and CST research has been facilitated over decades, which includes periods of time prior to the digitization of documents and media. These one-of-a-kind documents can have tremendous value for current research across many fields of scholarly study. This can be particularly true for understanding R&D, commercial best practices, as well as fundamental design techniques with respect to costs, measurement for uncertainty quantification and anxcillary environmental impacts. This work assessed documents and media originally at the SNL NSTTF but was later extended to other reserach and commerical groups globally. Originally, there were a large number of paper-based documents in various physical document repositories at the SNL NSTTF that were identified internally to be digitized and provided to the CSP community and general public. During 2022 the outstanding paper-based documents that were previously determined documents were digitized and uploaded into the SNL SRN Library catalog for subsequent dissemination to the two digital repositories. The CSP Library Archive, which can be accessed online [1] was originally developed as a Structured Query Language (SQL) database, which included metadata that was manually registered for over 12 metadata tags. To ensure the documents collected (as well as any future documents and media) are collectively tagged appropriately within the context of the CSP archive and not affiliated with other SNL databases, a CSP file extension was added for efficient querying within the construct of the database. A website was developed for users to interface with the database which was made outwardly facing from the National Laboratories servers.

The CSP Library Archive uses commercial off-the-shelf (COTS) software, LibraryThing to catalog items and uses Library Thing's product TinyCat Library Catalog to make the archive available and searchable to anyone who has access to the internet. Records in the catalog contain title, authors, report numbers, abstract, links to full text, tags and a unique identifier. TinyCat's capabilities are typical of library catalogs. Users can conduct a basic keyword search or do an advanced search to narrow to the title, author, report number and/ or abstract field. The TinyCat interface has customization capabilities which were used to optimize the detailed record display. Certain fields were used as a convenience to display records information, i.e, "Library Review" contains the records abstracts. The CSP document and media records were batch loaded into LibraryThing. Exel data files containing metadata for each document were converted to MaRC files using a program called MaRC Edit and then imported in the catalog. This will be how future archive additions will be handled. This project digitized over 15,000 documents and associated media (e.g. videos, pictures, etc.) which were scanned for archiving and uploaded to the CSP Library Archive. After scanning, metadata was created for each respective document to support catalogue and tagging for the library digital archiving. CSP historical documents were collected from the SNL NSTTF, as well as those from the Australian Solar Thermal Research Institute (ASTRI), Stellenbosh University, the U.S. DOE where further are being considered for digitization and inventory, from the German Aerospace Agency (DLR), and Plataforma Solar de Almería. Additionally, this work also includes historical engineering drawing documents for various CSP systems, which will provide more detailed design information for CSP researchers and SolarPACES. Overall, the following provides the extent of documents and media that were evaluated, digitized and inventoried:

- ~20,000 paper-based documents
    - Assessed for inventory
    - Digitally scanned & Categorized
    - Inventoried within Externally-Facing Website
- Over 300 media videos (Reels, VHS, etc.) and pictures digitally scanned, corrected and inventoried
- Creation of a searchable, external Sandia website and inventory of documents into the DOE OSTI document repository.
- >15,000 documents that this activity pertained to include:
    - SAND reports (>1,500)
    - External documents held by SNL (>2,000), & External to Sandia (>5,000)
    - SAN external reports (~144)
    - Unreviewed Internal Sandia documents (>100)
    - UCI documents (~50) (UCI internal non-SAND documents (5))
    - Documents held by DOE (~3,000)

- Additional Paper Documents Scanned (>5,000)
- >400 Media (Videos & Pictures)

During this project the team digitized over 300 videos that were located at the NSTTF that dated back to approximately 1975. These videos were delivered to the Sandia Labs Technical Library (Fig. 2), which processed the various media types into a digital form. These included a variety of analog types, such as video reels, VHS, cassettes, etc. After the digitization step the team also facilitated a Review and Approval (R&A) process with Sandia management to review each video to ensure that each do not contain sensitive information that would not be appropriate for public viewing. After the review the team then uploaded each of the respective videos to LibraryThing approved website, which can be found at: https://www.librarycat.org/lib/SandiaCSP. For this work some features and improvements were facilitated to assist with the search feature, look and utilization of the files.

Figure 2. Historical Videos which include media types of VHS, Reels, cassettes, and Photos for Digitization as Media for the CSP Archive.

3.1. User Manual

To educate prospective users for how the website works and to understand how to search documents, the team developed a digital user manual that provides details (overview and justification of its existence) of the website and how to use it. This has been provided as a link that a user can click on to access the online document. Figure 3 below is the title portion of the user guide which opens as a .pdf from the user link: https://pubdocserve.sandia.gov/sand_doc/2021/2112676m.pdf.

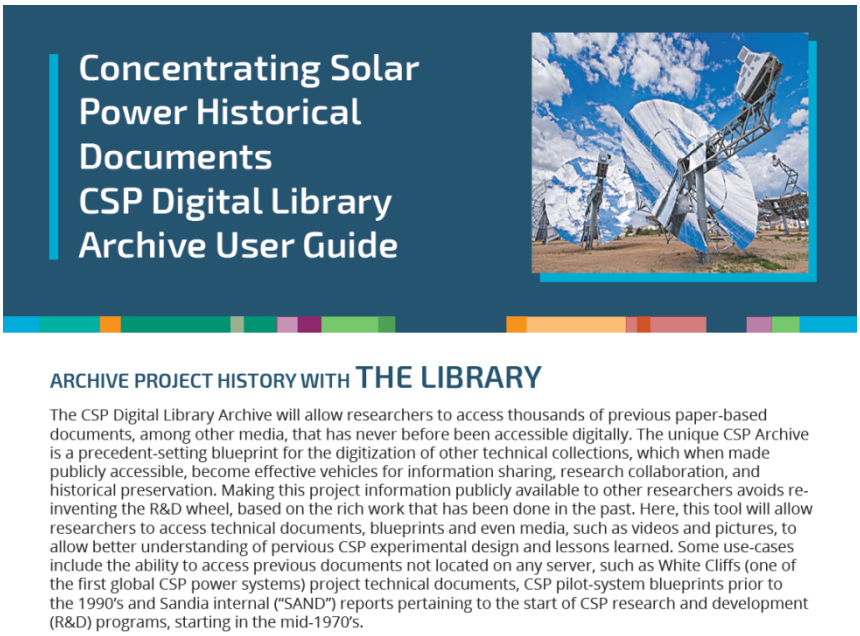

Figure 3. CSP Library Archive User Guide Image

3.2. Improved Search Tool & Metadata User Access

During the quarter the team also pulled abstracts for each of the archived files in the meta database and included key words/phrases beyond just the titles to allow for improved search efficacy. The team was careful to choose relevant key words to allow improved catalogue inventory and search functionality for the website. The team has included abstracts as well within the website search tool for improved visibility of respective documents. Figure 4 provides an example of an included abstract for one of these documents.

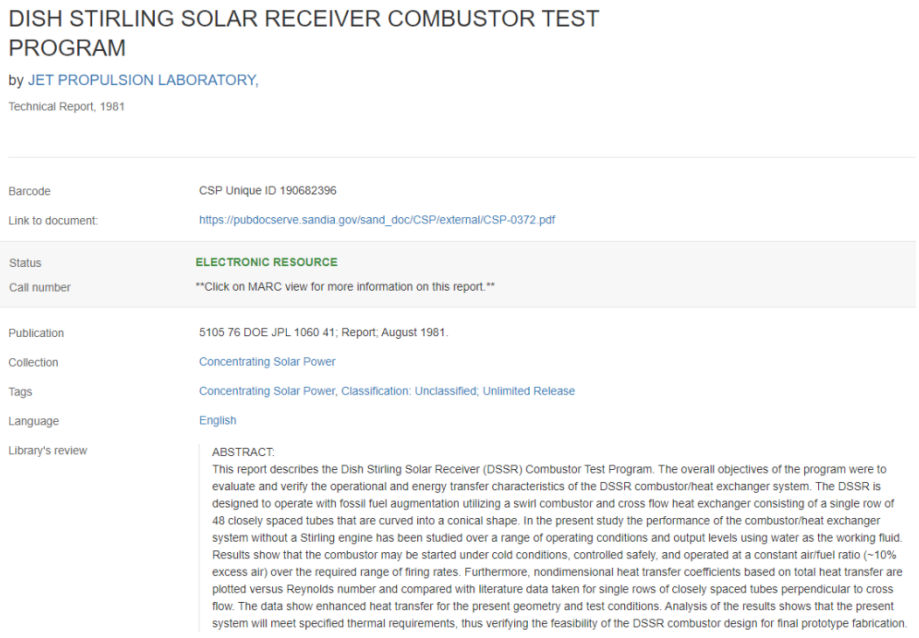

Figure 4. Digital Library Archive Document Example with Abstract

3.3. Organized Title Review Feature

To provide the user with a way to review all the titles in an organized fashion, the team also developed a top-down Table of all documents to allow the user to view all of the titles within a comprehensive Table of Contents. This table is was processed through Sandia's Review & Approval (R&A) process before being added to the website.

3.4. CSP Unique Identifier

During the project, the team added unique identifiers (e.g. doi) as well as a catalog number (i.e. CSP#) for all of the documents within the archive.

4. ARCHIVE MARKETING

To strategically market the CSP library archive as a well-known repository for use by CSP research and industry/commercial institutions, during the previous quarter the SNL team executed a marketing strategy that included a strategic press release from Sandia National Labs, which can be found at the following URL: https://newsreleases.sandia.gov/csp_archive/. Since its online release, the publication has been subsequently been re-broadcast by PV Magazine (https://pv-magazine-usa.com/2021/10/06/sandia-offers-public-access-to-csp-archives/) and FocusTechnica (https://www.focustechnica.com/sandia-offers-public-access-to-csp-archives/) as well as by a local Television station KRQE. The team has already received feedback and further interest in its unique utilization by researchers in the U.S. and in Europe. During the SolarPACES 2021/2022 conferences the Sandia team marketed the digital library archive through the use of tri-fold brochures and presented poster. The team plans to continue to market the use of the archive as well as inventory of other documents and media that could be included.

4.1. CSP Archive Tri-Fold Advertisement

Development of a tri-fold brochure that can be digitally provided to SNL and DOE collaborators, customers and other interested parties. Figure 5 presents a small image of the trifold which includes an overview for the intent and utility of the digital archive for conducting research.

Figure 5. CSP Library Archive Tri-Fold.

5. EXTERNAL DOCUMENTATION DIGITIZATION

The team received and digitized a number of report documents and engineering drawings that were provided by ASTRI and other external groups. For example, the team received several boxes from ASTRI, Figure 6, which were digitized, R&A'd and integrated within the archival system. Additionally, the team received digital files from STERG, which too were integrated into the website as well. Previously, the STERG digitized a number of academic documents which too can be found at: Journal Articles – STERG Website (sun.ac.za), which include PhD thesis' related to concentrating solar thermal (CST) R&D (Theses – STERG Website (sun.ac.za)).

Figure 6. Boxes containing over 300 report and engineering documents from ASTRI for archival within the Sandia CSP Library Archive.

Additionally, the team had discussions with Christoph Richter who is part of the German Aerospace Corporation (DLR), where a number of unique documents were found at the Plataforma Solar de Almería in Spain, Figure 7. However, Plataforma Solar Almeria (PSA) required more time to review the documents before sending over to Sandia. Their preference was to obtain funding to digitize the documents there where they are willing to consider a possible funding source through SolarPACES (or other funding source) to digitize the documents and share the files with Sandia. For DLR, the team there has already digitized many of their paper-based documents already and uploaded to their repository: https://elib.dlr.de/).

Figure 7. Plataforma Solar de Almería Historical Unique Documents for Possible Future CSP Library Archive Inventory.

6. UTILIZATION OF CSP LIBRARY ARCHIVE

This work highlights the importance of digitization and archives within the public domain of previous research and its impact on current U.S. DOE-funded projects (Table 1), including that of the Gen 3 particle-pathway (G3P3) [2]. As an example, for a current DOE HelioCon project, ongoing efforts at SNL to advance components and controls for CSP technologies significantly benefits from access to a global CSP library. Current research and development (R&D) to improve heliostat technology while reducing field implementation costs has shown control systems and lack of Standards documentation as crucial gaps in the industry requiring improvement [3]. Many useful documents that advance understanding of these gaps have been archived in the global library. In addition, documentation contained in the library provides useful information to SNL engineers about onsite equipment, such as original Winsmith documents pertaining to the drives used in SNL heliostats or assessments of heliostat stretched membrane mirrors for furnace applications. Expanding on examples of pertinent literature from Table 1 show information pertaining to integral parts of CSP research including site selection, static loading simulations, and research into both theoretical and practical costs/performance of CSP systems.

Table 1. CSP Archive Exemplar Components & Controls R&D Documents & Current Potential Impacts

Topic	Abbreviated Article Title	Lead Author	Year	Notable Research Finding
Drives	Development of a low cost drive tracking mechanism	Peerless-Winsmith	1981	Contains significant information on heliostat drive design
Controls	An Assessment of Heliostat Control System Methods	SERI	1986	Contains an excellent report of control system engineering as was once standard
Standards	A Standards Application and Development Plan for Solar Thermal Technologies	SERI	1981	One of the most complete documents on quality assurance and standards in CSP
Truss System	Assessment of second-generation stretched-membrane mirror modules	Albert A. Heckes	1990	Useful design information and background on stretched mirrors contracted for SNL
Practical Cost & Performance	Solar Thermal Process Heat and Electricity Generation Performance and Costs for 'Big Dish' Technology	Stephen Kaneff	1991	Contains detailed cost breakdowns for dish systems ranging from $50kW_e$-$100MW_e$
Theoretical Cost & Performance	Study of the Potential for a Solar Thermal Power Station in Victoria	David Wilson	1990	Theorectical cost analysis of a 6 MW, 90 MW, and 330 MW CSP facility

Mirror Structure	A Geometrical Study of Paraboloidal Mirrors and Focal Absorbers	L.C.F. Whyte	1974	Equations governing geometry of Mirrors for highest efficiency
CSP Credibility	Mass Utilization of Solar Thermal Energy	Stephen Kaneff	1992	Details comparing CSP with fossil fuels
Thermodyn-amic Equations	Theoretical Principles For Solar Energy Collector Studies	P.O Carden	1974	Equations governing incoming potential energy to work & losses
Thermal Energy Storage	Evaluation Material From Industrial Waste For Thermal Storage	Stephen Kaneff	1987	Experiments on sustainable materials for thermal energy storage
Aggregate Comparison of CSP Systems	Review of Existing Mirror Panel Concepts for Point Focus Concentrating Collectors	Applied Solar Pty. Ltd.	1999	Highlights features of unique CSP systems from across the world
R & D	Prefeasibility Study Two Designed Systems Using 400m Apature Big Dishes	Stephen Kaneff	1997	Detailed information for entire 400m^2 solar collector system
Site Selection	Site Selection Guide For Solar Thermal Electric Generating Plants	J.C. Grosskre-utz	1974	CSP plant requirements, site selection, and site criteria for CSP

As an example of the utilization of the archive, the report "Site Selection Guide for Solar Thermal Electric Generating Plants" [4] found details of potential locations for CSP systems in the Southwest United States, with the top four sites occurring in California. This research hypothesized a 1,000 MW_e system. Figure **Error! Reference source not found.** displays four sites seriously considered during that time: Blythe, Inyokern, Manix, and Searles. The report takes a multitude of factors into consideration and performs detailed analysis on insolation, meteorological conditions, water supply, access, land use, land ownership, topography, and electric transmission. Required land area showed 15-20 acres necessary per megawatt, so for a base load generating a daily average of 1,000 MW_e over a year, approximately 25 square miles would be required. This research also showed typical water requirements for a 1,000 MW generating plant operating at 0.5 capacity factor being 14,100 GPM peak and 7,200 GPM average. Although the cost breakdowns will have changed since the report was written through inflation and technological advancements, the data for what is required in CSP applications is a helpful reference for current projects. For the study, cost estimates for constructing plant access roads and railroad spurs were made on the basis of $74,000 per mile for roads and $200,000 per mile for railroad. The cost of transporting water was based on piping and pump costs of $264,000 per mile, and the cost for transmission lines for a 1,000 MW load was $3.1 million, $4.8 M, $10.0 M, $28.1 M. The detailed considerations of the factors listed above returned an overall economic comparison of each site with confidence on why certain locations would be desirable. These desirable site features hold true for today's potential projects and should be considered when preparing for new CSP facilities in the United States.

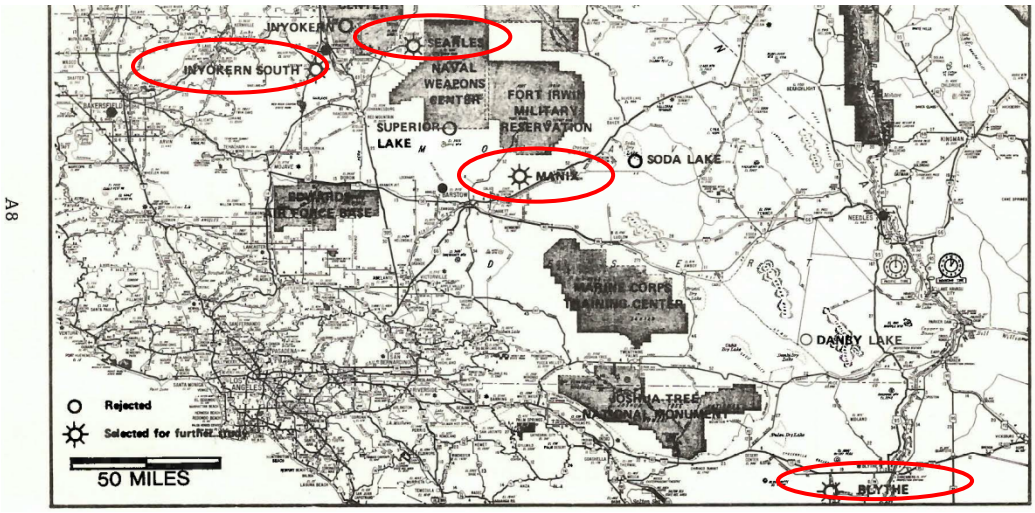

Figure 8. Potential Site Locations for 1,000 MW CSP System.

Also, included in the archive are over 700 schematics from projects developed through the Australian Solar Thermal Research Institute (ASTRI). These projects include the White Cliffs Solar Power Station with collaboration with the Australian National University (ANU), the first commercial solar power plant built, which consisted of fourteen 20 m^2 dishes in operation from 1982 to 2004. These previous paper-based detailed schematics provide an array of information from initial research to fabrication, to operational data and range from bolt specs to electrical diagrams to hydraulic diagrams as shown in Figure **9**9. Practical application data sometimes is lacking in the field of CSP, and with the archive now expanded to include information for the entire build-out of multiple CSP facilities, this information is now digitally accessible for the first time. Regarding the White Cliffs Solar Power Station, the operational longevity gives insight into operational requirements over the lifetime of the system that can heighten our knowledge about levelized costs of industrial scale projects.

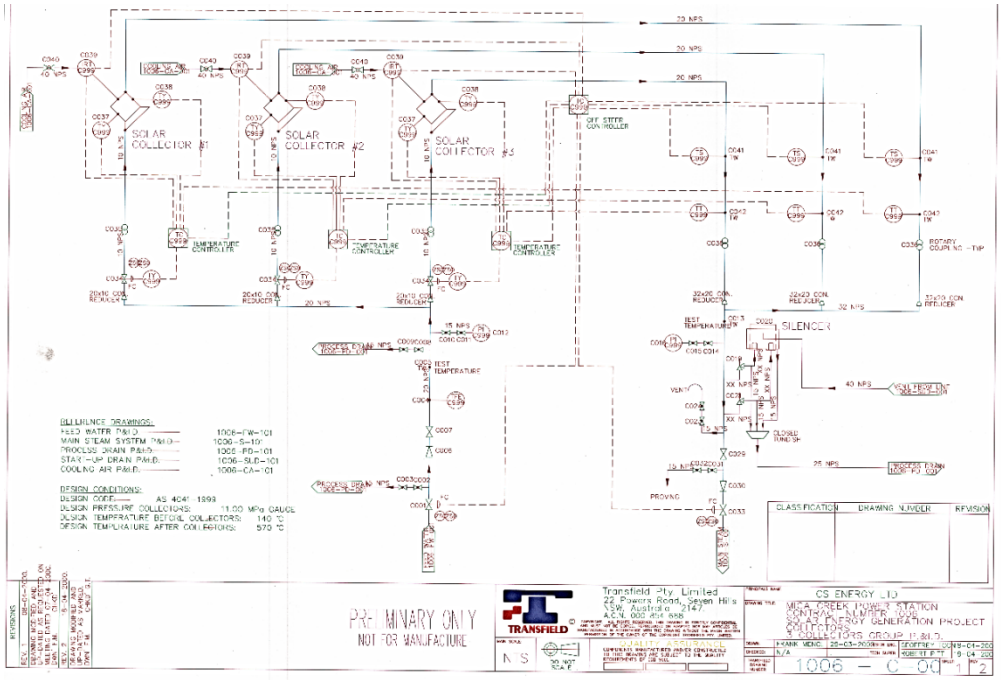

Figure 9. Hydraulic Schematic for Mica Creek Power Station.

Research papers in the archive also include work performed at ANU with large paraboloidal dish technology, culminating in a 400 m^2 50kW_e prototype built in 1994. Figure shows the wind loading conditions on a single 400 m^2 Power Dish in a specified orientation with 60 MPH winds applied. Additional schematics show differing orientations of the same dishes with the same wind loading conditions. This analysis is one example of hundreds available that can be refenced to help reduce engineering modeling costs for future projects.

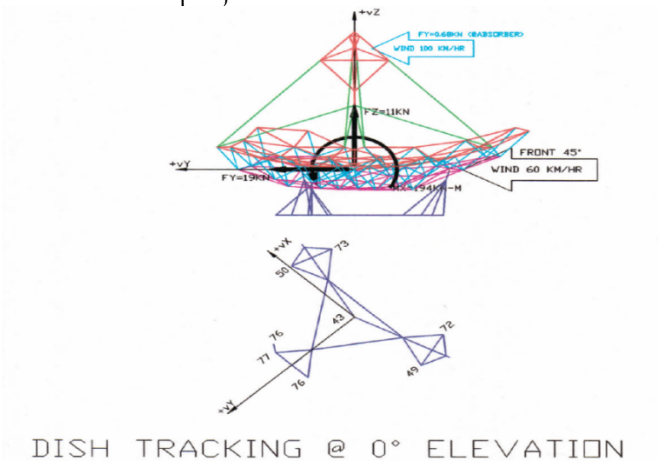

Figure 10. Mica Creek Wind Loading Conditions.

Additional recently-digitized research through ASTRI provided information for power output, efficiency, process heat, and cost breakdowns interpolated for 200 kW, 1 MW, 10 MW, and 100 MW systems. Figure shows how scaling CSP systems effect efficiency, power output, and life cycles. With this data, Figure shows a cost breakdown alongside electrical generation of each system. Each of the item lines in the tables are expanded upon in the full report to give detailed and accurate knowledge on how the values provided were generated.

TABLE H — SUMMARY OF ANU DISH-BASED SYSTEMS — PARAMETERS AND COSTS

Site Insolation:	2360 kWh/m²/annum	
Dish Parameters:	Aperture Area	334 m²
	Reflectivity	0.94
	Rated Insolation (to gain nett rated output)	950 W/m²
	Receiver absorptivity at rated insolation	0.94
	Energy collection and transport efficiency (to fixed base of dish) at rated insolation	0.88
	Annual heat supplied at fixed base of dish	660 $MWh_{thermal}$/annum

System Rated Output at 950 W/m²		50 kWe Demo Plant	50 kWe	200 kWe	1 MWe	10 MWe	100 MWe
Assessed Output at 950 W/m²		52.9 kW	52.9 kW	241 kW	1.02 MWe	10.5 MWe	100.4 MWe
Collector Aperture	m²	334	334	1 336	5 680	42 420	316 630
Number of Collectors		1	1	4	17	127	948
Nett Annual Heat Energy delivered to engine or turbine (a)	MWh_{th} per annum	660	660	2 640	11 220	83 840	619 400
Number of engines (e)/turbines (t)		1e	1e	1e	5e*	1t	1t
Nett enthalpy to engine/turbine at rated output (950 W/m²)		279.5 kW	279.5 kW	1 118 kW	4.74 MW	35.3 MW	262 MW
Gross engine/turbine efficiency of conversion at rated output	%	21.5	21.5	23.5	23.5	32.5	42.0
Auxiliary Power at rated output	kWe	2–4.2	2–4.2	4–8	20–42	700	8 000
Nett Electrical Output		52.9 kWe	52.9 kWe	241 kWe	1.02 MWe	10.5 MWe	100.4 MWe
Engine/Turbine-Alternator Efficiency at rated output	%	18.9	18.9	21.6	21.6	29.7	38.8
Efficiency of Overall System Nett electrical output/solar input at rated output	%	16.7	16.7	19.0	19.0	26.1	33.4
Nett Annual Electrical Output (b)	MWhe per annum	124	124	558	2 360	24 140	234 800
Annual Average Overall Collection and Conversion Efficiency solar to electricity	%	15.7	15.7	17.7	17.6	24.1	31.4
Process Heat							
System Installed Costs	$million	0.1649	0.1132	0.439	1.848	11.74	76.61
Heat supplied/annum [see (a)] Life Cycle Cost at 8% nett interest rate	¢/kWh_{th}	2.74	1.86	1.77	1.77	1.42	1.27
Electricity Generation							
System Installed Costs (total)	$million	0.2362	0.1775	0.6556	2.398	20.1	136.06
Installed Costs	$/kWe	4 465	3 355	2 720	2 350	1 910	1 355
Nett Electricity Produced per annum [see (b)]	MWh_e per annum	124	124	558	2 360	24 140	234 800
Life Cycle Cost at 8% nett interest rate	¢/kWhe	23.0	16.5	13.7	11.7	9.5	6.6

* Alternatively a 1 MW turbine could be employed instead of 5 engines.

Figure 11. Summary of Power Generation & Requirements for Multiple Dish Systems.

System Details	Total System Cost $	Output per Annum MWh_e	Cost/kW Installed	Life Cycle Costs*	
				i*=10% ¢/kWhe	i*=5% ¢/kWhe
50 kWe Demonstration Unit (1 dish)	236 200	124	4 465	26.0	18.3
50 kWe Commercial Unit (1 dish)	177 500	124	3 355	18.5	13.5
200 kWe Commercial Unit (4 dishes)	655 600	558	2 720	15.6	11.0
1 MWe Commercial Unit (17 dishes)	2.398 m	2 360	2 350	12.7	8.9
10 MWe Commercial Unit (127 dishes)	20.1 m	29 140	1 910	10.9	7.5
100 MWe Commercial Unit (948 dishes)	136 m	234 800	1 355	7.3	5.1

Figure 12. Summary of Costs Associated with Scaled Dish Systems.

Understanding fabrication and operational costs for CSP industrial projects is paramount to make sure the project is profitable. A 1999 report on point focus concentrating collectors titled "Review of Existing Mirror Panel Concepts for Point Focus Concentrating Collectors" studied 44 "Realized and Proposed Collector Systems" from 1978 to 1998. Figure depicts information on the 400 m^2 50 kW_e prototype mentioned above, one of 44 collectors studied in the report. This example was chosen for congruency of overlap in research at CSP facilities. Other systems worldwide have similar parallelisms within the archived literature. The ease of viewablity of information, including optical efficiency, weight, focal ratio, and cost allows each of the 44 collectors studied to be easily compared for pros and cons.

Energy Research Centre 400 m^2 'Big Dish' 1988-94

Location of Organization: **ANUTECH, Canberra**

Overall Configuration: **See Figures 45a, 45b, 45c, 45d, 45e 45f, 45g**

Status: **Prototype**
Numbers Built: **2 comprising SG3 in Canberra and SG3 Mark 2 at Israel National Solar Energy Centre, Sede Boqer**
Heated Fluid: **Water/Steam**
Focal Ratio F/D: **0.57**
Optical Configuration: **Paraboloidal structure carrying paraboloidal mirror panels**
Mirror Details: **SG3: 2 mm back-silvered glass mirrors glued to steel sheet frame; SG3 Mark 2: 1 mm low iron glass glued to fibreglass scored substrate**
Optical Aperture Area/Diameter: **400 m^2; Hex. aperture dia. 22.7, 25.5 m**
Reflector Elements: **SG3 - 54; SG3 Mark 2 - 216**
Optical Efficiency: **SG3 - 0.86; SG3 Mark 2 - 0.96**
Reflector Slope Error: **SG3: Average 6 mrad. SG3 Mark 2; ?**
Intercept Factor: **1.0**
Geometric Concentration Ratio: SG3 - 260; SG3 Mark 2 - ?
Peak Conc. Ratio: **SG3- 1800 suns; SG3 Mark 2, not yet measured, >4000 by design**
Reflector Panel Construction: **Mirrors glued to substrate held in paraboloidal form by wire frames**
Thickness of Reflective Panels: **SG3 ~ 75 mm; SG3 Mark 2 ~ 20 mm**
Weight of Reflective Panels: **SG3 ~ 8 t. total; SG3 Mark 2 ~ 5.5 t. total**
Mirror Support Structure: **Rigid steel tubular frame**
Mounting and Actuation: **Elevation: SG3: Curved beam with 'walking' hydraulic ram; SG3 Mark 2: Twin direct-acting Rams. Azimuth: SG3 - single 'walking' hydraulic ram; SG3 Mark 2: two 'walking' rams**
Drives: **Elec. Pump driven hydraulic system**
Foundations: **Circular concrete ring with integral hub foundation**
Maximum Tracking Wind Velocity: **SG3: and SG3 Mark 2: 80 km/h**
Survival Wind Velocity: **SG3: 130 km/h; SG3 Mark 2: 180 km/h**
Natural Collector Vibration Frequency: **SG3: ~ 4 Hz; SG3 Mark 2: 3 Hz**

Costs: **Mirror Panels: SG3: $AUD 107,000 (1994). SG3 Mark 2: $158,000**

Comments: **SG3 is an experimental prototype. SG3 Mark 2 is an experimental facility with which to conduct experiments of many kinds and has accordingly strict demands on concentration ratio and accuracy generally. References: Kaneff (1990a,b,c; 1991 a,b,c,;1992 b; 1993 a,b; 1994 a,b,c; 1995 a; 1997/98; 1999 a,b). Kaushika and Kaneff (1988,1993)**

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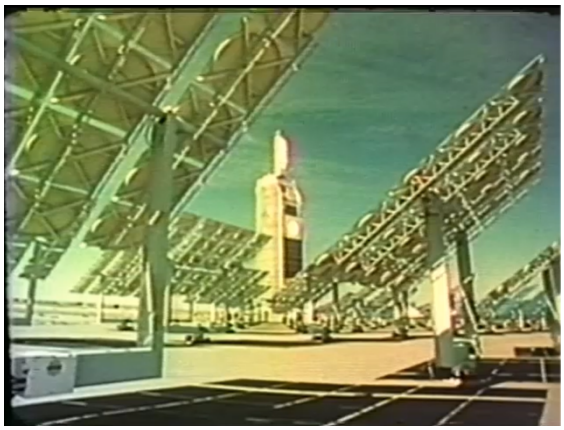
Figure 13. Collector System Highlights for 400 m^2 Dish.

During the evaluation of the videos, may were found pertaining to SNL NSTTF construction and initial on-sun receiver testing (Figure 14a), as well as with the construction, commissioning and testing of SolarOne and SolarTwo (Figure 3b) projects.

a. 

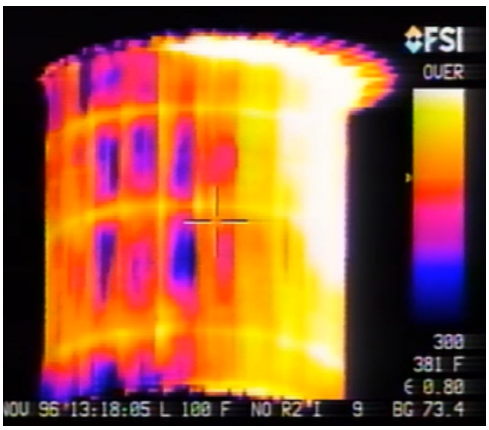
b. 

Figure 14. a. Initial SNL NSTTF on-sun testing and b. Solar-Two receiver thermal IR testing.

The digitization of media and documents also included engineering drawings, such as those pertaining to early CSP/CST systems. Figure 15 provides a diagram from an early U.S. DOE Solar water splitting project from 1983, research that continues, and is still relevant today.

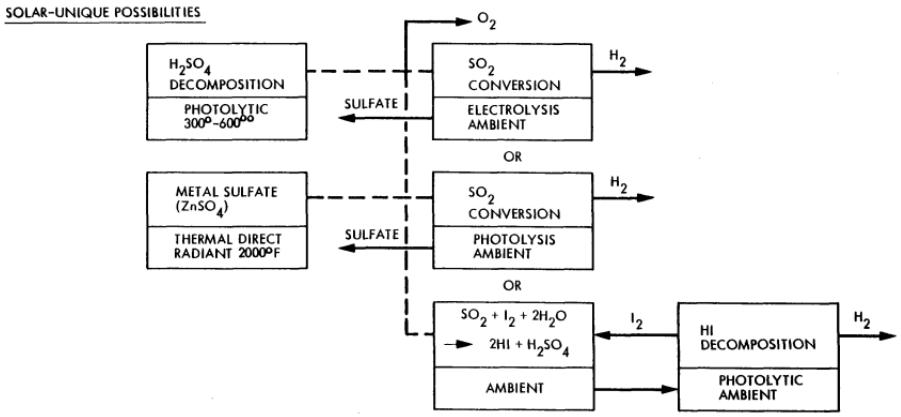


Figure 15. Early solar water-splitting U.S. DOE-sponsored research process diagram.

7. CONCLUSIONS & SIGNIFICANT ACCOMPLISHMENTS

A comprehensive digital library archive was developed as a repository of paper-based documents dating back to the start of significant CSP R&D over the last 50 years. This archive, with over 15,000 documents, spans work produced from multiple countries, including the United States, Australia and South Africa, among others. Research is included to illustrate how these one-of-a-kind, previous paper-based-only documents can directly impact current CSP projects/programs as well as the inclusion of media (e.g. videos, pictures), and engineering drawings which provide more value of the archive to CSP researchers and solar research organizations such as SolarPACES.

8. REFERENCES

[1] Sandia National Laboratories, CSP Library Archive, https://www.librarycat.org/lib/SandiaCSP, 2022

[2] Ho, C.K., "Gen 3 Particle Pilot Plant (G3P3): Integrated High-Temperature Particle System for Concentrating Solar Power and CSP Overview," No. SAND2019-9921PE, Sandia National Laboratories, 2019.

[3] Zhu, G., Augustine, C., Mitchell, R., Muller, M, Kurup, P., Zolan, A., Yellapantula, S., Brost, R., Armijo, K.M., Sment, J., Schaller, R. and Gordon, M., "Roadmap to Advance Heliostat Technologies for Concentrating Solar-Thermal Power," National Renewable Energy Laboratory, 2022.

[4] Black & Veatch, "Site Selection Guide for Solar Thermal Electric Generating Plants," NASA CR-134669, National Astronautics and Space Administration, CSP, 190683530, 1974.

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