Consider a system with the following eigenstates.

$$
\begin{aligned}
|0\rangle &= (1\ 0\ 0\ 0)^\dagger && \text{no electrons} \\
|1\rangle &= (0\ 1\ 0\ 0)^\dagger && \text{one electron in state } \phi_1 \\
|2\rangle &= (0\ 0\ 1\ 0)^\dagger && \text{one electron in state } \phi_2 \\
|3\rangle &= (0\ 0\ 0\ 1)^\dagger && \text{two electrons, one in state } \phi_1\text{, one in state } \phi_2
\end{aligned}
$$

Then for the wavefunction basis

$$\phi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$$

and for $L = 10^{-9}$ meters we have

$$\hat{E} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0.38\,\text{eV} & 0 & 0 \\ 0 & 0 & 1.50\,\text{eV} & 0 \\ 0 & 0 & 0 & 6.55\,\text{eV} \end{pmatrix}$$

Let $|\xi\rangle$ be the state vector

$$|\xi\rangle = \frac{1}{2}|0\rangle + \frac{1}{2}|1\rangle + \frac{1}{2}|2\rangle + \frac{1}{2}|3\rangle = \begin{pmatrix} 1/2 \\ 1/2 \\ 1/2 \\ 1/2 \end{pmatrix}$$

The expected energy is

$$\langle\xi|\hat{E}|\xi\rangle = \frac{0\,\text{eV}}{4} + \frac{0.38\,\text{eV}}{4} + \frac{1.50\,\text{eV}}{4} + \frac{6.55\,\text{eV}}{4} = 2.11\,\text{eV}$$

For the system we are considering, the result of a single measurement is either 0 eV, 0.38 eV, 1.50 eV, or 6.55 eV. The value 2.11 eV is the expected average across multiple measurements. Recall that a measurement causes the system to exit state $|\xi\rangle$ and enter an eigenstate $|0\rangle$, $|1\rangle$, $|2\rangle$, or $|3\rangle$ corresponding to the measured eigenvalue. The system must be put back in state $|\xi\rangle$ before the next measurement.

To use a slot machine analogy, state $|\xi\rangle$ is like the wheels spinning. Observing the system makes the wheels stop. The stopped wheels are in an eigenstate $|0\rangle$, $|1\rangle$, $|2\rangle$, or $|3\rangle$. Once they are stopped the wheels don't change, they remain in the same eigenstate. You have to pull the lever to get the wheels spinning again.