

GAMEPLAY_SYSTEMS.md

Version: 1.0.0 **Last Updated:** 2024-12-19 **Status:** Approved **Dependencies:** [GAME_DESIGN.md, TECHNICAL_ARCHITECTURE.md]

Change Log

- v1.0.0 (2024-12-19): Consolidated from energy_production and minigame documents
-

2.1 Mining & Energy Production

Mining Loop Architecture

Core Mining Flow

1. **Approach Orb** (Proximity < 30 units)
2. **Start Mining** → Opens quantum circuit minigame
3. **Solve/Skip Puzzle** → Determines extraction rate
4. **Extract Packets** → Based on performance
5. **Continue/Stop** → Player choice

Daily Circuit Integration

Each cardinal circuit rotates daily at midnight UTC:

- Same puzzle all day allows pattern discovery
- Community learns optimal solutions

- Successful solutions charge circuit
- 80% charge enables tunnel formation

Extraction Rates

Performance Tier	Fidelity	Mining Multi	Circuit Charge
Failed	<70%	0.5x	0%
Default (Skip)	70%	1.0x	0%
Good	70-85%	1.25x	1%
Bonus	85-95%	1.5x	3%
Perfect	95-98%	1.75x	4%
Quantum	>98%	2.0x	5%

Energy Generation Formula

$$\text{Energy_Output} = \text{Base_Rate} \times \text{Circuit_Efficiency} \times \text{Resonance_Multiplier} \times \text{Population_Activity}$$

Circuit Energy Systems

Circuit Types (3-6-9 Pattern)

1. Primary (3 circuits)

- Cardinal directions
- 20-minute emission cycles
- Base energy output

- Always active

2. Secondary (6 circuits)

- Diagonal connections
- 15-minute cycles
- 2× energy output
- Unlock at 50% development

3. Tertiary (9 circuits)

- Quantum tunnels
- 10-minute cycles
- 3× energy output
- Unlock at 90% development

Resonance Effects

- Aligned circuits: +50% energy
- Opposed circuits: -25% energy
- Perpendicular: No interaction
- Entangled: Instant energy sharing

2.2 Quantum Circuit Minigame

Puzzle Mechanics

Bloch Sphere Fundamentals

Players manipulate quantum states on a Bloch sphere to match target configurations:

Starting State: Always $|0\rangle$ (north pole) **Target State:** Daily rotation from circuit **Goal:** Apply gates to reach target with high fidelity

Available Gates

Gate	Symbol	Operation	Bloch Effect
X	σ_x	Bit flip	π rotation around X
Y	σ_y	Bit+phase flip	π rotation around Y
Z	σ_z	Phase flip	π rotation around Z
H	H	Superposition	X→Z axis rotation
S	S	Phase gate	$\pi/2$ around Z
T	T	$\pi/8$ gate	$\pi/4$ around Z

Fidelity Calculation

$$\begin{aligned}\text{Fidelity} &= |\langle \psi_{\text{target}} | \psi_{\text{achieved}} \rangle|^2 \\ &= (1 + \mathbf{v}_1 \cdot \mathbf{v}_2) / 2 \quad (\text{for Bloch vectors})\end{aligned}$$

Difficulty Progression

Discovery Mode (Tutorial)

- Visual rotation rings
- Unlimited attempts
- No timer
- Gates: X, Y, Z, H only

Circuit Mode (Standard)

- Build gate sequences
- Limited gate budget (3-7)
- Soft timer for bonus
- All gates available

Challenge Mode (Advanced)

- Random daily targets
- Minimum gate requirements
- Competitive leaderboards
- QAI competition

Integration with Mining

Every mining attempt:

1. Links to nearest circuit's daily state
 2. Player attempts to match state
 3. Fidelity determines rewards
 4. Success charges circuit
 5. Circuit at 80% enables tunnels
-

2.3 Wave Packet Physics

Packet Properties

```
WavePacketSignature {  
  frequency: FrequencyBand // R, RG, G, GB, B, BR  
  amplitude: float // 0.0 - 1.0 (intensity)  
  phase: float // 0 - 2π (position)  
  coherence: float // 0.0 - 1.0 (purity)  
  entangled_with: Option<ID> // Paired packet  
}
```

Decoherence Model

Base Lifetime: 10 seconds in vacuum

Modifiers:

- Proximity bonus: +5s per nearby same-frequency packet
- High-energy zones: ×0.5 lifetime
- Observation lock: 2s phase stability
- Storage quality: ×0.1 to ×1.0 preservation

Interference Mechanics

When multiple players mine same orb:

$$\text{Interference} = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos(\Delta\phi)$$

Results:

- Constructive (in-phase): Up to 2× extraction
- Destructive (opposed): Down to 0× extraction
- Partial: Proportional bonus/penalty

Quantum Entanglement

Properties:

- Instant state correlation
- Shared phase/amplitude
- Opposite spins
- Distance-independent effects

Applications:

- Paired extraction (both players get packets)
- Instant transmission through tunnels
- Cross-world energy transfer
- Quantum communication

2.4 Circuit & Tunnel Networks

Circuit Charging Mechanics

Charge Sources

1. **Player Solutions:** 0-5% per perfect solve

2. **Passive Generation:** 0.1% per hour
3. **Resonance Bonus:** +50% from aligned circuits
4. **Population Multiplier:** More players = faster

Charge Requirements

- 0-79%: Building phase
- 80-99%: Tunnel ready
- 100%: Maximum efficiency

Charge Consumption

- Tunnel formation: -50% charge
- Maintenance: -1% per hour
- Overload protection: Cap at 100%

Quantum Tunnel System

Creation Requirements

1. Both circuits at 80%+ charge
2. 10,000 energy unit investment
3. Quantum coherence > 70%
4. Maximum 6 tunnels per world

Tunnel Properties

- **Travel:** Instant (quantum teleportation)
- **Capacity:** 100 packets/second

- **Efficiency:** 70-95% (based on maintenance)
- **Stability:** Requires constant energy

Cross-Tier Routing

Only through cube-center worlds:

- Main → Face: Via cube center
 - Face → Face: Via cube center
 - Main → Main: Direct if adjacent
 - Strategic control importance
-

2.5 Crafting & Processing Pipeline

Processing Stages

Stage 1: Packet Compression

Input: 25 wave packets (same frequency) **Output:** 1 energy point **Properties:** Retains frequency, loses phase

Stage 2: Geometric Formation

Input: 4-20 energy points **Output:** 1 geometric shape **Types:**

- Tetrahedron (4 points)
- Cube (8 points)
- Octahedron (6 points)

- Dodecahedron (12 points)
- Icosahedron (20 points)

Stage 3: Device Construction

Input: Multiple geometric shapes **Output:** Functional devices **Examples:**

- Mining Enhancer: 2 Tetrahedra + 1 Cube
- Quantum Storage: 3 Octahedra
- Tunnel Stabilizer: 1 Dodecahedron + 1 Icosahedron

Crafting Mechanics

Color Harmony System

- Same frequency: 100% efficiency
- Adjacent frequency: 75% efficiency
- Opposite frequency: 50% efficiency
- Mixed frequencies: Create unique properties

Shape Properties

Shape	Points	Primary Use	Special Property
Tetrahedron	4	Speed	+Movement rate
Cube	8	Storage	+Capacity
Octahedron	6	Mining	+Efficiency
Dodecahedron	12	Energy	+Generation
Icosahedron	20	Quantum	+Stability

Device Tiers

1. **Basic:** Single shape devices
2. **Advanced:** 2-3 shape combinations
3. **Quantum:** 4+ shapes with resonance
4. **Legendary:** Perfect geometric harmony

Economic Value Chain

Raw Packets (1x value)
↓ (25:1 compression)
Energy Points (20x value)
↓ (4-20:1 shaping)
Geometric Shapes (100-400x value)
↓ (2-5:1 crafting)
Functional Devices (1000-5000x value)

Value Modifiers:

- Rarity: Blue/Magenta worth 3× Red/Yellow
- Purity: Perfect coherence +50% value
- Shell Distance: +10% per shell
- Market Demand: ±50% based on supply