4 Summary and Recommendations

The development of High Energy Power and Propulsion systems will enable many exciting new human and science missions in the future. In particular, the development of nuclear fission power and propulsion systems will enable long-stay human lunar and Mars exploration, and transport of humans to and from Mars. However, the long-lead times required to develop both the nuclear and non-nuclear technologies and components and their associated infrastructure development will present a major technical, programmatic, and budgetary challenge. These long lead times require that these technologies and system developments be started immediately so that the capabilities are available when required. Likewise, the development of future lightweight, highly efficient radioisotope power systems will enable many future robotic science missions to the surface of Mars, Europa, Titan, Venus, as well as other deep space probes. The use of radioisotope electric propulsion will enable a certain class of science missions to small planetary bodies (small moons and asteroids) as well as provides capability to visit multiple small body destinations. Reusable solar electric propulsion cargo tugs offer the potential of economic transfer of cargo to and from the Earth and moon and Mars. Finally batteries, fuel cells, and other advanced energy storage devices will be ubiquitous in all areas of human and science exploration, from powering astronauts and rovers, to providing critical power for planetary landers and nighttime or shadowed power in conjunction with solar power systems.

- Fission Systems
  - Infrastructure reestablishment
  - Technology capture (i.e., Rover, Nerva , SP-100 …)
  - High temperature fuels and materials
  - Shielding
  - Autonomous control
  - Lifetime
  - Dynamic power conversion
  - Heat rejection
  - PMAD
  - High power thruster technology
  - Ground Testing (subsystems and systems)
- Radioisotope systems
  - Lightweight components (power conversion, heat rejection, PMAD)
  - High efficiency power conversion (reduce PU -238 cost)
  - Sub-kW electric propulsion sub -system
  - Infrastructure
- Solar Systems
  - Very large (100s of kWe to MWe), high specific power (300 to 500 W/Kg) solar arrays
  - Ground testing of very large, deployable arrays
  - Radiation resistant solar cells
  - High power thruster technology
- Energy Storage
  - Fuel Cells: Medium power PEM Fuel Cells, Regenerative fuel cells, Small fuel cells
  - Primary Batteries: High specfic energy, RAD hard Low temperature batteries
  - Secondary Batteries: High Specfic energy, Long Life, RAD Hard, Low Temp. Batteries
  - Fly wheels

Acronym list

BNTP	Biomodal Nuclear Thermal Propulsion
CBS	Capability Breakdown Structure
CEV	Crew Exploration Vehicle
EDS	Earth Departure Stage
EP	Electric Propulsion
GPHS	General Purpose Heat Source
HEP&P	High Energy Power and Propulsion
INL	Idaho National Lab
ISRU	In-situ Resource Utilization
JIMO	Jupiter Icy Moon Obiter
LSAM	Lunar Surface Access Module
MMRTG	Multi Mission Radioisotope Thermoelectric Generator
NEP	Nuclear Electric Propulsion
NERVA	Nuclear Engine for Rocket Vehicle Applications
MMW-NEP	Multi Megawatt Nuclear Electric Propulsion
NTP	Nuclear Thermal Propulsion
PIE	Post Irradiation Evaluation
PMAD	Power Management and Distribution
REP	Radioisotope Electric Propulsion
RPS	Radioisotope Power System
SEP	Solar Electric Propulsion
SRC	Strategic Roadmap Committee
SRG	Stirling Radioisotope Generator
TRL	Technology Readiness Level